Life Cycle Responses to Health Insurance Status*

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Abstract

Health insurance status can change over the life cycle for exogenous reasons (e.g. Medicare for the elders, PPACA for younger agents, termination of coverage at retirement in employer-provided plans). Durability of the health capital, endogenous mortality and morbidity, as well as backward induction suggests that these changes should affect the dynamic life cycle beyond the period at which they occur. The purpose of this paper is to study these lifetime effects on the optimal allocation (consumption, leisure, health expenditures), status (health, wealth and survival rates), and welfare. We analyse the impact of young (resp. old) insurance status conditional on old (resp. young) coverage through the structural estimation of a dynamic model with endogenous death and sickness risks. Our results show that young insurees are healthier, wealthier, consume more health care yet are less exposed to OOP risks, and substitute less (more) leisure before (after) retirement. Old insurees show similar patterns, except for lower precautionary wealth balances. Compulsory health insurance is unambiguously optimal for elders, and for young agents, except early in the life cycle. We draw other implications for public policy such as Medicare and PPACA.

Keywords: Household Finance. Endogenous Morbidity and Mortality Risks. Demand for Health. Medicare and Patient Protection and Affordable Care Act. Simulated Moments Estimation.

JEL Classification: D91, G11, I13

1 Introduction

The health insurance status of individuals can change exogenously over the life cycle. For instance, employer-provided insurance often ends at retirement. Moreover, prior to the signing into law of the Patient Protection and Affordable Care Act (PPACA, a.k.a. Obamacare) in 2010, Medicare provided guaranteed and subsidized insurance principally for elders,[1] whereas PPACA extends these provisions to younger individuals. The purpose of this paper is to analyse the impact of such exogenous, and predictable changes in health insurance for the life cycle allocations (i.e. consumption, health expenditures and leisure), status (wealth, health levels and survival), as well as welfare of households.

Health insurance coverage at any given period of life likely affects decisions at other periods as well. Indeed, because health can be thought of as a durable good, insurance-induced changes in health status when young do have lifetime consequences on exposition to mortality and morbidity risks (i.e. the *Long Reach of Childhood* effect, Smith, 1999; Case and Paxson, 2011). Moreover, a standard backward induction argument makes it clear that young agents should internalize the effects of being insured or not when old, and its consequences for future health statuses and corresponding exposition to the risks of sickness and of dying.

Insurance for health expenditures affects dynamic decisions through two main channels: the budget constraint, and the exposition to morbidity and mortality risks. First, disposable resources are reduced by the amount of the insurance premia. The extent of this income effect depends on the public subsidization through Medicare or PPACA, whereas the financing of these programs through distortionary income taxes affects the leisure/labor supply substitution. Moreover, health insurance lowers the effective price of health care, making health expenditures relatively less costly compared to other means for adjusting health, such as healthy leisure activities. This change in relative price also alters the leisure/labor supply substitution and consequently the level of disposable resources.

[1] See Table 1 for details on Medicare coverage and financing.

Second, conditional upon sickness, the out-of-pocket (OOP) medical expenditures are reduced by health insurance, thereby lowering the exposure to future health costs, and mitigating the incentives for maintaining precautionary wealth balances. Furthermore, to the extent that health status determines the capacity to work and the response to treatment, insurance also reduces the incentives for maintaining precautionary health balances. Moreover, the changes in current health expenditures and healthy leisure induced by insurance will impact future health status, and therefore the likelihood of both sickness and death. If better health lowers the probability of morbidity, this again reduces the incentives for maintaining precautionary wealth and health balances, whereas a longer expected lifetime for healthier individuals justifies more savings for old age in both financial and health capitals.

The timing of the coverage is also important for the dynamic allocation. On the one hand, employer-provided coverage that is expected to end at retirement can lead to a pre-retirement acceleration of health expenses and accumulation of the preventive health and wealth stocks. Corresponding improvements in health will alter expected longevity and exposition to future risks, and will in turn affect the inter-temporal allocation for consumption and leisure. On the other hand, post-retirement health insurance such as Medicare makes it possibly optimal to postpone health care until coverage begins which may lead to pre-retirement deterioration in the health status. Again, the resulting changes in wealth and health will alter the dynamic allocation over leisure and consumption via its effects on the budget constraint and the exposition to morbidity and mortality risks.

The previous discussion suggests that (i) the timing of health insurance coverage should affect the allocations *throughout* the life cycle, and (ii) the mechanisms through which these effects take place are non trivial when morbidity and mortality risks are endogenous. Understanding how changes in coverage affect the life cycle allocations appears to be particularly warranted given the resources already devoted to Medicare (see Table 2), and at a period where PPACA starts imposing compulsory insurance on large, previously uninsured segments of the US population.[2]

This paper primarily relates and contributes to the literature (summarized in Table 3) on the consequences of morbidity and mortality risks for the life cycle allocations by households. In the presence of incomplete or imperfect insurance and asset markets, the effects of sickness risk on medical expenses, nonemployment and wages uncertainty, as well as those of longevity uncertainty on the risk of living too long or too short cannot be completely hedged away. Consequently, the agents are forced to remain partially exposed and/or adopt costly self-insurance strategies. This literature thus analyses the corresponding consequences for decisions and outcomes related to asset accumulation, medical expenses, labor market supply, as well as the demand for social insurance. Whereas most are treated separately in the literature, this paper innovates by considering all these consequences simultaneously within a unified framework.

Towards that objective, we propose a stochastic life cycle model where health is assimilated to human capital. More precisely, the health stock is depreciable, and can be augmented through both health investment (i.e. expenditures) and time (i.e. leisure). Depreciation is age-increasing in order to capture more pressing health problems facing the elders. The health production technology is subject to decreasing returns and path dependence, in the sense that health issues cannot be resolved through expenditures and leisure only but also depend on past decisions via the current health status. The joint inclusion of leisure and expenditures in the production of health is innovative and is meant to capture the tradeoffs between more work and disposable resources for medical spending versus more rest and healthy leisure as preventive and curative health measures. It also accounts for moral hazard problems in insurance whereby agents insured against health expenditures risk may find it optimal to shirk on unobservable healthy activities.

[2]The percentage of health uninsured Americans aged 19–64 was 21% in 2011-12, ranging from 5% in Massachusets, and 11% in DC or Vermont, to 29% in Nevada or Florida, and 32% in Texas (Henry J. Kaiser Family Foundation, 2014).

Our setup further innovates in its joint treatment of endogenous exposure to morbidity and mortality risks, that are usually analysed separately and/or as exogenous processes. More precisely, sickness entails additional depreciation (also increasing in age) of the health stock, but its likelihood of occurrence can be diminished through better health. Similarly, the longevity is stochastic and endogenous in the sense that healthier agents face a lower risk of dying. Both the morbidity and mortality endogeneities are fully internalized in the dynamic allocations made by households, while self-insurance against sickness and death is also subject to diminishing and bounded returns.

Our specification of the budget constraint contributes to existing literature by fully endogenizing the labor supply decisions, taking as given the observed patterns of increasing wages up to age 65, and falling thereafter. Although we abstract from irreversible retirement in order to capture the rising trend in elders' employment,[3] this limitation is not restrictive. Indeed, we fully allow for corner solutions with no labor market participation as an optimal response to falling wages, and rising health issues for the elders. Importantly, health insurance is exogenously set and includes private, Medicare, and no insurance variants; this allows us to carry out counter-factual analysis whereby the coverage status is varied across age in order to assess the life cycle effects.

We also innovate in our specification of preferences. Instantaneous utility is defined over consumption and leisure, as well as bequeathed wealth. Since the risk of dying is health-dependent, we show that this modelling choice constitutes an explicit alternative to the traditional approach of resorting to implicit valuable services of health. We further show that the stochastic horizon with endogenous health-dependent death intensity is iso-morphic to a fixed horizon problem with endogenous health-dependent discounting; an healthier agent faces a lower likelihood of dying and behaves as though he were more patient. The endogenous risk of living too short is thus accounted for through the bequest function, whereas that of living too long is internalized through the health-dependent discounting.

[3]According to the BLS, the employment of workers aged 65 and over increased by 101% between 1977 and 2007, compared with an overall increase of 59 % for adults (Bureau of Labor Statistics, 2008).

Precisely because the discounting is endogenous, the model admits no closed-form solution, and it is therefore solved numerically. By minimizing the distance between the simulated allocations and outcomes and the corresponding observed life cycle moments, we recover a Simulated Moments Estimation (SME) of the deep parameters. Importantly, this estimation is *super-structural* in the senses that it does not rely on any of the exogenous auxiliary processes (e.g. idiosyncratic income shocks, survival rates) that are commonly appended and estimated outside of the model in a two-step estimation approach. Rather, the only stochastic processes that are involved are the morbidity and mortality innovations, and those processes are entirely generated by the model, and estimated as such in a single-step procedure. This approach significantly complicates the estimation, yet ensures a one-to-one mapping, and therefore full internal consistency between the theoretical and the empirical methods.

Key to our analysis, the differences in this simulated output across the insurance and age dimensions can be isolated in order to identify the marginal allocative effects of the health insurance status when young (conditional upon old-age status), and when old (conditional upon young-age status). First, we find that young insurees are noticeably healthier, and that this effect is stronger if they become uninsured when old. Moreover, durability implies that health remains higher for some time after coverage ends. Both results are consistent with young insurees building up precautionary health balances in anticipation of post-retirement termination of insurance coverage. Old insurees are also healthier starting at middle age, even if they were uninsured when young. We therefore find no evidence of optimal stockpiling of expenses in anticipation of post-retirement coverage. Rather, this pre-entitlement increase is consistent with forward-looking internalization of path dependence in the health production whereby the productivity of health expenditures and leisure when old depends positively on the health stock accumulated when young.

Better health naturally leads to increases in survival rates for both young and old insurees. However, that effect remains moderate. More potent impacts can be found for health investment and OOP expenses. The former are larger for young insurees, especially when coverage ends at retirement. Investment is also higher for old insurees, although smaller in magnitude, suggesting that other means are used to maintain health. As is to be expected, despite higher consumption of medical care, the exposition to OOP risks is sharply reduced for both young and old insurees.

Perhaps the most powerful inter-temporal substitution induced by insurance can be found in healthy leisure decisions. Young insurees find it optimal to reduce leisure when young, and increase it after retirement. This effect obtains for two reasons. The lower price of health expenditures relative to healthy leisure and the fact that wages fall sharply after retirement provide incentives to work more when young, and less when old. Old insurees have smaller pre-retirement effects, but clearly take on more leisure after they retire. The combination of more work and less OOP expenses for young insurees leads to much higher *ex-post* wealth when young. Conversely, the combination of more leisure and less exposure to OOP risk entails that old insurees maintain lower *ex-ante* precautionary wealth after retirement.

Finally, we find that health insurance is generally optimal for young insurees, except early on in the life cycle. Up to their mid-30's, high initial health stocks, low wealth, and low wages make it optimal for the young to self insure through leisure rather than through markets. Conversely, post-retirement health insurance is always optimal for both young and old agents alike. As health-related problems start to escalate in periods of low labor income, lower exposure to OOP risks is a welcomed alternative to uninsurance.

Regarding public policy implications, our results suggest that allowing for coverage is much more important than determining whether health insurance is privately, or publicly provided. Indeed, our results show little differences whether Medicare is operational or not when contrasted with unsubsidized private markets. In unreported additional testing, we also verify the effects of PPACA by extending the Medicare provision to younger agents. Again, the results are virtually unchanged compared to privately provided compulsory insurance. The reason can be traced to the opposing effects of Medicare on the budget constraint. On the one hand Medicare subsidizes the health insurance premia leading to an increase in wealth. On the other, it imposes taxes on labor income that distort the labor-leisure choices. Since coverage parameters (deductibles, co-payments) are otherwise similar, the net effect is minimal. Finally, although clearly optimal from the elders' point of view, it is not entirely clear that it is so from the younger agents' perspective. Indeed, self-insurance through better health is optimal early on in the life cycle; imposing market-provided insurance – as currently proposed under PPACA – is not necessarily optimal from a life cycle perspective.

The rest of the paper proceeds as follows. Following a discussion of the literature in Section 2, we outline the theoretical framework in Section 3. The empirical methods are discussed in Section 4. Finally, the iterative and simulation results are presented and discussed in Section 5. All tables and figures are regrouped in the Appendix.

2 Relevant literature

First, a vast literature initiated by Kotlikoff (1989) studies consumption decisions in the presence of health-related risks[4] and concludes that prudent agents faced with OOP expenses and labor income uncertainty, as well as the risk of living too long should increase precautionary savings (Hubbard et al., 1994, 1995; Levin, 1995; Skinner, 2007; De Nardi et al., 2009). The empirical evidence is partially supportive of that conjecture. On the one hand slow asset deccumulation is indeed observed for elders (Palumbo, 1999; Dynan et al., 2004; De Nardi et al., 2009, 2010). On the other hand, observed savings by young agents are generally thought to be insufficient with respect to standard life cycle predictions (Skinner, 2007). Attempts to rationalize observed behaviour emphasize the role of distortions induced by social safety nets (Hubbard et al., 1994, 1995; Scholz et al., 2006). In particular, consumption floors, Social Security, Medicaid and Medicare,

[4]Other studies of health-related risks effects on savings decisions include Hubbard et al. (1994, 1995); Palumbo (1999); Dynan et al. (2004); French (2005); Scholz et al. (2006); Hall and Jones (2007); Edwards (2008); De Nardi et al. (2009); Fonseca et al. (2013); De Nardi et al. (2010); Ozkan (2011); French and Jones (2011); Scholz and Seshadri (2012); Hugonnier et al. (2013) among others.

all hedge downward risks, and thus reduce precautionary motives, whereas assets-based means testing for some of these policies effectively impose full taxation on wealth beyond a certain threshold. This paper also analyses the life cycles of asset accumulation in the presence of health-related risks, under various health expenditures insurance regimes (none, private, public), and also emphasizes their influence for precautionary savings for both young and old agents.

