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Saving Motives over the Life-Cycle*

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Abstract

Three key drivers of savings are life-cycle, precautionary, and bequest motives. What is their relative quantitative importance? We revisit this question focusing on the role of preferences and institutions. We address the challenge of disentangling the effects of different saving motives on one's decisions by considering many aspects of people's behavior both before and after retirement. We illustrate why this approach is informative about the underlying preference parameters, and hence allows us to uncover the relative strength of different motives. Our decomposition exercises reveal that bequest motive is the key driver of savings starting from the middle-age and long before retirement. We also find that life-cycle motive and precautionary motive due to medical expense shocks play a minor role. The former result is due the crowding out effect of Social Security. The latter is due to the combined effect of health insurance and the means-tested transfers.

1 Introduction

People save for different reasons. The decline in income after retirement gives raise to life-cycle saving motive, uncertainty in income net of medical expenses generates precautionary motive, and the desire to leave inheritance results in bequest motive. What is the distinct contribution of these motives in shaping people's saving decisions over the life-cycle?

We revisit this question with a particular focus on the role of preferences and institutions. We first study how different aspects of people's behavior allow us to infer the underlying

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preference parameters. We then evaluate the importance of each saving motive in the current institutional environment and in the counterfactual environment with changed institutions.

The starting point in such an analysis is how to disentangle the effects of different saving motives on people's decisions. In particular, can we tell apart savings for precautionary and bequest motives? Similarly, can we separate wealth accumulated for life-cycle versus precautionary reasons? We argue that these questions can be answered by accounting for several aspects of people's behavior both early-in-life and after retirement.

To explain our approach, consider first the well-known challenge of separating bequest and precautionary motives. It arises because every dollar saved for precautionary reasons can be bequeathed if one does not survive. This identification challenge was emphasized by Dynan et al. (2002) who proclaimed that these two motives "cannot generally be distinguished". However, recently substantial progress has been made in the context of retirement saving models (e.g., Ameriks et al., 2020; De Nardi et al., 2016; Lee and Tan, 2023; Lockwood, 2018). These studies commonly combine data on wealth decumulation with information on other aspects of after-retirement behavior, while keeping wealth at the start of retirement exogeneously fixed.[1] We show that another way to address this identification challenge is to account for before-retirement behaviors, namely, for wealth accumulation and the distribution of people by the age of claiming Social Security benefits.

Accounting for pre-retirement wealth accumulation is important for the following reason. A particular model's parametrization can well explain the decumulation of an exogenously fixed amount of wealth within the context of a retirement saving model. At the same time, it may fail to account for why this particular amount of wealth was accumulated. This is because bequest motive not only affects how quickly wealth is decumulated but also how much pre-retirement wealth is accumulated.

Claiming decisions are important as they add a portfolio choice aspect to a regular consumption-saving problem. This is because the later people claim, the higher is their pensions. Hence, delaying claiming is equivalent to acquiring additional annuity income, and claiming decisions represent an annuitization problem. Importantly, bequest motive has an opposite effect on the decisions to save and to annuitize. Thus, people with stronger bequest motive save more but claim earlier because they have lower demand for annuities.

Turning to life-cycle versus precautionary motives, in many studies these motives are tied together by construction. This is due to the assumption of the constant relative risk aversion (CRRA) utility function, which implies that risk aversion is equal to the inverse of the

[1]Specifically, Ameriks et al. (2020) use the answers to strategic survey questions as the additional identifying information, De Nardi et al. (2016) use the Medicaid recipiency rates, Lee and Tan (2023) use the response to the unanticipated change in pension benefits due to the Social Security notch, and Lockwood (2018) uses the purchase of long-term care insurance.

intertemporal elasticity of substitution (IES). However, risk aversion controls the strength of precautionary motive, while IES controls the strength of life-cycle motive. Imposing the one-to-one relationship between the two limits any model's flexibility in quantifying the relative importance of these two motives. In our approach, we use a flexible preferences specification allowing for arbitrary relationship between risk aversion and IES. We show that the *shape* of wealth profiles both over accumulation and decumulation phases is informative about these two preference parameters.

We estimate our model with the method of simulated moments (MSM) using the Medical Expenditure Panel Survey (MEPS), Health and Retirement Study (HRS) and Panel Study of Income Dynamics (PSID) datasets. The estimated model can well reproduce many empirical patterns related to claiming, employment, and saving decisions.

Our findings are as follows.

First, the results of our estimation show that to account for saving and claiming behavior, the model has to feature relatively high degree of impatience, high risk aversion, low IES, and large utility from leaving bequests implying high marginal propensity to bequeath (MPB). Importantly, our estimated risk aversion is very distinct from the inverse of IES.