Second, two alternative frameworks can be used to study the effects of health-related risks on medical expenses. First, stochastic health expenditures have been modelled as exogenous, and thus tantamount to undiversifiable income shocks, by Hubbard et al. (1995); Rust and Phelan (1997); Palumbo (1999); French (2005); Scholz et al. (2006); Edwards (2008); De Nardi et al. (2009, 2010); French and Jones (2011); Scholz and Seshadri (2013). Persistence and predictability of health expenses can be obtained by assuming a Markovian process, and/or correlating these shocks to observable exogenous health and socioeconomic statuses. Second, endogenous health expenditures have been modelled as generating an implicit utilitarian service flow by Blau and Gilleskie (2008); De Nardi et al. (2010). More explicit approaches in the spirit of Grossman (1972) model health as a durable good providing utility services, and that can be adjusted through health expenditures (Case and Deaton, 2005; Hall and Jones, 2007; Yogo, 2009; Fonseca et al., 2013; Khwaja, 2010; Ozkan, 2011; Galama et al., 2012; Scholz and Seshadri, 2012, 2013). Following pioneering work by Cropper (1977), other alternatives append self-insurance services by allowing health to (partially) reduce morbidity and/or mortality risks (Hall and Jones, 2007; Ozkan, 2011; Scholz and Seshadri, 2012, 2013; Hugonnier et al., 2013). Our modelling choices follow this last strand of endogenous health-related risks literature and emphasize the effects of self-insurance for dynamic allocations.

Third, the consequences of health outcomes for labor revenues have been modelled by assuming inelastic labor supply, and focusing on their effects on wages by Case and Deaton (2005); Fonseca et al. (2013); Khwaja (2010); Scholz and Seshadri (2012), as well as by Hugonnier et al. (2013) who show that the health effects are then iso-morphic to those obtained through utilitarian flows. More explicit approaches study the intensive margin, allowing agents to increase working hours in the presence of high OOP expenses, and thereby reducing the motivation for precautionary savings (Rust and Phelan, 1997; Palumbo, 1999; French and Jones, 2011). Alternatives instead associate illness to work incapacity (Khwaja, 2010; Scholz and Seshadri, 2012). The latter can further be endogenized by allowing for preventive benefits of healthy leisure on health production (Leibowitz, 2004). As discussed by Ehrlich and Becker (1972); Leibowitz (2004), self insurance through leisure then raises moral hazard issues for agents insured through markets who can find it optimal to shirk on preventive measures. We follow the healthy leisure literature and allow for insurance status effects on health prevention decisions. At the same time, a large literature analyses the role of health uncertainty for work decisions on the extensive margin. In particular, this literature shows that postponing retirement until Medicare eligibility is optimal when retirement is associated with the loss of employer-provided health insurance benefits (Rust and Phelan, 1997; Palumbo, 1999; Fonseca et al., 2013; French and Jones, 2011; Scholz and Seshadri, 2013). Conversely, retirement can also be accelerated if in poor health, and eligible for early retirement (Wolfe, 1985; Bound et al., 2010; Galama et al., 2012). Although our modelling of leisure choices does allow for nonemployment, we abstract from discrete and irreversible retirement decisions in our analysis.

Finally, the detrimental consequences of morbidity and mortality risks can also be mitigated through social insurance programs. Positive effects of Medicare for elders have been shown to include better health and longevity (Lichtenberg, 2002; Khwaja, 2010; Finkelstein and McKnight, 2008; Card et al., 2009; Scholz and Seshadri, 2012), higher utilization rates (Lichtenberg, 2002; Khwaja, 2010; Finkelstein, 2007; Card et al., 2009), but lower exposure to OOP risks (Khwaja, 2010; Finkelstein and McKnight, 2008; Scholz and Seshadri, 2012; De Nardi et al., 2010), lower precautionary wealth (De Nardi et al., 2010, 2009; Scholz and Seshadri, 2012) and higher consumption and leisure (Currie and Madrian, 1999; French, 2005). On the other hand, the positive effects of Medicare for younger agents have been much less studied. Exceptions include Ozkan (2011); Scholz and Seshadri (2012) who describe stockpiling medical expenses until entitlement begins, and reduced precautionary wealth for younger agents. Our paper attempts to gain further insights on these effects of Medicare on younger generations, and emphasizes previously unstudied effects on the intensive labor margin, while maintaining all the stylized facts associated with elders.

Normative elements associated with Medicare include redistribution from rich to poor (McClellan and Skinner, 2009; Bhattacharya and Lakdawalla, 2006; Rettenmaier, 2012). This literature establishes that, although richer households pay more taxes, they also live much longer and consume more health expenditures, rendering Medicare a regressive system from an actuarial point of view. However, a market completion argument paints a more progressive picture through the access to health insurance made possible for poorer households. Finally, the pay-as-you-go nature of Medicare has made it very beneficial for the first cohorts of participating elders (Cutler and Sheiner, 2000), whereas the risk-sharing between healthy young agents and unhealthy retirees has also made it welfare-improving for the latter, yet much less so for the former (Cutler and Sheiner, 2000; McClellan and Skinner, 2009; Khwaja, 2010; Ozkan, 2011). Taking into account the distortions induced by the income taxes needed to finance these programs only worsens the burden placed on the working young agents (Baicker and Skinner, 2011). Although we do not emphasize redistribution between rich and poor, we contribute to the normative literature by providing a separate assessment of the actuarial and market completion costs and benefits to young and elders.

3 Model

This section describes the environment in which an agent faces endogenous morbidity and mortality risks. The exposure to these risks can be hedged through healthy leisure and medical decisions, as well as through market-provided health insurance. We first discuss the dynamics of these two health-related risks, followed by a description of the budget constraint and the preferences of the agent. Finally, dynamic conditions characterizing the optimal allocation are presented.

Health dynamics We consider the decisions of a finitely-lived risk-averse individual, confronted with both sickness and death uncertainty. Let $y \in \mathbb{N}$ denote the calendar year, with $y = 0$ being the reference year, and let $\kappa \in \mathbb{N}_-$ be the birth year of an individual aged $t = y - \kappa = 1, 2, \ldots, T^m \leq T$. We let $\lambda^k : \mathbb{R}_+ \to \mathbb{R}_{++}$ denote an age-invariant, decreasing and convex intensity function of health (H_t). Health risks $\epsilon^k \in \{0, 1\}$ denote generalized Bernoulli morbidity ($k = s$) or mortality shocks ($k = m$), whose probability of occurrence are given as:

$$\Pr\left(\epsilon_{t+1}^k = 1 \mid H_t\right) = 1 - \exp[-\lambda^k(H_t)], \quad k = m, s. \tag{1}$$

Hence, an unhealthy agent faces higher risks of both sickness and death, and is subject to diminishing returns in risk reduction as health improves. The age at death $T^m \in [0, T]$ is bounded above by T, the maximal biological longevity, and is the first occurrence of the mortality shock:

$$T^m = \min\{t : \epsilon_t^m = 1\}.$$

The health capital is depreciable, and is depleted further upon occurrence of the morbidity shock $\epsilon^s = 1$. It can be adjusted through gross investment $I^g : \mathbb{R}_+ \times \mathbb{R}_+ \times \mathbb{I} \to \mathbb{R}_+$, an increasing, and concave function of health, real investment (I), and leisure ($\ell \in \mathbb{I} \equiv [0, 1]$):

$$H_{t+1} = \left(1 - \delta_t - \phi_t \epsilon_{t+1}^s\right) H_t + A_t I^g(H_t, I_t, \ell_t), \tag{2}$$

$$d_t = d_0 \exp[g^d t], \quad d \in \{\delta, \phi\}, \tag{3}$$

$$A_t = A_0 \exp[g^A(t + \kappa)], \tag{4}$$

where g^d are age-specific growth rates of depreciation, and where g^A is a year-specific growth rate of the medical technology. The law of motion (2) derives from the health-as-capital specification in the demand-for-health literature (Grossman, 1972), to which are appended morbidity shocks (Hugonnier et al., 2013), as well as age-increasing deterministic δ_t and stochastic depreciation $\phi_t \epsilon^s_{t+1}$. Age-increasing depreciation in (3) and displayed in Figure 1.a captures more pressing health issues for older agents, including the demand for long-term care by elders (Palumbo, 1999). When combined with health-dependent death intensities, it is also convenient for ensuring that life maintenance is getting costlier with age, and induce falling health (Case and Deaton, 2005) as well as increasing mortality rates in endogenous life horizon problems (Ehrlich and Chuma, 1990).[5]

Gross investment in (2) incorporates convex adjustment costs (Ehrlich, 2000; Ehrlich and Chuma, 1990), and healthy leisure inputs (Sickles and Yazbeck, 1998). Diminishing returns and the presence of health in I^g implies path dependency, in that current health issues reflect past behaviour, and cannot be completely solved through medical allocations. The inclusion of leisure in the gross investment function captures non-market inputs in health maintenance (e.g. prevention through physical activities), as well as potential moral hazard issues for agents who can find it optimal to cut down on prevention once insured against medical costs (Leibowitz, 2004; Ehrlich and Becker, 1972). The non-negativity constraint for gross investment is standard and prevents agents from selling their own health in markets. Finally, in the spirit of Hall and Jones (2007), the health process also includes exogenous productivity improvement in health production, whereby TFP growth in (4) is determined at the year level $y = t + \kappa$ in order to account for cohort effects that are discussed further below (see Section 5.3.3).

Budget constraint The agent evolves in an incomplete financial markets setup comprising a risk-free asset, with gross rate R^f and a health expenditures insurance contract; death risk is not insurable through markets but (partially) diversified through gross

[5]See Robson and Kaplan (2007) for discussion and alternative models of ageing and death.

investments exclusively. Given health prices P_t^I, the health insurance contract is defined by a co-payment rate $\psi \in (0,1)$ applicable on health expenditures $P_t^I I_t$, a deductible level $D_t > 0$, and an insurance premium $\Pi_t^x \in \{0, \Pi, \Pi^M\}$. The latter is the market premium Π for every insuree, or the subsidized premium $\Pi^M = \pi\Pi$ at rate $\pi \in (0,1)$ for insured elders only when Medicare is operational.

We assume that the health expenditures insurance status $x = (x^y, x^o) \in \{\mathrm{N}, \mathrm{P}, \mathrm{M}\}^2$ for young (x^y) and old (x^o) agents is set exogenously among three alternatives, (N)o insurance, (P)rivate insurance and (M)edicare. Exogenous participation can be rationalized by noting that health insurance is mainly decided upon and provided by employers and/or by government intervention, when the agent is not excluded altogether from health insurance markets because of moral hazard and adverse selection reasons (e.g. Currie and Madrian, 1999; Blau and Gilleskie, 2008; McGuire, 2011).

Denote by $\mathbb{1}_X = \mathbb{1}_{x=P,M}$ the insured; $\mathbb{1}_M = \mathbb{1}_{x=M}$, the Medicare; $\mathbb{1}_D = \mathbb{1}_{P_t^I I_t > D_t}$, the deductible reached; and $\mathbb{1}_R = \mathbb{1}_{t \geq 65}$ the old age indicators. The out-of-pocket medical expenditures $OOP_t^x(I_t)$, health insurance premia, medical prices, and insurance deductibles processes are given by

$$OOP_t^x(I_t) = P_t^I I_t - \mathbb{1}_X \mathbb{1}_D (1-\psi)(P_t^I I_t - D_t), \tag{5}$$

$$\Pi_t^x = \mathbb{1}_X \Pi \left[1 - \mathbb{1}_M \mathbb{1}_R (1-\pi)\right],$$

$$P_t^I = P_0^I \exp[g^P (t+\kappa)], \tag{6}$$

$$D_t = D_0 \exp[g^D (t+\kappa)], \tag{7}$$

where g^P is the inflation rate of medical prices, and g^D that of the deductibles. As illustrated in Figure 2, the contract (5) is standard and has the insured agent in plans P and M cover all medical expenditures $P^I I$ up to deductible D and pay a share of expenses ψ afterwards; the uninsured agent in plan N covers all medical expenses. The assumption of identical deductibles and co-payments under plans P and M in (5) is made for tractability, yet is not unrealistic given that Medicare deductibles and typical co-payment are close to those of many private plans values, and that subsidization occurs mainly through insurance premia for seniors.[6]

Finally, both the health investment prices P_t^I in (6) and deductibles D_t in (7) are time-varying, so as to allow cohort effects that parallel the growth in health production technology A_t in (4). In particular, the medical technology available to an individual aged t years born $\kappa = -30$ years ago is more productive than for someone the same age born $\kappa = -50$ years ago, i.e. $A_{t-30} > A_{t-50}, \forall t$. Consequently, agents aged t in cohort $\kappa = -30$ face higher prices, compared to agents of the same age in cohort $\kappa = -50$, i.e. $P_{t-30}^I > P_{t-50}^I$, which in turn also justify a higher level of deductible, i.e. $D_{t-30} > D_{t-50}$. This additional degree of freedom will allow us to better gauge the importance of cohort effects by varying κ in the empirical evaluation below.

Denoting labor income $Y_t^x(\ell_t)$, consumption C_t, and wealth W_t, the income process and budget constraint are given as:

$$Y_t^x(\ell_t) = \mathbb{1}_t^R Y^R + (1 - \mathbb{1}^M \tau) w_t (1 - \ell_t), \tag{8}$$

$$W_{t+1} = \left[W_t + Y_t^x(\ell_t) - C_t - OOP_t^x(I_t) - \Pi_t^x \right] R^f, \tag{9}$$

where R^f is the gross risk-free rate of interest. The labor revenues (8) capture the effects of pension income (e.g. Social Security) in Y^R, the tax effects of Medicare in τ which reduces disposable income for every worker, as well as the age variation in w_t displayed in Figure 1.b. The wealth process (9) highlights the age- time-, and plan-dependency of disposable resources.

Preferences Let $\beta \in (0, 1)$ be a subjective discount parameter, $U : \mathbb{R}_+ \times \mathbb{I} \to \mathbb{R}_{++}$ denote a monotone increasing and concave instantaneous utility when alive, and $U^m : \mathbb{R} \to \mathbb{R}_-$ an increasing and concave bequest utility function associated with death. Using the mortality shock process (1), and assuming VNM preferences, the within-period utility

[6] Medicare coverage for young disabled and Medicaid for poor households are abstracted from for tractability reasons.

$\mathcal{U}_t$, with bequest motive is given by:

$$\begin{aligned}\mathcal{U}_t &\equiv U(C_t, \ell_t) + \beta\,(1 - \exp[-\lambda^m(H_t)])\,U^m(W_{t+1}),\\ &= U(C_t, \ell_t) + [\beta - \beta^m(H_t)]\,U^m(W_{t+1}),\\ &= \mathcal{U}_t(C_t, \ell_t, I_t, W_t, H_t) \geq 0,\end{aligned} \tag{10}$$

where $\beta^m(H_t) \equiv \beta \exp[-\lambda^m(H_t)] < \beta$ is an endogenous discount factor that increases in health. Preferences (10) combine the flow utility of living, consuming, and taking leisure time, with the expected discounted disutility from dying and leaving bequests. Because one's own health is non-transferable, U^m is a function of next-period bequeathed wealth only. In particular, a negative U^m indicates a utility cost of mortality, whereas the marginal utility of bequests is positive to capture "joy-of-giving" elements, i.e. the cost of dying is attenuated by bequeathing larger amounts. However, as outlined in Shepard and Zeckhauser (1984) and Rosen (1988), within-period utility $\mathcal{U}_t$ must remain positive in order to guarantee preference for life in endogenous mortality settings. Preferences (10) provide an explicit alternative to implicit models of health valuation $\mathcal{U} = U(C, \ell, H)$, where $\mathcal{U}_H \geq 0$. Indeed, since the endogenous subjective discount factor β^m is monotone increasing, and U^m is negative, we obtain that $\mathcal{U}_{H,t} \geq 0$ which ensures positive service flows of health associated with mortality risk reduction.

Next, using the Law of Iterated Expectations, the agent's objective function can be written as:

$$\begin{aligned}V_t &= \max_{\{C_t, I_t, \ell_t\}_t^{T^m}} \mathcal{U}_t + \mathrm{E}_t\left\{\sum_{s=t+1}^{T^m} \beta^{s-t}\,\mathcal{U}_s \mid H_t\right\},\\ &= \max_{\{C_t, I_t, \ell_t\}_t^{T}} \mathcal{U}_t + \mathrm{E}_t\left\{\sum_{s=t+1}^{T} \prod_{j=t}^{s-1} \beta^m(H_j)\,\mathcal{U}_s \mid H_t\right\},\\ &= \max_{C_t, I_t, \ell_t} \mathcal{U}_t + \beta^m(H_t)\mathrm{E}_t\left\{V_{t+1} \mid H_t\right\},\end{aligned} \tag{11}$$

where $V_t = V_t^x(W_t, H_t)$ is a value function, and where the optimization is subject to the health process (2), and the budget constraint (9). Equation (11) shows that an agent with endogenous stochastic horizon T^m, constant discounting β, and evolving in an incomplete market environment (first line) is iso-morphic to an agent with deterministic horizon T, endogenous discounting $\beta^m(H)$, and operating in a complete market setup (second and third lines). Put differently, endogenous mortality risk implies that an unhealthy agent has a shorter expected life horizon and is tantamount to a more impatient individual. As the following discussion makes clear, the forward-looking agent fully internalizes the impact of his leisure and health expenditure decisions on the discounting he applies to future utility flows.

Optimality Letting subscripts denote partial derivatives, the first-order and Envelope conditions for problem (11) reveal that the optimal allocation is characterized by:

$$U_{C,t} = \left(\left[\beta - \beta^m(H_t) \right] U^m_{W,t+1} + \beta^m(H_t) \mathrm{E}_t \left\{ U_{C,t+1} \mid H_t \right\} \right) R^f, \tag{12}$$

$$U_{C,t} OOP^x_{I,t} = \beta^m(H_t) \mathrm{E}_t \left\{ V_{H,t+1} \mid H_t \right\} A_t I^g_{I,t}, \tag{13}$$

$$(1 - \mathbb{1}^M \tau) w_t = \frac{U_{\ell,t}}{U_{C,t}} + \frac{I^g_{\ell,t}}{I^g_{I,t}} OOP^x_{I,t}, \tag{14}$$

where the marginal out-of-pocket cost is $OOP^x_{I,t} = P^I_t \left[1 - \mathbb{1}_X \mathbb{1}_D (1 - \psi) \right]$, and where the marginal value of health solves the recursion:

$$\begin{aligned} V_{H,t} = & \overbrace{\beta^m_{H,t} \mathrm{E}_t \left\{ V_{t+1} - U^m_{t+1} \mid H_t \right\}}^{\text{Mortality control value}} + \overbrace{\beta^m(H_t) \mathrm{E}_{H,t} \left\{ V_{t+1} \mid H_t \right\}}^{\text{Morbidity control value}} \\ & + \underbrace{\beta^m(H_t) \mathrm{E}_t \left\{ V_{H,t+1} \left[1 - \delta_t - \phi_t \epsilon^s_{t+1} + A_t I^g_{H,t} \right] \mid H_t \right\}}_{\text{Durability and productive capacity value}}, \end{aligned} \tag{15}$$

where $\mathrm{E}_{H,t}(\cdot) \equiv \partial \mathrm{E}(\cdot \mid H_t) / \partial H_t$ is the marginal effect of health on the conditional expectation.

The Euler condition (12) equalizes the marginal utility cost of foregone current consumption when savings are increased to the expected discounted marginal benefit of future wealth. The latter is the sum of the positive marginal utility of bequeathed wealth plus the positive marginal utility of future consumption times the rate of return on the safe asset. As health improves, the probability of dying falls, and $\beta^m(H_t)$ increases, thereby shifting weight away from the former in favour of the latter.

The Euler equation (13) equates the current marginal utility cost of out-of-pocket health expenditures to the expected future marginal benefit of the additional health procured by investment. As Figure 2 makes clear, the marginal OOP cost of health expenditures is kinked at the deductible for insured agents, and encourages them to spend more once the deductible D_t is reached. Medicare also implies that $OOP^x_{I,t}$ is age-dependent as young uninsured agents become covered at age 65, encouraging them to postpone health expenditures until coverage begins. Observe furthermore from (4) that ageing is accompanied by exogenous increases in productivity A_t, providing additional justification (to age-increasing depreciation) for the higher demand for healthcare observed for elders (e.g. Hall and Jones, 2007; Fonseca et al., 2013).

Equation (14) is a static optimality condition that equates the marginal cost of leisure (i.e. after-tax wages) to its marginal benefit. The latter is the sum of the marginal rate of substitution between leisure and consumption plus the marginal reduction in out-of-pocket expenditures made possible by resorting to leisure instead of investment to improve health. Moral hazard can arise because this additional benefit of leisure is lower for the insured thereby making self-insurance through healthy activities less advantageous, once the deductible is covered. The effects of Medicare on the leisure-investment tradeoff are mixed. On the one hand, Medicare taxes reduce the opportunity cost of leisure regardless of age. On the other hand, the lower reduction in marginal out-of-pocket cost after Medicare coverage begins alters the leisure-investment tradeoff, and encourages elders to work more instead.

Finally, the Envelope condition (15) decomposes the marginal value of health into three parts. First, it includes the benefits obtained through the reduction in mortality risk $\beta^m_{H,t} > 0$ times the continuation utility net of bequest utility. Recall that $U^m_{t+1} < 0$ such that the increased expected benefit of surviving for healthier agents is augmented by a lower expected utility cost associated with dying, thereby ensuring that the marginal value of lower mortality risk for healthier agents is always positive. Second, it includes the marginal value of morbidity risk reduction $\mathrm{E}_{H,t}$. A straightforward argument indicates that this value is positive.[7] Third, durability and productive capacity also implies that the marginal value of health captures the expected future marginal value of the undepreciated health stock, plus the marginal product of health in the gross investment technology. Observe that undepreciated health will decline with ageing as the depreciation rates δ_t, ϕ_t become large. Increasing depreciation plus finite lives and non bequeathable health then make it increasingly costly to maintain the health capital for the elders.

4 Empirical strategy

This section outlines the empirical methods that we rely upon to solve and estimate the model. After discussing the choice of functional forms and insurance plans, we introduce the iterative, and simulation procedures from which the Simulated Moments Estimation is obtained.[8] We close the section by an overview of the data used in the estimation.

4.1 Functional forms and insurance plans

First, in order to complete the parametrization the model in Section 3, we consider decreasing convex intensities and a CRS gross investment functions, as well as CES and

[7] Conjecture that $V_{H,t} > 0, \forall t$ in (15), in which case $\beta^m(H_t)\mathrm{E}_{H,t}\{V_{t+1} \mid H_t\} > 0$ since health is valuable and the low future health outcome is less likely for healthier agents. Observing that $\beta^m_{H,t} > 0$, and $U^m(W_{t+1}) < 0$, while $\delta_t + \phi_t < 1$ and $I^g_{H,t} \geq 0$ and solving forward (15) then confirms the positive marginal value of health conjecture.

[8] A more detailed technical appendix outlining the SME procedure is available upon request.

CRRA utility functions:

$$\lambda^m(H) = \lambda_0^m + \lambda_1^m H^{-\xi^m}, \tag{16}$$

$$\lambda^s(H) = \lambda_2^s - \frac{\lambda_2^s - \lambda_0^s}{1 + \lambda_1^s H^{-\xi^s}}, \tag{17}$$

$$I^g(H, I, \ell) = I^{\eta_I} \ell^{\eta_\ell} H^{1-\eta_I-\eta_\ell}, \quad \eta_I, \eta_\ell \in (0,1), \tag{18}$$

$$U(C, \ell) = \left[\mu_C C^{1-\gamma} + \mu_\ell \ell^{1-\gamma}\right]^{\frac{1}{1-\gamma}}, \quad \mu_C, \mu_\ell \in (0,1), \tag{19}$$

$$U^m(W) = \mu_m \frac{W^{1-\gamma}}{1-\gamma}. \tag{20}$$

Equations (16) and (17) both encompass limits to self-insurance as the intensities are bounded below by λ_0^m, and λ_0^s. Morbidity risk is also bounded above by λ_2^s to avoid spiralling optimal paths where health falls, inducing more sickness, and further depreciation and certain subsequent sickness and death (see Hugonnier et al., 2013, for discussion). The Cobb-Douglas technology (18) ensures diminishing returns to expenditures, leisure and health inputs for gross investment. Next, the Constant Elasticity of Substitution (CES) specification (19) allows for unconditionally positive utility and therefore helps guarantee preference for life over death, $\mathcal{U}_t > 0$ in (10). Conversely, the bequest function (20) is negative for curvature $\gamma > 1$, ensuring that death is costly, whereby the marginal value of bequeathed wealth remains positive.

Next, we consider 5 exogenous insurance plans corresponding to No and Private insurance when young ($1 \leq t < 65$), and No, Private or Medicare when old ($t \geq 65$), and denoted $x = (x_y, x_o) \in \mathbb{X} = \{\text{PM, PP, PN, NM, NN}\}$.[9] The descriptions as well as corresponding expressions for OOP's, premia and income are outlined in Table 4. Plans PM (our benchmark case), and PP encompass full insurance with, and without Medicare. Plan PN captures the effects of employment-provided insurance which is terminated at retirement, whereas plans NN and NM illustrate the effects of market failures leading to exclusion from health insurance. This classification allows for a convenient identification of the marginal effects of (i) young agents insurance status conditional on the elders

[9] Plan NP is arguably of limited empirical relevance, and is abstracted from.

insurance status (by contrasting PM vs NM, and PN vs NN), as well as those of the (ii) elders' insurance status conditional on young insurance status. For the latter, the marginal effect of private insurance is obtained by contrasting PP vs PN, whereas that of Medicare obtains from the PM vs PN and NM vs NN comparisons. Finally, the pure budget constraint effects of Medicare are isolated from the coverage effects by imposing full insurance, and computing the difference between plans PM vs PP.