Second, we provide a detailed illustration of how combining information on pre- and post-retirement behaviors helps us to uncover the key preference parameters. To do this, we re-estimate our preference parameters within the context of a retirement saving model. In this re-estimation, we fix the intensity of bequest motive at two different levels, either high or low. We show that these two partial life-cycle models with different bequest intensity can be parameterized to equally well account for the decumlation of a fixed retirement wealth. This is achieved by compensating weaker (stronger) bequest motive with stronger (weaker) precautionary motive. At the same time, the implications of these two models regarding pre-retiremnt behaviors differ from each other and from the baseline in three dimensions: (i) wealth level accumulated by the start of retirement; (ii) the shape of life-cycle wealth profiles; (iii) the distribution of people by the age of claiming Social Security benefits. Hence, while different combinations of saving motives can explain the evolution of post-retirement wealth, these combinations are inconsistent with before-retirement behaviors. Accounting for decisions made over the entire-life cycle helps us to uncover the "true" drivers of savings.

Our third set of results relates to the decomposition of the effects of the three saving motives. We evaluate the contribution of each saving motive to average assets, and show that the results differ considerably by age. Precautionary motive contributes 84% to average wealth at ages 25-29, and only 11% after the age of 85. Bequest motive becomes a dominant saving motive after the age of 50 when its contribution exceeds 50%. Hence, bequest motive plays an important role in wealth accumulation long before retirement. We also find that life-cycle motive and precautionary motive against medical expense shocks play a minor role in wealth accumulation.

In the final part of the paper, we study the role of the institutions in our result that life-cycle motive and precautionary motive against medical expense shocks have a minimal contribution. We start with life-cycle motive. This motive mainly serves to maintain consumption after retirement, and thus parallels the role of Social Security. To evaluate this interaction, we repeat our decomposition exercise in the environment without Social Security. In this case, the contribution of life-cycle saving motive to average wealth-holding of people aged 65-69 increases to 45%, thus exceeding the corresponding number in the baseline economy by an order of eight. This shows that the crowding-out effect of Social Security is especially large when considered within the context of life-cycle saving motive.

We next evaluate the role of health insurance and the means-tested transfers for precautionary savings against medical expense shocks. Health insurance represents state-contingent savings that absorb part of regular savings for precautionary reasons. The means-tested transfers provide the minimum consumption guarantee and thus determine the utility level in the worst-outcome situation (the largest possible medical expense shock).

To investigate the role of these factors, we consider three counterfactual experiments. In the first two experiments, we either remove state-contingent savings (health insurance) or reduce the generosity of the consumption minimum floor (from more than $6,000 in the baseline economy to $100). In each case, we find an increase in the contribution of medical expense shocks to average saving. While in the baseline economy, precautionary savings against medical expense shocks account for 1% of average pre-retirement wealth, in the counterfactual cases either without health insurance or with less generous means-tested transfers the corresponding numbers are 8% and 4%, respectively.

In our last counterfactual exercise, we simultaneously remove state-contingent savings and reduce the generosity of the means-tested transfers. This exercise dramatically changes our previous results making medical expense risk the key driver of wealth accumulation. In particular, the contribution of precautionary savings against medical expense shocks to pre-retirement wealth now constitutes more than 50%. This series of experiments highlights that medical expense shocks play a minor role in wealth accumulation in the baseline economy not because this risk is unimportant but because of the alternative insurance mechanisms.

Better understanding of saving decisions has important implications for evaluating public policies that affect saving incentives. Among such policies, two should be especially mentioned. First are reforms to Social Security and pension systems. As is well established in the literature starting from Auerbach and Kotlikoff (1987) these reforms can have important effects on savings. The quantitative assessment of these effects crucially depends on how important is life-cycle saving motive compared to other saving motives. For example, Fuster et al. (2003) show that the strength of bequest motive has a large effect on the welfare consequences of the Social Security elimination.

The second group of related policies is the introduction of various tax-deferred saving accounts that are specifically designed to address a particular saving motive, i.e., life-cycle motive (Individual Retirement Accounts, IRA) or precautionary motive (Health Saving Accounts, HSA). Without knowing the quantitative importance of each saving motive, it is difficult to assess the welfare implications of these saving accounts.

Apart from its relevance for policy evaluations, understanding the relative importance of different saving motives has non-trivial implications for a number of long-standing questions in public economics, such as to what extent public pensions crowd out private savings (Blau, 2016) or what accounts for the annuity puzzle (Inkman et al, 2011, Pashchenko, 2013). The answer to the first question largely depends on how strong is life-cycle motive for saving, while knowing the strength of bequest motive is important for answering the second one.

Related literature Starting from Modigliani and Brumberg (1954), many studies explore saving behavior over the life-cycle (see reviews in Browning and Lusardi, 1996; De Nardi et al., 2016b; De Nardi and Fella, 2017; French et al., 2023). In this area, we are most closely related to structural papers evaluating the contribution of particular factors to overall savings. These studies differ in their context and incorporate different saving motives into their framework.

Several prominent studies focus on the two out of three major saving motives using models where the preference parameters are estimated using the MSM. Ameriks et al., (2020), De Nardi et al. (2010, 2016a), and Lockwood (2018) consider bequest and precautionary motives, while Cagetti (2003) and Gourinchas and Parker (2002) study life-cycle and precautionary motives. Hubbard et al. (1994) evaluate the importance of each of the three motives but provide a wide range of values varying depending on (exogenously) set preference parameters.

A number of studies provide an in-depth investigation of a particular driver of savings. Kopecky and Koreshkova (2014) and Nakajima and Telyukova (2024) evaluate the impact of medical expenses on aggregate wealth and savings after retirement, respectively. Fella et al. (2024) investigate the importance of bequest motives for savings of Norwegian retirees.

Another group of studies extend the standard framework by including additional reasons to save going beyond the standard bequest, precautionary, or life-cycle motives. McGee (2021) and Nakajima and Telyukova (2020) evaluate the importance of housing, a special asset with direct utility value, for wealth decumulation after retirement. Boar (2021) argues that an important driver of wealth accumulation is the so-called dynastic precautionary motive: savings to insure income shocks of one's adult children. De Nardi et al. (2025) extend the standard bequest motive by modeling couples and distinguishing between side bequests (left when one spouse dies) and terminal bequests (left when both spouses die). Borella et al. (2025) incorporate marriage dynamics, and show that the possibility to get married or to get divorced has large effects on people's saving decisions. Christensen et al. (2022) introduce stochastic marginal utility of consumption, which can explain saving behavior of Danish retirees.

It is also important to mention studies that underline the importance of precautionary motive not only for saving but also for labor supply decisions. This issue is investigated theoretically by Floden (2006) and quantitatively by Low (2005) and Pijoan-Mas (2006).

We also relate to the literature examining the impact of the institutional environment on economic aggregates including wealth. This includes studies focusing on the change in private health insurance (Jung and Tran, 2016, Pashchenko and Porapakkarm, 2013), in public health insurance (Conesa et al., 2018; Zhao, 2017), or in Social Security (Jones and Li, 2023; Imrohoroglu et al., 1995). None of these studies, however, investigate the differential impact of the institutional changes on various motives to save.

The final strand of related literature considers a consumption-saving problem in the framework where risk aversion is not restricted to be equal the inverse of IES. This approach has been used in household finance to understand investments in stocks (Gomes and Michaelides, 2005), in macro literature to investigate the marginal propensity to consume (MPC) in models with liquid and illiquid assets (Aguiar et al., 2024; Kaplan and Violante, 2014), in structural models with survival uncertainty to understand the evolution of value of life over the life-cycle (Cordoba and Ripoll, 2017) or investments in survival-contingent assets (Pashchenko and Porapakkarm, 2022).

The rest of the paper is organized as follows. Section 2 introduces the baseline model, Section 3 describes our estimation, Section 4 presents the results, and Section 5 concludes.

2 Baseline Model

2.1 Demographics and preferences

We construct a life-cycle model with three stages. At the first stage, individuals make consumption, saving, and labor supply decisions. At the second stage, they can also decide whether to claim Social Security benefits. At the third stage, individuals are retired and only make consumption-saving decisions.

The model's period is one year. Individuals enter the model at age $t = 25$. They differ ex-ante in their fixed productivity type (ξ), which affects their labor earnings and the evolution of health.

Health status of an age-t agent, h_t, can take two values: good ($h_t = 1$) or bad ($h_t = 0$). The probabilities to transition between these two states depend on fixed productivity type ξ, and are described by the matrix $\mathcal{H}_t(h_t|h_{t-1}, \xi)$. Health affects medical spending, productivity, and survival probability. We denote the probability to survive from period t to $t+1$ as ζ_t^h.

Each period, an individual incurs a stochastic out-of-pocket medical expenditure shock x_t^h which depends on his age and health; we denote the probability distribution of medical shocks as $\mathcal{G}_t(x_t^h)$. Individuals after a certain age are also exposed to the nursing home risk; these shocks arrive with age- and health-dependent probability pn_t^h. We denote the out-of-pocket costs of nursing homes as xn_t.