4.2 Iterative methods

The iterative step consists in solving the model numerically by backward induction via a Value Function Iteration approach. This involves discretizing the state space which involves the health and wealth statuses. Let $Z = (H, W) \in \mathbb{Z}$, the discretized state space of dimension K_Z, $\epsilon = (\epsilon^s, \epsilon^m) \in \{0, 1\}^2$, the health shocks, and $Q = (C, I, \ell) \in \mathbb{Q}$, the discretized control space of dimension K_Q. For a given cohort $\kappa \in \mathbb{N}_-$, and for each insurance plan $x \in \mathbb{X} = \{$PM, PP, PN, NM, NN$\}$, the Value Function Iteration consists of iterating recursively over ages $t = T, T-1, \dots, 1$ in order to solve:

$$
\begin{aligned}
V_t^x(Z) &= \max_{\{Q_t \in \mathbb{Q}\}} \mathcal{U}(Q_t, Z) + \beta^m(Z) \mathrm{E}_t \left\{ V_{t+1}^x(Z_{t+1}) \mid Z \right\}, \\
\text{s.t. } Z_{t+1} &= Z_{t+1}(Q_t, Z, \epsilon_{t+1})
\end{aligned}
\tag{21}
$$

at each state $Z \in \mathbb{Z}$. Contrary to standard backward iterative procedures, the model is solved for all periods, rather than only until a sufficient degree of convergence has been obtained, in order to account for the time variation in health productivity, wages and prices, as well as for the Long Reach of Childhood effects. The age- and plan-specific allocations, and welfare are obtained as:

$$
\{Q_t^x(Z), V_t^x(Z)\}_{t=1}^T, \quad \forall Z \in \mathbb{Z}, x \in \mathbb{X}, \tag{22}
$$

and are used in the simulation phase.[10]

4.3 Simulation methods

The iteration phase in (21) is performed over a pre-determined state space $\mathbb{Z}$. In order to compute the optimal solutions along the optimal path, it is necessary to simulate the model forward by using the allocation (22) in conjunction with the shocks ϵ generated from the endogenous intensities in (1) and the laws of motion for Z in (2) and (9). Specifically, for each simulated agent $i = 1, 2, \ldots, K_I$ and Monte-Carlo replication $n = 1, 2, \ldots, K_N$ we use the following steps for the adult population aged 16 and over:

1. We initialize the state using draws taken (with replacement) from the observed population wealth and health levels at age 16:

$$Z_{16}^{i,n} \sim \mathbb{Z}_{16}^{POP}.$$

2. For each year $t = 16, 17, \ldots T$,

   (a) The optimal rules $Q_t^{i,n}$ and value function $V_t^{i,n}$ are computed using a bilinear interpolation of the policy functions (22) that were obtained in the iterative phase, and are evaluated at the state $Z_t^{i,n}$.

   (b) The mortality and morbidity shocks are endogenously drawn from the generalized Bernoulli,

$$\epsilon_{t+1}^{k,i,n} \sim \{0,1\}^2 \mid \lambda^k(Z_t^{i,n}).$$

   (c) The state variables are updated,

$$Z_{t+1}^{i,n} = Z_{t+1}\left(Q_t^{i,n}, Z_t^{i,n}, \epsilon_{t+1}^{i,n}\right).$$

[10] To facilitate exposition, we henceforth drop the explicit dependence of variables on plan x from the notation.

The output we recover, $\left\{Q_t^{i,n}, V_t^{i,n}, Z_t^{i,n}\right\}$, is the one along the optimal path over ages $t = 16, \ldots, T$, and can be used to compute both the life cycle and the unconditional statistics across surviving agents. In particular, let $\mathbb{1}_t^{i,n} \in \{1, \mathrm{NaN}\}$ be the alive indicator for agent i, in simulation n, at age t. The theoretical life cycle moment $\hat{M}_t$ for allocation, welfare, and state, and the survival rate $\hat{S}_t$ is given at each age t by integrating over surviving agents and simulation replications:

$$\begin{aligned}
\hat{M}_t &= \frac{\sum_{i=1}^{K_I}\sum_{n=1}^{K_N} \mathbb{1}_t^{i,n}\left\{Q_t^{i,n}, V_t^{i,n}, Z_t^{i,n}\right\}}{\sum_{i=1}^{K_I}\sum_{n=1}^{K_N} \mathbb{1}_t^{i,n}}, \\
\hat{S}_t &= \frac{\sum_{i=1}^{K_I}\sum_{n=1}^{K_N} \mathbb{1}_t^{i,n}}{K_I K_N}.
\end{aligned} \tag{23}$$

Similarly, the corresponding unconditional moments $\hat{M}$ for allocation, welfare, state and life expectation $\hat{S}$ are obtained by integrating the life cycle moments and survival rate over age for the adult population:

$$\hat{M} = \frac{\sum_{t=16}^{T} \hat{M}_t}{T-16}, \tag{24}$$

$$\hat{S} = \sum_{t=16}^{T} \hat{S}_t. \tag{25}$$

These theoretical moments can be contrasted with the empirical moments in order to estimate the model.

4.4 Calibration and estimation strategy

The previous iteration and simulation phases are performed conditional upon a given parameter set $\Theta = (\Theta^c, \Theta^e)$ where Θ^c denotes the calibrated parameters subset, and Θ^e is the estimated parameters subset:

$$\begin{aligned}
\Theta^c =& (T, \kappa, \lambda_2^s, \xi^m, \xi^s, P_0^I, g^P, A_0, g^A, \psi, \Pi, \Pi^M, D_0, g^D, \tau, Y^R, R^f, \eta_I, \eta_\ell, \beta, \mu_C, \mu_\ell, \mu_m) \\
\Theta^e =& (\lambda_0^m, \lambda_1^m, \lambda_0^s, \lambda_1^s, \delta_0, g^\delta, \phi_0, g^\phi, \gamma).
\end{aligned}$$

The values for the calibrated parameter Θ^c are identified via the literature whenever possible, and through an extensive trial and error process. The estimated parameters Θ^e are those for which we have scant prior information, namely the parameters of the intensity processes $\lambda^k(H)$, as well as the deterministic and stochastic depreciation processes (δ_t, ϕ_t). The coefficient of relative risk aversion γ is also included in the estimation set as further check of the model's realism. The parameters in Θ^e are identified through an SME estimator. In particular, let $\hat{\mathbf{M}}(\Theta) \in \mathbb{R}^{K_M}$ be the collection of theoretical life cycle moments $\{\hat{M}_t\}$ given in (23), $\mathbf{M} \in \mathbb{R}^{K_M}$ be the corresponding observed moments, and $\Omega \in \mathbb{R}^{K_M \times K_M}$ be a weighting matrix. The Simulated Moments Estimation (SME) of Θ^e is given as:

$$\hat{\Theta}^e = \underset{\Theta^e}{\operatorname{argmin}} [\hat{\mathbf{M}}(\Theta) - \mathbf{M}]' \Omega [\hat{\mathbf{M}}(\Theta) - \mathbf{M}]. \tag{26}$$

In practice, the theoretical life cycles moments $\hat{\mathbf{M}}(\Theta)$ in (26) are computed over 5-year intervals between the age of 20 and 80, and involve consumption, health investment and out-of-pocket expenditures, leisure, wealth, and health for our benchmark insurance case PM (Private when young, Medicare when old).[11] The corresponding empirical moments $\mathbf{M}$ are taken from various widely-used health and socio-economic surveys corresponding to the American population for years 2010 and 2011, and are discussed in further details below. The SME of $\hat{\Theta}^e$ in (26) is consequently over-identified with a total of 7 life cycles $\times 13$ five-year bins $= 91$ moments used to identify 9 structural parameters.

We differ from mainstream practices in our estimation strategy. In particular, standard approaches typically append *ad-hoc* exogenous stochastic processes to the model (e.g. exogenous stochastic health shocks, wages or labor income, ...) that are used to simulate the optimal trajectories. As part of a two-step methodology, these processes are then estimated separately, and the parameters and/or fitted processes substituted back into the model for the simulation phase. The simulation output is then used in the

[11] More precisely, we initialize the simulation by taking 100 draws (without replacement) from the observed distribution over health and wealth at age 16, such that this sample is representative of the general population at the beginning of adult age. We then simulate 500 trajectories from the initial grid along the optimal path. This procedure is therefore equivalent to simulating 50'000 individual life cycles from which the 5-year moments are computed.

second-step estimation to estimate a (typically small) subset of parameters. In contrast, we generate the simulation trajectories conditional upon the realization of the morbidity and mortality shocks which are drawn from the *endogenous* intensities given by (1). Put differently, *ad-hoc* processes are neither appended to the model, nor estimated separately in a two-step approach. Rather, we rely on a fully structural, single-step SME estimation framework. Moreover, the set of moments we consider is much larger, and corresponds to the full set of conditional means generated by the model (i.e. allocations, and state variables along the optimal paths). This additional information plays a crucial role in allowing us to identify and estimate a much larger subset of deep parameters for which we have limited prior information.

4.5 Data

Our empirical strategy requires life cycle data on consumption, leisure, total and out-of-pocket health expenditures, wealth, and health status. Ideally, a single panel data-base regrouping all these variables would be used. Unfortunately, to the best of our knowledge, such a data-base does not exist. We therefore rely on various well-known panels that are representative of the American population. These sources are presented in Table 5.

First, for wealth, we use the Survey of Consumer Finances (SCF). Our measure for financial wealth includes assets (stocks, bonds, banking accounts, IRA accounts ...) either directly, and indirectly held (e.g. through pension funds). Next, we use the National Health Interview Survey (NHIS) to obtain a measure of health. This survey reports ordered qualitative self-reported health status ranging from very poor to excellent that are converted to numerical measures using a linear scale. Survival rates are recovered from the National Vital Statistics System (NVSS). The total and out-of-pocket medical expenses are taken from the Medical Expenditures Survey (MEPS), and are the mean expenses per person, conditional upon expenditures. Next, consistent with the income equation (8), leisure is the share of time spent not working, and is obtained from the American Time Use Survey (ATUS). Finally, nondurables consumption is taken from the Consumer Expenditures Survey (CEX) as being per-capita total expenditures net of health care and vehicles.

5 Results

This section describes the parameters, predicted optimal policies, welfare, and other variables derived from the model. Following a brief discussion of the parameters, and output obtained from the iterative phase, we present the results obtained from the simulation phase. The normative implications for health care policy are then reviewed.

5.1 Parameters

The values and sources for the calibrated parameters Θ^c are presented in Table 6, whereas the values (standard error in parentheses) for the estimated parameters Θ^e are reported in Table 7. First, the calibrated morbidity and mortality parameters show a larger convexity for the former ($\xi^s > \xi^m$), consistent with stronger effects of health in reducing sickness risk, than mortality risk. This realistic feature is also confirmed by the estimated values for the endogenous intensity components ($\lambda_1^s > \lambda_1^m$). Moreover, the large calibrated value for λ_2^s is consistent with the absence of limitations in morbidity risk reduction.

Second, the calibrated values for the health investment technology (η_I, η_ℓ) are indicative of an important role of healthy leisure, and of current health status. We also witness a positive exogenous trend in healthcare productivity (A_t) that is however less than that observed in health care prices and insurance deductibles ($g^A < g^P, g^D$). Turning to labor income, Panel (b) of Figure 1 shows that real wages display an upward trend over the life cycle up to retirement and fall sharply afterwards. Finally, the preferences parameters are consistent with a 3% annual discount rate, a consumption (leisure) share of $\mu_c = 1/3$ ($\mu_\ell = 2/3$) (e.g. Kydland, 1995, p. 148), and a low weight $\mu_m = 2\%$ attributed to joy-of-giving in the bequest function (e.g. French and Jones, 2011; De Nardi et al., 2009).

Third, regarding the estimated parameters, we find that they are all significant at the 5% level. The depreciation parameters confirm that both deterministic and stochastic depreciations are increasing in age ($g^\delta, g^\phi > 0$). Panel (a) of Figure 1 shows that stochastic morbidity ϕ_t is a strong determinant of total health depreciation rates, and that this contribution becomes larger with age. Equivalently, sickness is much more consequential for elders. Furthermore, our estimated parameters warrant the conjecture that both mortality and morbidity are endogenous ($\lambda_1^s, \lambda_1^m \neq 0$), and that both risks are not fully compressible ($\lambda_0^s, \lambda_0^m \neq 0$). Unsurprisingly, they also confirm that the incidence of sickness is much more likely than that of death ($\lambda_{0,1}^s > \lambda_{0,1}^m$). Finally, the curvature parameter indicates that the risk aversion with respect to bequeathed wealth is realistic, and that consumption and leisure are mainly complements, with a low elasticity of substitution between the two ($1/\gamma < 1$).

5.2 Iterative results

Figure 3 displays the optimal allocations, as well as the welfare functions of the predetermined health and wealth state. For that purpose, we compute the mean values between ages 60–65, under benchmark plan PM. As expected, consumption (Panel A), leisure (Panel B), investment (Panel C), are all monotone increasing in wealth. Consumption, leisure and investment are decreasing in health, except for the latter which is increasing at very low health and wealth. As discussed earlier, a lower risk of dying when health improves is tantamount to lower discounting and induces the healthier agent to increase savings in the face of a longer expected life horizon. Moreover, the lower risk of becoming sick for healthier agents justifies a reduction in both health expenditures, and healthy leisure activities, consistent with findings that the rich and unhealthy spend more on preventive and curative health care (e.g Smith, 1999; Wu, 2003; Barros et al., 2008; Scholz and Seshadri, 2012). However, for the very poor and very unhealthy, the risk of dying becomes high enough that investment is abandoned in favour of other expenses when health deteriorates further.

Finally welfare in Panel D is clearly monotone increasing in both wealth and in health, as can be expected from the discussion of Envelope condition (15). Observe that concavity is more pronounced with respect to health, as can be anticipated from the diminishing returns in the self-insurance technology (16) and (17), and in the gross investment function (18).

5.3 Simulation results

The previous results are obtained over a given state space, and at a given period in the life cycle. In what follows we calculate the age-dependent policies along the simulated optimal path, thereby fully endogenizing the evolution in the health and wealth statuses. We start by integrating along the age dimension in order to compute the unconditional moments. This is followed by an analysis of the age-dependent statistics.

5.3.1 Unconditional moments

We first compute the unconditional statistics (24) for the surviving agents over ages 20–80, and the expected life (25). This exercise is repeated for the five health insurance plans (PM, PN, PP, NN and NM). More precisely, using the calibrated and estimated parameters for our benchmark case PM, we recalculate the iterative and simulation output for each of the four other insurance plan, from which the life cycle, and the unconditional moments are computed. The latter are contrasted with the observed moments.

Contrasting the unconditional observed and predicted moments in Table 8 confirms that the model does quite well in capturing the age-independent features of the data. Investment, consumption, leisure, health and expected longevity are accurately reproduced, while the other variables are reasonably close given the caveats associated with the model and/or data.[12]

[12] Indeed, the model's OOP variables do not take expense caps into account and thus likely overstates the actual out-of-pocket expenditure. Allowing for expenses caps in the model results in corner solutions in which the agent spends extreme amounts on health expenditures once the deductible has been reached.

Overall, our results provide evidence that the effects of being insured when young (i.e. contrasting PM vs NM, and PN vs NN) are consistent with a sharp reduction in OOP expenditures. Moreover, both wealth and health levels are noticeably higher for young insurees, leading to increases in welfare compared to the uninsured. When looking at the effects of health insurance for the elders (i.e. contrasting PM vs PN, NM vs NN, and PP vs PN), we find that OOP's are also lowered, whereas consumption shares of wealth (i.e. $C^s \equiv C/W$) are increased. The net effect is a lower level of wealth, consistent with lower precautionary wealth when insured against health expenditures in old age. Again, welfare is higher for the insured.

5.3.2 Life-cycle properties

The simulated life cycles are presented in Figures 4–9, and are given as the mean allocations, and states at each age across the simulation output, using (23) . To facilitate the discussion, the simulated and observed (when available) levels are reported in Panels A, and B, respectively.[13] The marginal effects of health insurance are computed as the differences of the means across insurance statuses. We report the marginal effects of being insured when young (i.e PM-NM, and PN-NN) in Panels C, and the marginal effects of being insured when old (i.e. PM-PN, NM-NN and PP-PN) in Panels D.

Health status The simulated health statuses in Figure 4.A predict a level, and an optimal decline that are both consistent with those observed for the data in Panel B (see Case and Deaton, 2005; Scholz and Seshadri, 2012; Van Kippersluis et al., 2009, for further evidence and discussion). The optimal level calculated under plan PM however remains somewhat high for the very old, compared to the data which comprises agents who are uninsured at various periods of their lives.

[13] The simulated variables in Panels A correspond to our benchmark PM case. The confidence intervals are computed from the estimated variance-covariance of the parameters, using the delta method, and are plotted as the dashed red lines for the variables with observable counterparts.

Our results in Panel C and D indicate that insurees are healthier, with larger effects when uninsured at other periods. In particular, the differences in health for the insured young agents in Panel C peak around 50, and fall thereafter, with more effects when the elders' status is uninsurance (PN-NN).[14] The effects of elders' insurance statuses on their health in Panel D are similar in sign and in magnitude, and confirm that old insurees are permanently healthier after 50, and earlier on when the young agent's status is uninsurance (NM-NN). We find no evidence of optimal stockpiling pointing to a decline in health prior to entitlement.

These results highlight the path-dependence of health capital that induces spillover effects of health insurance across age. The durability of the health capital implies that young insurees will also remain healthier than otherwise for some time after they lose insurance at old age. On the other hand, the Cobb-Douglas technology in (18) implies that the marginal productivity of health investment increases in health, making it optimal for young uninsured to build up their health stock prior to old age coverage, and its associated high expenses (see below). Finally, we observe the same marginal effects whether elders' insurance is provided through Medicare (PM-PN), or through private insurers (PP-PN). This suggests that the budget constraint effect of Medicare: PM-PP = (PM-PN) - (PP-PN) is limited once the coverage effect is accounted for.

Health expenditures and healthy leisure The simulated health dynamics both induce and result from investment and healthy leisure decisions made over the life cycle. First, in Figure 5.A, both the level, and the upward trend of observed investment are accurately matched. The model however under-predicts the level of expenditures for the very old. In Panel C, the insured young agents invest more, especially around middle age. Again, the effects are strongest when the elders' status is uninsured. The results of Panel D show that the insured elders invest more at middle age and after, except in cases involving PN. When the private coverage ends at retirement, agents find it

[14] See also McWilliams et al. (2007) for medical evidence that previously insured young agents have better morbidity conditions after age 65.

optimal to raise investment before age 65 more than they would if coverage was expected to continue. Again we find little evidence of optimal stockpiling in NM vs NN with no reduction in investment prior to Medicare coverage. Interestingly, the differences in health investment become minimal after 75, indicating that insurees rely on other means than health expenditures to adjust their health status (see the discussion on leisure below).

Second, the increase in out-of-pocket expenditures in Figure 6.A is consistent with the data. The level is somewhat over-estimated, possibly because our model abstracts from limitations such as expenses caps. The insurance effects in Panels C and D are clearly consistent with a decrease in exposure to OOP costs, despite an increase in utilization for insurees. We find little evidence of differences based on private versus public insurance in generating this fall in OOP exposure.

Third, the leisure paths in Figure 7.A display strong similarities with observed patterns; they are initially low, followed by a sharp increase when wages fall after age 60 (see Figure 1, Panel b), consistent with observed behavior (e.g. Rust and Phelan, 1997). Our results in Panels C are indicative of moral hazard effects of health insurance. Indeed, young insurees tend to reduce leisure when young, and postpone it up to middle age. Insured elders in Panel D do not reduce leisure when young, but also increase it after middle age. This increase is particularly important when very old and acts as an alternative to medical expenses to maintain health status.

Wealth, and welfare First, the simulated wealth dynamics in Figure 8.A coincide very well with the data in Panel B. In particular, the model replicates the asset accumulation when young, a peak occurring around retirement, followed by post-retirement dissavings.[15] The insured young agents in Panel C are clearly wealthier than the uninsured. This result highlights the effects of both lower exposure to OOP expenses and lower levels of leisure in generating higher *ex-post* wealth for younger agents. Observe that this effect is larger and more long-lasting in cases where the agent is also insured when

[15] See also De Nardi et al. (2010, 2009); Dynan et al. (2004) for discussion and evidence of asset decumulation in old age.

old (PM vs NM). This can be explained by the lower level of leisure after middle age in Figure 7.C. Conversely, in Panel D, the insured elders have lower wealth than the uninsured after middle age. This result is related again to the expected lower exposure to OOP expenses for old insurees which reduces the need to build up *ex-ante* precautionary wealth reserves, as well as the higher level of leisure compared to the uninsured. The effect is again stronger when Medicare is involved (NM vs NN). The subsidization of insurance premia further reduces the need to build up wealth reserves to cover insurance when employment is reduced after retirement.

Finally, the combination of single-peaked wealth, falling health and survival rates implies that welfare in Figure 9.A is also increasing up to retirement, and slowly falling thereafter. Recent evidence for similar inverted-U shape for welfare can be found for German and British panel data by Wunder et al. (2013, Fig. 4) who document an increase up to age 65 associated with increasing financial resources, followed by a fall associated with declining health. The plots in Panel C reveal that insurance for the young agents is sub-optimal up to the early 30's when wealth and wages are low, and health problems are scant, and optimal afterwards, consistent with the non-insurance data.[16] Conversely, Panel D reveals that insurance for the elders is always optimal. The optimality of the Medicare programs is also clearly apparent with plans PM and NM yielding the highest welfare.

5.3.3 Robustness to the cohort effects

The results obtained thus far fully account for the heterogeneity in the life cycles stemming from heterogeneous initial health and wealth statuses, and from the idiosyncratic exposition to morbidity and mortality shocks. However, for tractability reasons, we have assumed homogeneous preferences, technology, and cohort. In particular, the latter implies that the alive agents at any given point in time in our simulated populations all

[16]The percentage of people without health insurance falls from 31.4% for ages 25–34 to 15.7% for ages 45–54 (National Center for Health Statistics, 2011, Tab. 141). See also Cardon and Hendel (2001) for evidence of uninsurance among younger cohorts.

have the same age. This is admittedly restrictive in that we abstract from the overlapping generational structure of actual populations. Put differently, focusing on a single cohort (which is replicated a large number of times in the simulation) entails that cohort effects are not entirely accounted for in our simulation strategy. For example, elders in the current population obviously have access to the same medical technology than their contemporary younger fellow citizens. However, they likely had access to a lower level of medical technology when they were the same age as the current young agents. Because the technological level affects the health-related decisions, the life cycle of all variables may have been altered.

In order to better understand how these cohort effects may influence our results, we recompute the full iterative and simulation output for the PM insurance case, taking as given the estimated parameters, but changing the cohort indicators. In Figure 10, we plot our benchmark life cycles for $\kappa = -37$ (dashed blue line), along with those corresponding to a younger cohort $\kappa = -30$ (solid blue line), and to an older cohort $\kappa = -44$ (solid red line).

Overall our results show remarkable robustness to changing the cohort for leisure (Panel A), and wealth (Panel E). The results for health investment (Panel C) and levels (Panel D) are consistent with expectations. Because agents in the younger cohort have access to a more productive technology at any given age than the other cohorts, they are able to consume less medical services, yet still attain a better health level than others. The older cohort are obliged to invest more, and yet obtain a lower health level. The out-of-pocket results in Panel B display scant effects of cohorts. This stems from the counter-balancing influences on OOP expenditures of better technology, but higher prices and deductibles for the younger cohorts.

5.4 Discussion: Life cycle effects of Medicare

Our results have a number of implications for the life cycle responses to Medicare. First, our findings are consistent with Medicare and private insurance being close substitutes.

Indeed, the comparisons of the PM–PN and PP–PN paths in Panels D reveal very similar marginal effects of the insurance status for elders, whether that insurance is provided through Medicare, or through private markets.

Second and related, the pure budget constraint effects of Medicare, as isolated in Panels D, appear to be moderate, indicating that Medicare affects the life cycle mostly through its effect on coverage to otherwise uninsured elders (see also McClellan and Skinner, 2009, for a similar conclusion from a different perspective). Taxes on labor revenues reduce disposable income, and distort labor-leisure choices throughout the life cycle. However, the Medicare tax rate is low ($\tau = 1.45\%$), and the subsidy of health insurance premia after 65 is tantamount to a compensating lump-sum transfer, and increases wealth after retirement. The modest net effects indicate that current taxes and future subsidies apparently offset one another, thereby casting some doubt on the hypothesis that Medicare entitlement is positive financial net worth. This close substitution is also confirmed by unreported additional testing, whereby we incorporate Plan MM in order to analyse the effects of the Patient Protection and Affordable Care Act, and where the Medicare provisions are extended to agents under 65.[17] Our results again suggest that these budget constraint effects are very moderate, such that results under plans PM and MM are indistinguishable from one another.

Third, the effects of Medicare coverage for otherwise uninsured agents is much more significant, and is consistent with those outlined by the empirical literature. In particular, the model reproduces noticeably better health and moderately better survival (Lichtenberg, 2002; Khwaja, 2010; Finkelstein and McKnight, 2008; Card et al., 2009; Scholz and Seshadri, 2012), as well as more investment (Lichtenberg, 2002; Khwaja, 2010; Finkelstein, 2007; Card et al., 2009), yet lower OOP's (Khwaja, 2010; Finkelstein and McKnight, 2008; Scholz and Seshadri, 2012; De Nardi et al., 2010), as well as lower precautionary wealth (De Nardi et al., 2010, 2009; Scholz and Seshadri, 2012), and more leisure (Currie and Madrian, 1999; French, 2005).

[17] The full MM results are available upon request from the corresponding author.

Fourth, the pre-retirement effects of Medicare take the form of better health around middle age. This result is explained by the durability of the health capital. Because the marginal product of health investment and leisure increases in the health status, agents find it optimal to build up health in anticipation of when they will need it most, i.e. after retirement. This increase is achieved through more investment and leisure around middle age, and therefore speaks against the stockpiling hypothesis. On the other hand, our results also highlight lower precautionary wealth around middle age when post-retirement exposure to OOP risks is covered by Medicare. This is achieved through more leisure and consumption prior to entitlement.