An individual's total time endowment is normalized to one, and it can be used for either leisure, $\widetilde{l}_t$, or work, l_t. Labor supply is indivisible, so an agent either works full time ($l_t = \bar{l}$) or not at all ($l_t = 0$). Work brings disutility modeled as age-dependent fixed costs of leisure, ϕ_t^w, which is a linear function of age. The leisure of an individual can thus be represented as follows:

$$\widetilde{l}_t = 1 - l_t - \phi_t^w \mathbf{1}_{\{l_t > 0\}}.$$

Here $\mathbf{1}_{\{.\}}$ is an indicator function which is equal to one if its argument is true.

Individuals enjoy utility from consumption, leisure, and from leaving bequests. To be able to separately parametrize agents' attitude towards risk and intertemporal fluctuations, we use the non-expected utility framework (Epstein and Zin, 1989; Weil, 1990):

$$U_t = \left[\left(c_t^{\chi} (\widetilde{l}_t)^{1-\chi} \right)^{1-\gamma} + \beta \left\{ \zeta_t^h E_t U_{t+1}^{1-\psi} + (1 - \zeta_t^h) \eta \left(k + \phi\right)^{1-\psi} \right\}^{\frac{1-\gamma}{1-\psi}} \right]^{\frac{1}{1-\gamma}}$$

In this expression, χ is a parameter determining the relative weight of consumption in the consumption-leisure composite, ψ is risk-aversion, the inverse of γ captures the intertemporal elasticity of substitution (IES), β is the discount factor, η is the strength of the bequest motive, and ϕ is a shift parameter controlling to what extent bequests are luxury goods. In this formulation of bequest motive we follow De Nardi (2004).

2.1.1 Labor income, taxation, and transfers

The earnings of an individual are equal to $z_t^h l_t$, where z_t^h is the idiosyncratic productivity that depends on age, t, health, h_t, and fixed productivity type, ξ. We describe the parametrization of the idiosyncratic productivity in Section 3.1.2.

All individuals pay an income tax $\mathcal{T}(y_t)$, where the taxable income y_t is based on labor income, capital income, and a taxable portion of Social Security benefits y^{sstax}. Working individuals also pay payroll taxes, Medicare tax, τ_{MCR}, and Social Security tax, τ_{ss}. The Social Security tax rate for earnings above $\overline{y}_{ss}$ is zero.

Individuals with low earnings or high out-of-pocket medical expenses can be eligible to receive the means-tested transfers T_t^{SI}. These transfers guarantee each individual the minimum consumption level $\underline{c}$. The consumption floor is a stylized representation of public transfer programs such as Supplemental Nutrition Assistance Program (SNAP or food stamps), Supplemental Security Income, disability insurance, and uncompensated medical care.

2.1.2 Social Security benefits

Many rules regarding Social Security benefits vary by cohort. In our model, we use people born between 1936 and 1938 as our base cohort, and below we describe the rules as applied to this cohort.

Social Security benefits $ss(AE, j^R, mon)$ is a concave function of the average lifetime earnings, AE, and the age at which one claims benefits, j^R. In addition, there may be an adjustment due to the Social Security earnings test, mon. It only applies to some people who claimed before the FRA, and we explain how it is calculated in the end of this section.

Over one's working life, average lifetime earnings evolve as follows:

$$AE_{t+1} = \begin{cases} AE_t + \dfrac{y_t}{35} & ;\ \text{if } t < 60 \\ AE_t + \dfrac{1}{35}\max\{0, y_t - AE_t\} & ;\ \text{otherwise} \end{cases}$$

where

$$y_t = \min\left\{z_t^h l_t, \overline{y}_{ss}\right\}$$

The actual Social Security rules take into account the average earnings over the 35 years with the highest earnings. We use a simplified version of this rule because otherwise, we have to keep track of the entire earnings history, which will make our computation infeasible. Instead, we assume that over the 35-year period from age 25 to 60, AE_t is updated every period, and after age 60, AE_t is updated only if the current earnings exceed the average of previous earnings.

People who claim benefits at the full retirement age (FRA) receive basic pension described below:

$$ss(AE_t, FRA, 0) = \begin{cases} 0.9AE_t & ;\ \text{if } AE_t < B_1 \\ 0.9B_1 + 0.32(AE_t - B_1) & ;\ \text{if } B_1 \leq AE_t < B_2 \\ 0.9B_1 + 0.32(B_2 - B_1) + 0.15(AE_t - B_2) & ;\ \text{if } AE_t \geq B_2, \end{cases} \quad (1)$$

where B_1 and B_2 are the bend points, i.e., the levels of AE_t when the replacement rate changes first from 0.9 to 0.32, and then from 0.32 to 0.15. For our base cohort, B_1 is equal to \$6,372, and B_2 is equal to \$38,424 in annual values (we use the Social Security benefits formula for 2000).

For people who claim pensions before or after the FRA, basic pension is adjusted in the following way. People who claim at the earliest eligibility age of 62, receive benefits that are permanently decreased by 20%. When claiming after 62, benefits are increased by 6.7% with each year of delay until the FRA. For people who claim after the FRA, benefits are increased by 6.5% for every year of delay. The latest age people can claim benefits is 70 years old. The full schedule of benefits/rewards for early/late claiming for our base cohort is displayed in Table 1. The FRA for our base cohort is 65 years old.

Age	62	63	64	65 (FRA)	66	67	68	69	70
% of benefits	80	86.7	93.3	100	106.5	113	119.5	126	132.5

Table 1: Reduction (increase) in benefits for early (late) claiming, in % of the full benefits received at the FRA (65 years old).

Importantly, a decision when to claim Social Security benefits is equivalent to an annuitization problem. For example, consider an individual who postpones claiming for one year. He forgoes one-year worth of benefits but receives higher pensions starting next year. Hence, he acquires additional annuity income at the implicit price equal to one year of forgone benefits. Because of the parallel between claiming and annuitization decisions, the distribution of people by age of claiming captures the demand for Social Security annuity. We will exploit this feature in our structural estimation.

Basic pension benefits can be further adjusted due to the Social Security earnings test. The earnings test withholds benefits of working individuals who claim Social Security benefits before reaching the FRA and whose earnings exceed a threshold of \$10,080 (for our base cohort). We denote the earnings tax amount as T^{earn}: the tax takes away half of one's earnings in excess of the threshold until the total amount of benefits is withheld.

The withheld benefits go towards increasing individual's benefits from the FRA onward. In particular, for each month that the benefits were withheld, the penalty for early claiming is offset at the rate of 5/9%. We denote the total number of months during which the benefits were withed as mon. Hence, an individual who is subject to the earnings test, on reaching the FRA, will receive an increase in his benefits equal to $ss(AE, FRA, 0) \times \frac{5}{9} \frac{mon}{100}$. For example, suppose an individual claims at 62 but continues to work and has all of his annual benefits withheld. Starting from age 63, he no longer works. Hence his $mon = 12$, and at the FRA, he will start receiving benefits as if he claimed at 63 (6.7% higher compared to his initial benefits when he claimed at 62).

2.1.3 Optimization problem

Individuals younger than age 62. People younger than age 62 are not yet eligible to claim Social Security benefits. We denote the vector of state variables of an individual of age t as $\mathbb{S}_t$: $\mathbb{S}_t = (k_t, h_t, z_t^h, AE_t, \xi)$. In our formulation of the dynamic programming problem, we assume an individual first learns his health and productivity shock, and then makes his labor supply decision. After that, he learns the realization of his medical shock and makes consumption-saving decisions. We denote the value function before an individual learns his medical shock as $V(\cdot)$. We denote the interim value function after he learns the realization of his medical shock as $W(\cdot)$. We can thus write the dynamic programming problem as follows:

$$V_t(\mathbb{S}_t) = \max_{l_t} \left\{ \sum_{x_t^h} \mathcal{G}_t\left(x_t^h\right) W_t(\mathbb{S}_t; l_t, x_t^h)^{1-\psi} \right\}^{\frac{1}{1-\psi}} \tag{2}$$

where

$$W_t(\mathbb{S}_t; l_t, x_t^h) = \max_{c_t, k_{t+1}} \left\{ \begin{array}{c} \left(c_t^{\chi}(\widetilde{l}_t)^{1-\chi}\right)^{1-\gamma} + \\ \beta\left[\zeta_t^h E_t\left(V_{t+1}(\mathbb{S}_{t+1})\right)^{1-\psi} + (1-\zeta_t^h)\eta\left(k_{t+1}+\phi\right)^{1-\psi}\right]^{\frac{1-\gamma}{1-\psi}} \end{array} \right\}^{\frac{1}{1-\gamma}} \tag{3}$$

subject to

$$k_t\left(1+r\right) + z_t^h l_t + T^{SI} = k_{t+1} + c_t + x_t^h + Tax \tag{4}$$

$$T_t^{SI} = \max\left(0, \underline{c} + x_t + Tax - k_t\left(1+r\right) - z_t^h l_t\right) \tag{5}$$

$$Tax = \mathcal{T}\left(y_t^{tax}\right) + \tau_{ss}\min\left(z_t^h l_t, \overline{y}_{ss}\right) + \tau_{MCR} z_t^h l_t \tag{6}$$

$$y_t^{tax} = k_t r + z_t^h l_t \tag{7}$$

The conditional expectation on the right-hand side of Eq (3) is over z_{t+1}^h and h_{t+1}. Eq (4) is the budget constraint. Eq (5) describes the means-tested transfers that provide the minimum consumption guarantee $\underline{c}$. In Eq (6), the first term is the income tax and the last two terms are payroll taxes. Eq (7) describes taxable income.