Finally, our findings confirm that exclusion from health insurance market becomes very detrimental at middle age, but not for younger adults who may still prefer to remain uninsured when wealth is low, the health stock is high and health problems are scant. In contrast, health insurance for elders is always optimal. Universal eligibility of insurance, whether via Medicare or private markets, might therefore not be Pareto improving. Also, Medicare was found to be welfare improving at the individual level, with the effects on welfare accruing through the budget constraint being positive, but dwarfed compared to those incurred through market completion. This however does not imply dynamic Pareto optimality from society's point of view. Indeed, our bequest weight is low, such that our agents have limited concern for the future generations who end up paying part of the current costs of Medicare. Moreover, the general-equilibrium efficiency costs of tax-financed Medicare have not been addressed in our model and could turn out to be quite important.

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A Tables

Table 1: Medicare summary

Part	Covers	Taxes	Co-payment	Deductibles (Y)	Premia (M)
A	Inpatient care	2.9% payroll	20%	\$1,156	
B	Outpatient care	Gen. revenues	20%	\$140	\$99.90
D	Drugs	Gen. revenues	25%	\$310	\$39.36

Notes: Sources: Henry J. Kaiser Family Foundation (2012); Medicare.gov (n.d.); OASDI Board of Trustees (2012). Part A payroll taxes shared equally between employers and employees. Parts B and D financed 25% out of premia, 75% out of general tax revenues. When applicable, deductible and premia are averages based on taxable income.

Table 2: Federal Budget Outlays, 2011

Item	Budget (B\$)	Share (%)
National Defense	768.2	20.1
Social Security	748.4	19.6
Income Security	622.7	16.3
Medicare	494.3	12.9
Health	387.6	10.2
Education	115.1	3.0
⋮	⋮	⋮
Total	3818.1	100.0

Notes: Sources: U.S. Census Bureau (2011b, Tab. 473, p. 312), Federal Budget Outlays by Detailed Function.

Table 3: Literature classification

				Endogenous:				
Author(s)	Savings	Health expend.	Health prod.	Labour	Retire.	Leisure in health	Mortal.	Morbid.
Cropper (1977)	✓	✓	✓				✓	✓
Hubbard et al. (1995)	✓							
Rust and Phelan (1997)				✓	✓			
Palumbo (1999)	✓							
French (2005)	✓			✓	✓			
Case and Deaton (2005)	✓	✓	✓					
Scholz et al. (2006)	✓							
Hall and Jones (2007)	✓	✓	✓				✓	
Blau and Gilleskie (2008)		✓						
Edwards (2008)	✓							
De Nardi et al. (2009)	✓							
Yogo (2009)	✓	✓	✓					
Khwaja (2010)		✓	✓			✓		
De Nardi et al. (2010)	✓	✓						
Ozkan (2011)	✓	✓	✓				✓	✓
French and Jones (2011)	✓			✓	✓			
Scholz and Seshadri (2012)	✓	✓	✓			✓	✓	
Galama et al. (2012)	✓	✓	✓		✓			
Fonseca et al. (2013)	✓	✓	✓		✓			
Scholz and Seshadri (2013)	✓	✓	✓		✓	✓		
Hugonnier et al. (2013)	✓	✓	✓				✓	✓
This paper	✓	✓	✓	✓		✓	✓	✓

Table 4: Insurance plans, net effects and restrictions

(a) Statuses and net effects

Status: young	Status: old			Net effects
	Insured		Uninsured	
	Medicare	Private		
Insured				
- Private	PM	PP	PN	Insured old
Uninsured	NM		NN	Insured old
Net effects	Insured young		Insured young	

(b) OOP's, premia, and income

plan x	$OOP_t^x(I_t)$	Π_t^x	$Y_t^x(\ell_t)$
PM	$P_t^I I_t - \mathbb{1}_D(1-\psi)(P_t^I I_t - D_t)$	$\Pi\,[1 - \mathbb{1}_R(1-\pi)]$	$\mathbb{1}_R Y^R + (1-\tau)w_t(1-\ell_t)$
PP	$P_t^I I_t - \mathbb{1}_D(1-\psi)(P_t^I I_t - D_t)$	Π	$\mathbb{1}_R Y^R + w_t(1-\ell_t)$
PN	$P_t^I I_t - (1-\mathbb{1}_R)\mathbb{1}_D(1-\psi)(P_t^I I_t - D_t)$	$(1-\mathbb{1}_R)\Pi$	$\mathbb{1}_R Y^R + w_t(1-\ell_t)$
NM	$P_t^I I_t - \mathbb{1}_R\mathbb{1}_D(1-\psi)(P_t^I I_t - D_t)$	$\mathbb{1}_R \Pi \pi$	$\mathbb{1}_R Y^R + (1-\tau)w_t(1-\ell_t)$
NN	$P_t^I I_t$	0	$\mathbb{1}_R Y^R + w_t(1-\ell_t)$

Notes: Insurance plans: (N)o insurance, (P)rivate insurance, and (M)edicare. Indicators: $\mathbb{1}_X = \mathbb{1}_{x=P,M}$ (Insured), $\mathbb{1}_M = \mathbb{1}_{x=M}$ (Medicare), $\mathbb{1}_D = \mathbb{1}_{P_t^I I_t > D_t}$ (Deductible reached), $\mathbb{1}_R = \mathbb{1}_{t \geq 65}$ (Retired).

Table 5: Data sources

Variables	Data (2010, 2011), and explanations
W	Survey of Consumer Finances (SCF), Federal Reserve Bank. Financial assets held.
H	National Health Interview Survey (NHIS), Center for Disease Control. Self-reported health status (phstat) where Poor=0.10, Fair=0.825, Good=1.55, Very good=2.275, Excellent=3.0.
S	National Vital Statistics System (NVSS), Center for Disease Control. Survival rates
I	Medical Expenditures Survey (MEPS), Agency for Health Research and Quality. Total health services mean expenses per person with expense and distribution of expenses by source of payment.
OOP	Medical Expenditures Survey (MEPS), Agency for Health Research and Quality. Out-of-pocket health services mean expenses per person with expense and distribution of expenses by source of payment.
ℓ	American Time Use Survey (ATUS), Bureau of Labor Statistics. Share of usual hours not worked per week, 1-uhrsworkt/40
C	Consumer Expenditures Survey (CEX), Bureau of Labor Statistics. Non-durables consumption, net of health expenditures and vehicle purchases = 4*(totex4pq - healthpq - vehicle)

Table 6: Calibrated parameter values and sources

(a) Calibrated values

parameter	value	parameter	value	parameter	value	parameter	value
T	100	κ	-37				
ξ^m	2.5	λ_2^s	50	ξ^s	4.9		
A_0	1.5	g^A	0.004	η_I	0.20	η_ℓ	0.40
ψ	0.200	Π	0.0413	Π^M	0.0167		
P_0^I	1.8522	g^P	0.008	D_0	0.0100	g^D	0.008
Y^R	0.1476	τ	0.0145	R^f	1.04		
β	0.9656	μ_c	0.3333	μ_ℓ	0.6667	μ_m	0.0200
$W_{\min}$	0.05	$W_{\max}$	4	$H_{\min}$	0.1	$H_{\max}$	3
$C_{\min}$	0.05	$C_{\max}$	1	$I_{\min}$	0	$I_{\max}$	1
$\ell_{\min}$	0.05	$\ell_{\max}$	1				
K_W	10	K_H	10	K_Y	30		

(b) Sources

T, κ	Life tables, Arias (2010). Median age, U.S. Census Bureau (2011a, Tab. 2, p. 4).
λ_2^s, ξ^s, ξ^m	Hugonnier et al. (2013, Tab. 2)
P_0^I, g^P	National Center for Health Statistics (2012), Tab 126, CPI and annual percent change for all items, selected items and medical care components, 2010. The Boards Of Trustees, Federal HI and SMI Trust Funds (2012, p. 190)
ψ, Π, Π_M, τ D, g^D	Henry J. Kaiser Family Foundation (2011a,b); Medicare.gov (n.d.). The Boards Of Trustees, Federal HI and SMI Trust Funds (2012, p. 190)
R^f	Federal Reserve Bank of St-Louis (n.d.).
Y^R	Average monthly Social Security benefit for a retired worker Social Security Administration (n.d.).
w_t	Median usual weekly earnings of full-time wage and salary workers by selected characteristics, 2010 annual averages Bureau of Labor Statistics (2011, Tab 1)
η_I, η_ℓ	Free parameters
β, μ_C, μ_ℓ, μ_m,	Various literature, and French and Jones (2011), De Nardi et al. (2009)

Notes: The state space parameters $(W_{\min}, W_{\max}, H_{\min}, H_{\max}, K_W, K_H)$, as well as the control space parameters $(C_{\min}, C_{\max}, I_{\min}, I_{\max}, \ell_{\min}, \ell_{\max}, K_Y)$ are set as free parameters.

Table 7: Estimated parameter values

parameter	value	(standard error)	parameter	value	(standard error)
δ_0	0.0166	(0.0072)	g^δ	0.0154	(0.0062)
ϕ_0	0.0658	(0.0215)	g^ϕ	0.0157	(0.0046)
λ_0^m	0.0061	(0.0020)	λ_1^m	0.0091	(0.0044)
λ_0^s	0.2621	(0.1347)	λ_1^s	5.1022	(1.2468)
γ	3.4005	(1.4523)			

Notes: Estimated parameters based on SME estimator (26).

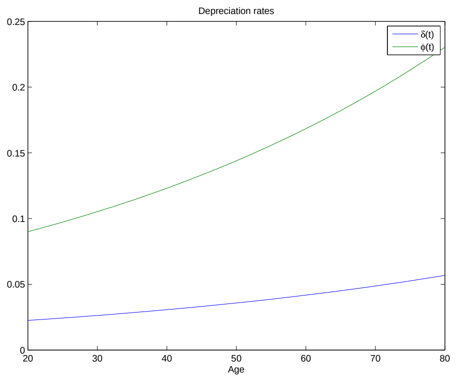
Table 8: Data and simulated unconditional moments (age 20–80)

		Simulated				
Series	Data	PM	PN	PP	NN	NM
I	0.0305	0.0345	0.0345	0.0345	0.0345	0.0345
OOP^*	0.0069	0.0214	0.0218	0.0218	0.0629	0.0457
C^*	0.1353	0.1892	0.1966	0.1941	0.1850	0.1899
ℓ	0.3774	0.3046	0.3187	0.3124	0.3064	0.3166
W^*	2.2112	1.4067	1.6260	1.5884	1.1401	1.1015
H	2.0863	2.5366	2.5400	2.5372	2.5066	2.5243
$S^\dagger$	77.9000	78.8929	78.8684	78.8360	78.7351	78.8229
V	NaN	8.9054	8.7184	8.8215	8.2932	8.5916

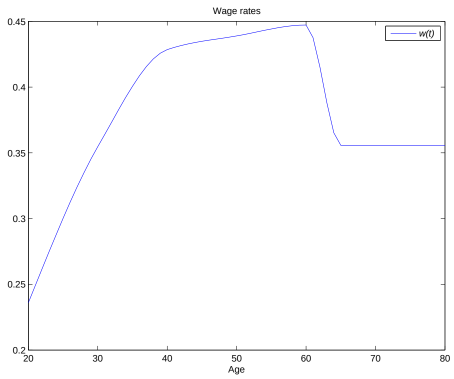
Notes: Unconditional statistics computed using (23)–(25). *: in 100,000\$ †: in years.

B Figures

Figure 1: Depreciation rates and wages



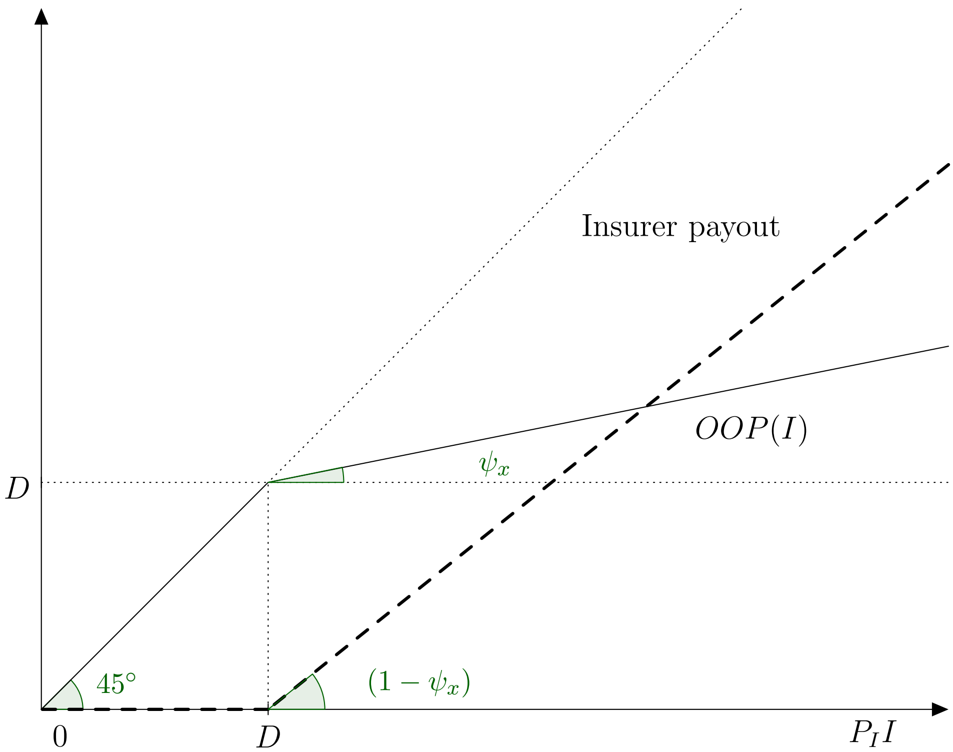
(a) Depreciation



(b) Wages

Notes: (a) From calibrated and estimated parameters in Tables 6, and 7. (b) Bureau of Labor Statistics (2011, Tab. 1).