Individuals older than age 62 and who still didn't claim benefits. People in this category make an additional decision: whether to claim Social Security benefits. We denote the claiming decision as i_t^C: $i_t^C = 1$ if an individual claims and $i_t^C = 0$ otherwise. The value function can be written as follows:

$$V_t(\mathbb{S}_t) = \max_{l_t, i_t^C} \left\{ \sum_{x_t^h} \mathcal{G}_t\left(x_t^h\right) W_t^E(\mathbb{S}_t; l_t, i_t^C, x_t^h)^{1-\psi} \right\}^{\frac{1}{1-\psi}}$$

The interim value function W_t^E takes different forms depending on whether an individual claims benefits or not; in the former case, there will be another two state variables next period: the age at which he begins collecting benefits and the number of months benefits were withheld due to the Social Security earnings test:

$$W_t^E(\mathbb{S}_t; l_t, i_t^C = 0, x_t^h) = \max_{c_t, k_{t+1}} \left\{ \begin{array}{c} u\left(c_t, \widetilde{l}_t\right)^{1-\gamma} + \\ \beta\left[\zeta_t^h E_t\left(V_{t+1}(\mathbb{S}_{t+1})\right)^{1-\psi} + (1-\zeta_t^h)\eta\left(k_{t+1}+\phi\right)^{\chi(1-\psi)}\right]^{\frac{1-\gamma}{1-\psi}} \end{array} \right\}^{\frac{1}{1-\gamma}}$$

$$W_t^E(\mathbb{S}_t; l_t, i_t^C = 1, x_t^h) = \max_{c_t, k_{t+1}} \left\{ \begin{array}{c} u\left(c_t, \widetilde{l}_t\right)^{1-\gamma} + \\ \beta\left[\zeta_t^h E_t\left(V_{t+1}^C(\mathbb{S}_{t+1}, t, mon_{t+1})\right)^{1-\psi} + (1-\zeta_t^h)\eta\left(k_{t+1}+\phi\right)^{\chi(1-\psi)}\right]^{\frac{1-\gamma}{1-\psi}} \end{array} \right\}^{\frac{1}{1-\gamma}}$$

subject to

$$k_t\left(1+r\right) + z_t^h l_t + ss(AE, t, 0)\mathbf{1}_{\{i_t^C=1\}} + T_t^{SI} = k_{t+1} + c_t + x_t^h + Tax \tag{8}$$

$$T_t^{SI} = \max\left(0, \underline{c} + x_t^h + Tax - k_t\left(1+r\right) - z_t^h l_t - ss(AE, t, 0)\mathbf{1}_{\{i_t^C=1\}}\right) \tag{9}$$

$$Tax = \mathcal{T}\left(y_t^{tax}\right) + \tau_{ss}\min\left(z_t^h l_t, \overline{y}_{ss}\right) + \tau_{MCR} z_t^h l_t + T^{earn}\mathbf{1}_{\{i_t^C=1\}} \tag{10}$$

$$y_t^{tax} = k_t r + z_t^h l_t + y_t^{ss_{tax}} \mathbf{1}_{\{i_t^C=1\}} \tag{11}$$

$$mon_{t+1} = \frac{T^{earn}}{ss(AE,t)} \times 12 \tag{12}$$

The budget constraint in Eq (8) now includes the Social Security benefits $ss(AE, t, 0)$ for individuals who claim (i.e., $i_t^C = 1$). Taxes in Eq (10) now include the Social Security earnings test for individuals who are younger than the FRA and who claimed benefits but continue working. The taxable income in Eq (11) can include taxable portion of the Social Security benefits $y^{ss_{tax}}$. Eq (12) describes the number of months pension benefits were withheld due to the Social Security earnings test.

In our description of the individual optimization, we omit the dynamic programming problem of people between ages 63 and 70 who already claimed benefits. This problem is similar to the one just described with three exceptions. First, individuals in this group no longer make claiming decisions. Second, for workers below the FRA, the accumulated number of months the benefits are withheld due to the Social Security earnings test are updated as follows:

$$mon_{t+1} = mon_t + \frac{T^{earn}}{ss(AE, j^R, 0)} \times 12.$$

Third, individuals who reach the FRA receive an addition to their benefits equal to $ss(AE, FRA, 0) \times \frac{5}{9}\frac{mon}{100}$.

Retired individuals After age 70, individuals make only consumption-saving decisions. We denote the vector of state variables for this group as $\mathbb{S}_t^R$, where $\mathbb{S}_t^R = (k_t, h_t, AE, \xi, j^R, mon)$. The dynamic programming problem can be written as follows:

$$V_t^R(\mathbb{S}_t^R) = \left\{ \sum_{x_t} \sum_{xn_t} \mathcal{G}_t\left(x_t^h\right) pn_t^h W_t^R(\mathbb{S}_t^R; x_t^h, xn_t)^{1-\psi} \right\}^{\frac{1}{1-\psi}}$$

where

$$W_t^R(\mathbb{S}_t^R; x_t^h, xn_t) = \max_{c_t, k_{t+1}} \left\{ \begin{array}{c} \left(c_t^{\chi}(\widetilde{l}_t)^{1-\chi}\right)^{1-\gamma} + \\ \beta\left[\zeta_t^h E_t\left(V_{t+1}^R(\mathbb{S}_{t+1}^R)\right)^{1-\psi} + (1-\zeta_t^h)\eta\left(k_{t+1}+\phi\right)^{1-\psi}\right]^{\frac{1-\gamma}{1-\psi}} \end{array} \right\}^{\frac{1}{1-\gamma}} \tag{13}$$

subject to:

$$k_t\left(1+r\right)+ss(AE,j^R,mon)+T^{SI}=k_{t+1}+c_t+\mathcal{T}\left(y_t^{tax}\right)+x_t^h+xn_t$$

$$T_t^{SI}=\max\left(0,\underline{c}+\mathcal{T}\left(y_t^{tax}\right)+x_t^h+xn_t-k_t\left(1+r\right)-ss(AE,j^R,mon)\right) \tag{14}$$

$$y_t^{tax}=k_t r+y^{ss_{tax}}$$

In Eq (13), the interim value function W_t^R is conditional on the realization of the out-of-pocket medical spending shock x_t^h and the nursing home shock xn_t.

3 Model estimation

To estimate our model, we follow a two-step procedure. This approach is common in the literature that estimates structural life-cycle models (e.g., De Nardi, French, and Jones, 2010; French, 2005; Gourinchas and Parker, 2002). At the first step, we set parameters related to the institutional environment such as Social Security rules and taxes, and also estimate directly from the data medical and nursing home expenses, labor productivity, survival and health transition probabilities. At the second step, we estimate the preference parameters and the consumption minimum floor using the Method of Simulated Moments (MSM).

In our estimation, we use three datasets: the Medical Expenditure Panel Survey (MEPS), the Health and Retirement Study (HRS), and the Panel Study of Income Dynamics (PSID). In all three datasets, we select a sample of male individuals.

We use the MEPS to estimate out-of-pocket medical expenses. We use the HRS to estimate nursing home costs and survival probabilities, and to construct moments related to claiming behavior. We use the PSID to estimate labor productivity, health transitions, as well as to construct moments related to employment and wealth profiles. We convert nominal values to 2002 dollars using the CPI as a deflator.

3.1 First step estimation

3.1.1 Health and survival probabilities

In our model, health can take two values, good and bad. In the data, we use self-reported health status. This variable takes five values: excellent, very good, good, fair, and poor. We classify people as being in good health if their self-reported health falls into the first three categories, and we classify them as being in bad health otherwise.

In our model, health transition probabilities depend on the productivity type ξ. Hence, we first estimate the fixed productivity using a fixed-effect regression of log labor income on a set of age dummy variables interacted with health from the PSID. We categorize individuals in our sample as being of low (high) fixed productivity type if their estimated fixed labor productivity is below (above) the median. For each current health status, we model the probability of moving to health status h_{t+1} conditional on surviving as a logit model which depends on a quadratic of age, dummy variable for fixed productivity, and cohort dummy variables, where cohort is defined based on a 5-year interval for birth year. The estimated transition probabilities for our base cohort are displayed at the top panel of Figure 1.

We estimate survival probability as a logit model which depends on a second-degree age polynomial interacted with current health status, and cohort dummy variables. Since the HRS is a biannual survey, we take the square root of our estimates to convert them into one-year survival probabilities. The estimated survival probability for our base cohort is plotted at the bottom left panel of Figure 1.