Figure 2: Out-of-pocket health expenditures and insurer payouts



Notes: Solid line: Out-of-pocket expenditures (5) for deductible D and co-payment rate ψ as function of health expenditures $P_I I$. Dashed line: Insurance payout by insurer.

Figure 3: Iteration results

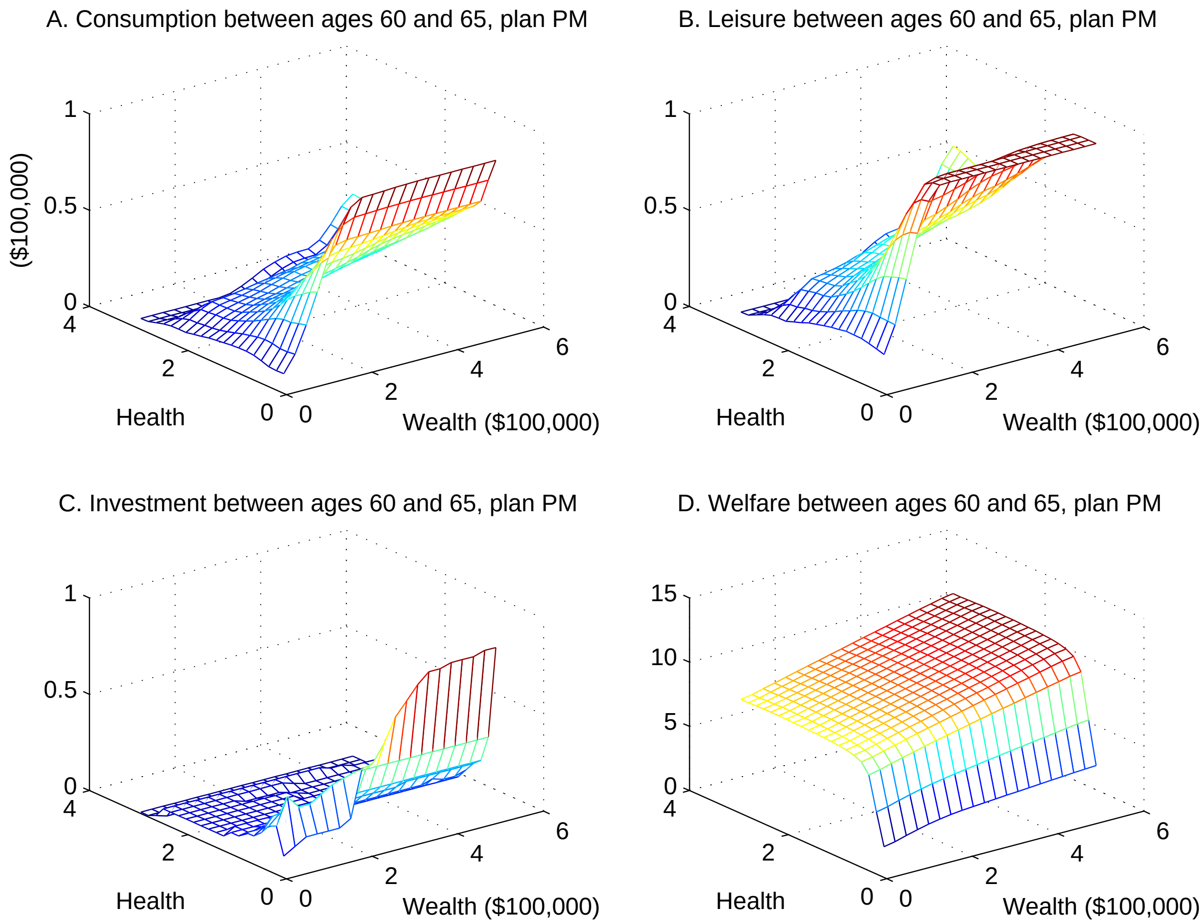


Figure 4: Life cycle health

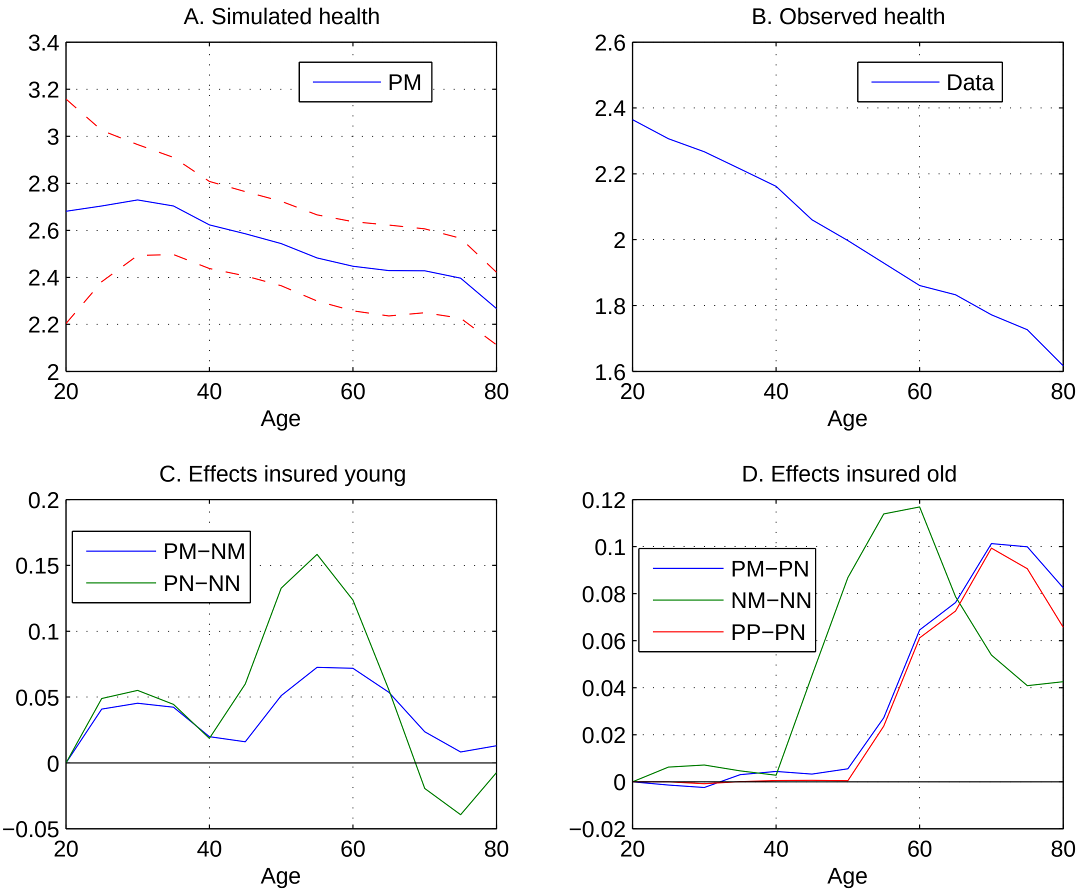


Figure 5: Life cycle health investment

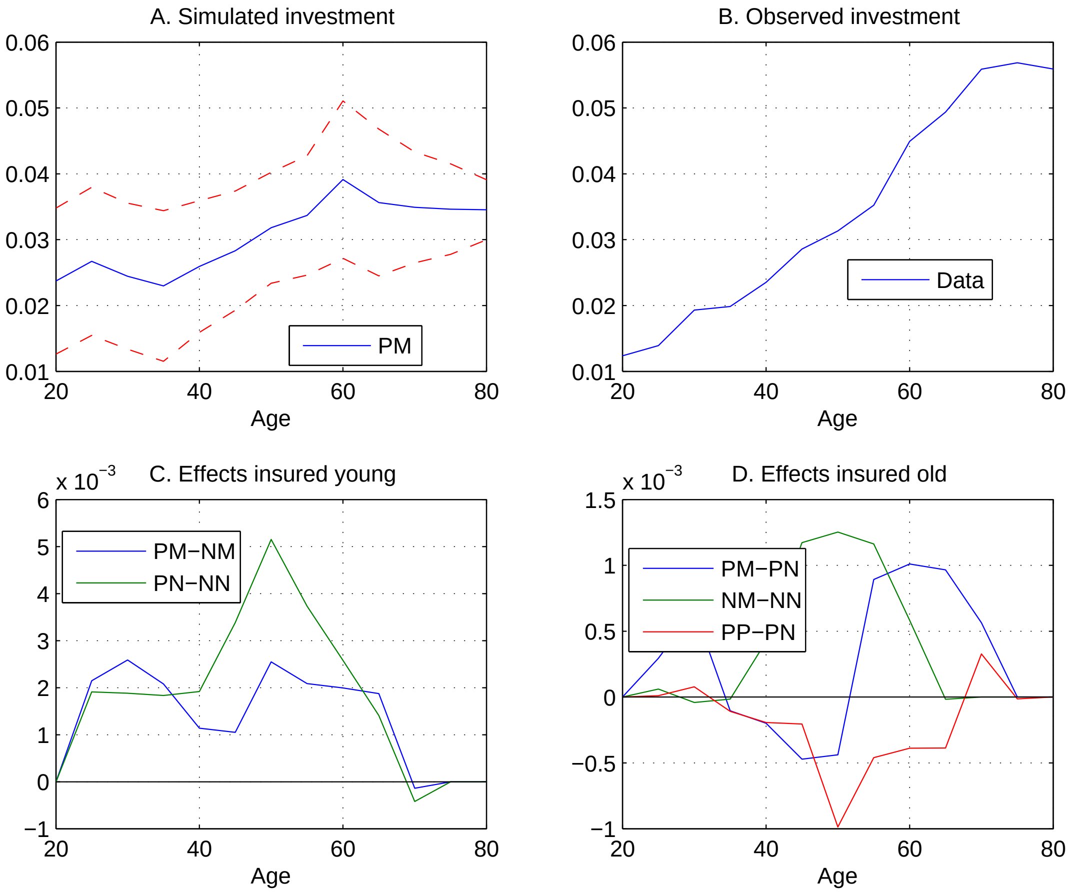


Figure 6: Life cycle out-of-pocket health expenditures

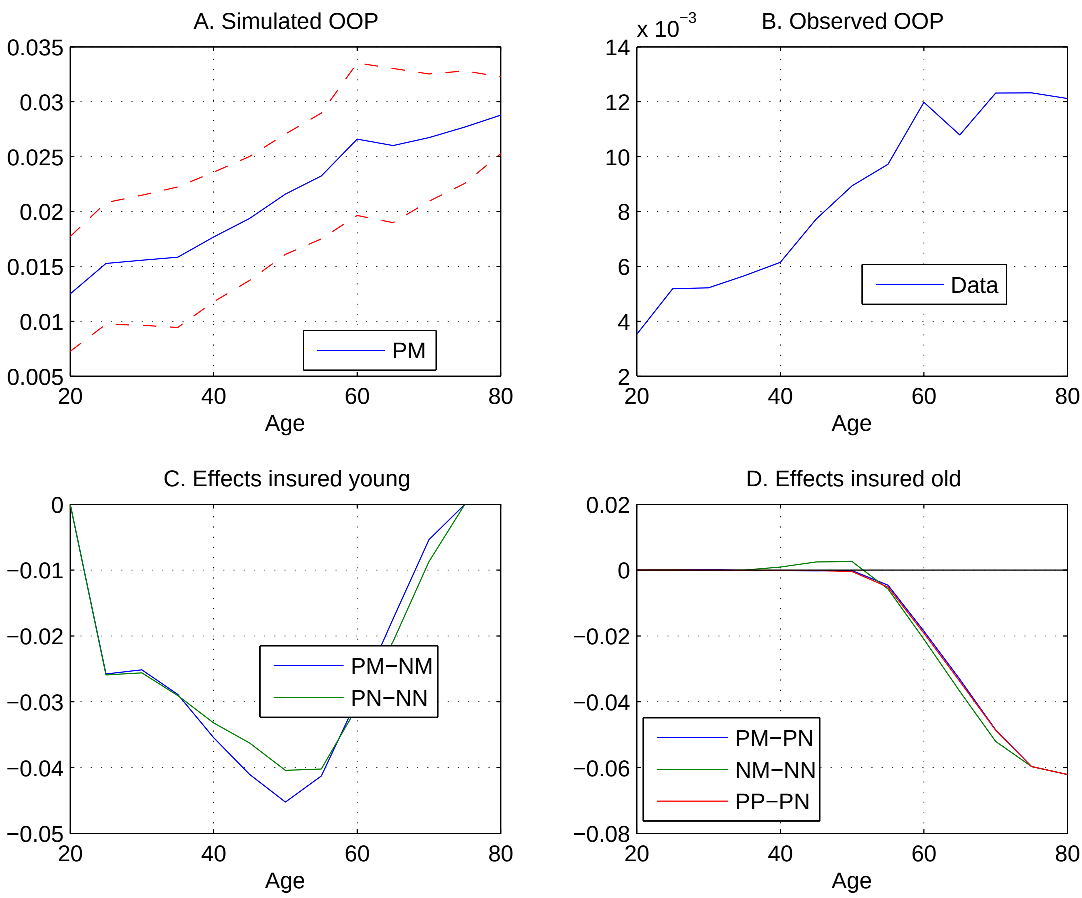


Figure 7: Life cycle healthy leisure

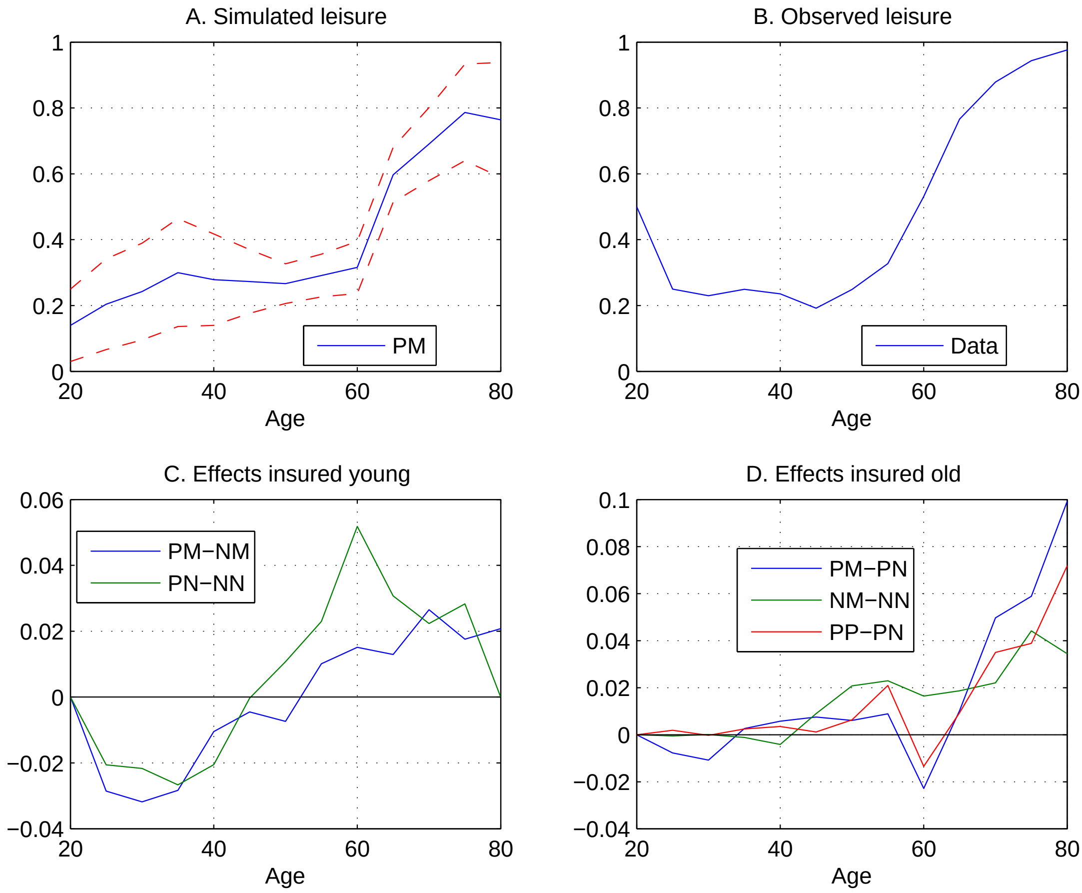


Figure 8: Life cycle wealth

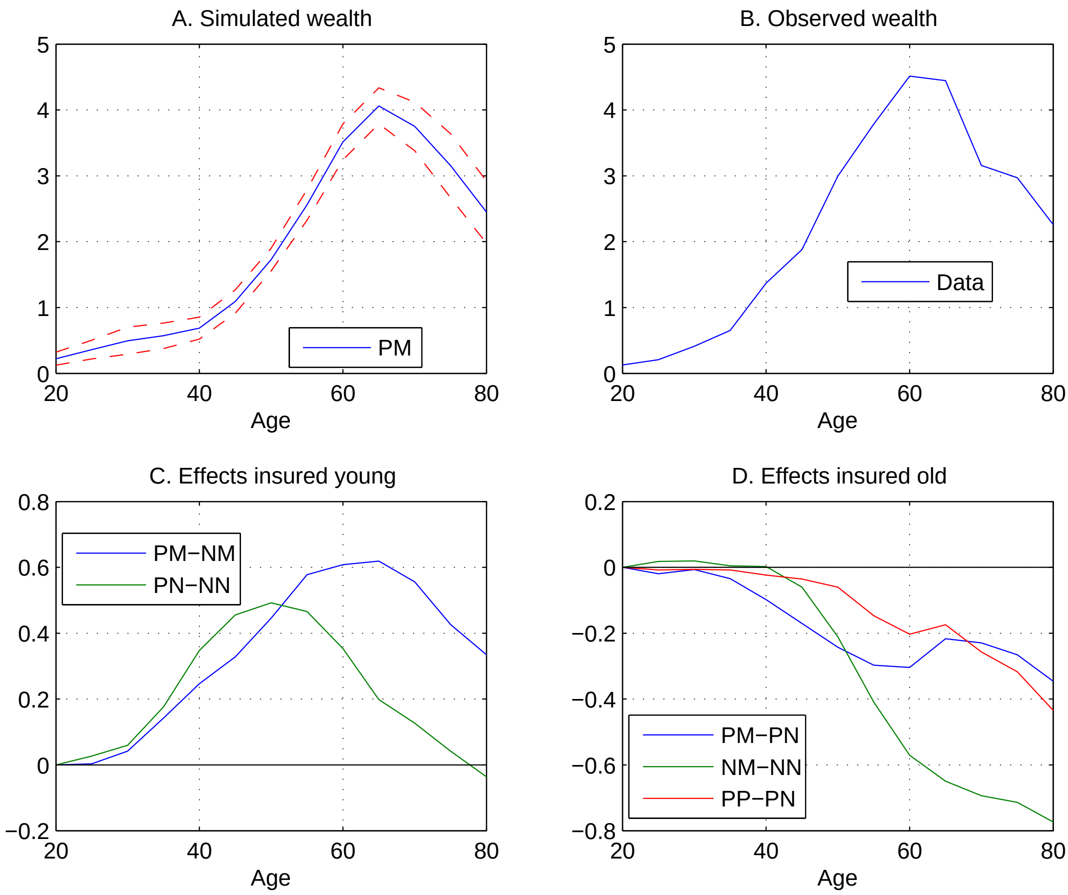


Figure 9: Life cycle welfare

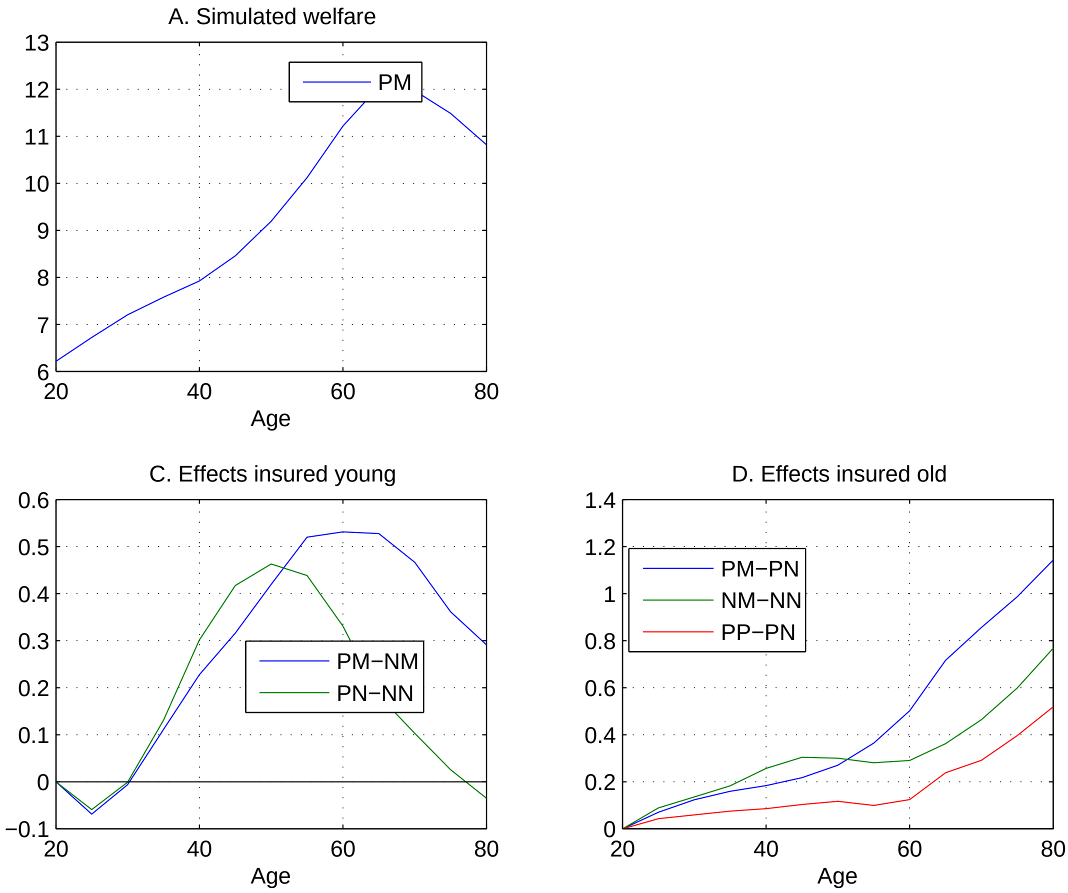
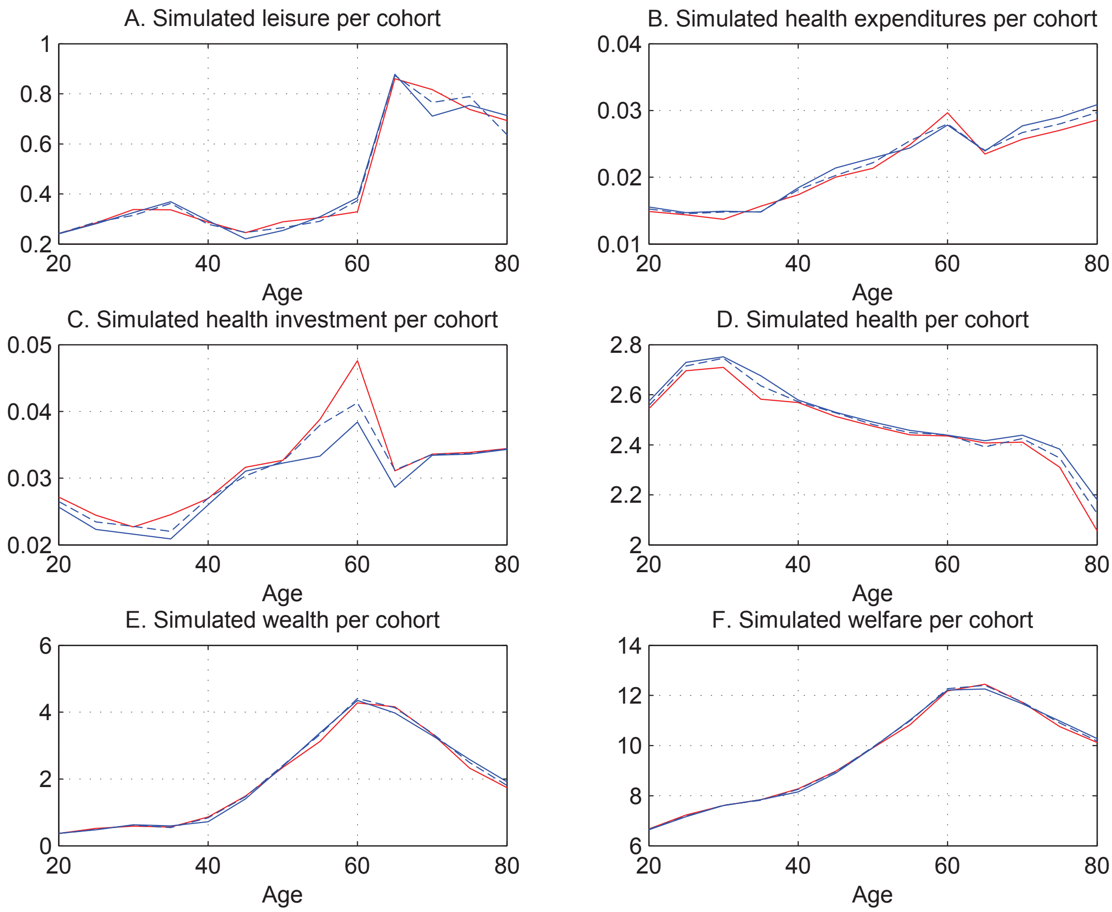


Figure 10: Cohort effects



Notes: Dashed blue line: $\kappa = -37$ (benchmark). Solid blue line: $\kappa = -30$ (young cohort). Solid red line: $\kappa = -44$ (middle-age cohort).