3.1.2 Labor productivity

We assume the productivity of individuals takes the following form:

$$z_t^h = \lambda_t^h \exp(v_t) \exp(\epsilon_t) \exp(\xi) \tag{15}$$

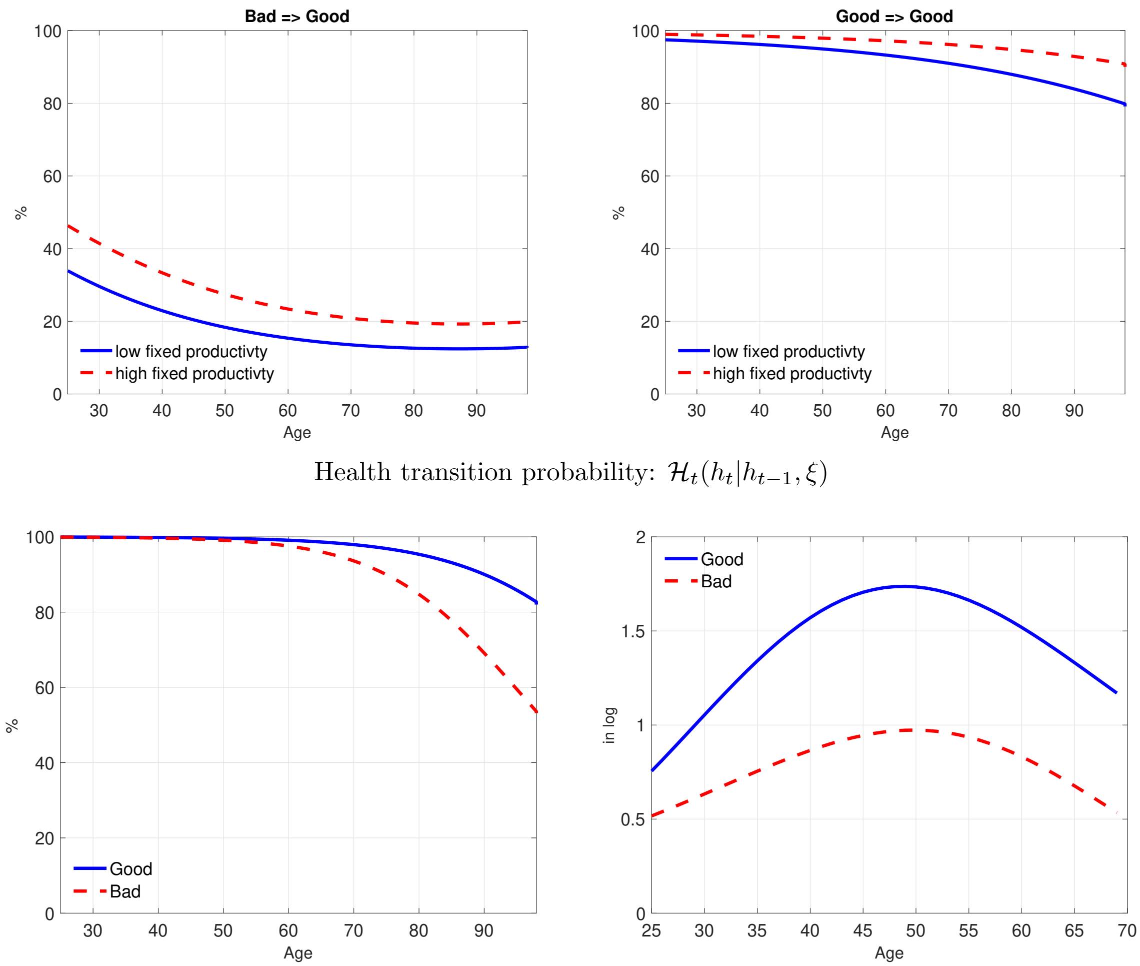
where λ_t^h is the deterministic component that depends on age and health, and the stochastic component consists of the persistent shock v_t, transitory shock ϵ_t, and a fixed productivity type ξ:

$$v_t = \rho v_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_\varepsilon^2) \tag{16}$$

$$\epsilon \sim N(0, \sigma_\epsilon^2), \quad \text{and} \quad \xi \sim N(0, \sigma_\xi^2)$$

We set ρ to 0.984, σ_ε^2 to 0.022, σ_ϵ^2 to 0.057, and σ_ξ^2 to 0.242. These values are common in the incomplete market literature (e.g., French, 2005; Hubbard et al., 1994; Storesletten et al., 2004).

We estimate the deterministic productivity λ_t^h from the PSID. For this, we use a sample of men who work at least 2,000 hours per year. We estimate a regression of log labor income on a second-order polynomial of age interacted with health, and cohort dummy variables, where cohort is defined based on a five-year birth year bracket. The resulting health-dependent deterministic labor productivity for our base cohort (normalized by GDP per capita in 2002) is displayed in the bottom right panel of Figure 1.



Health transition probability: $\mathcal{H}_t(h_t|h_{t-1},\xi)$

Survival probability by health: ζ_t^h

Health-dependent labor productivity: λ_t^h

Figure 1: Health transition probabilities, survival probabilities, and deterministic labor productivity

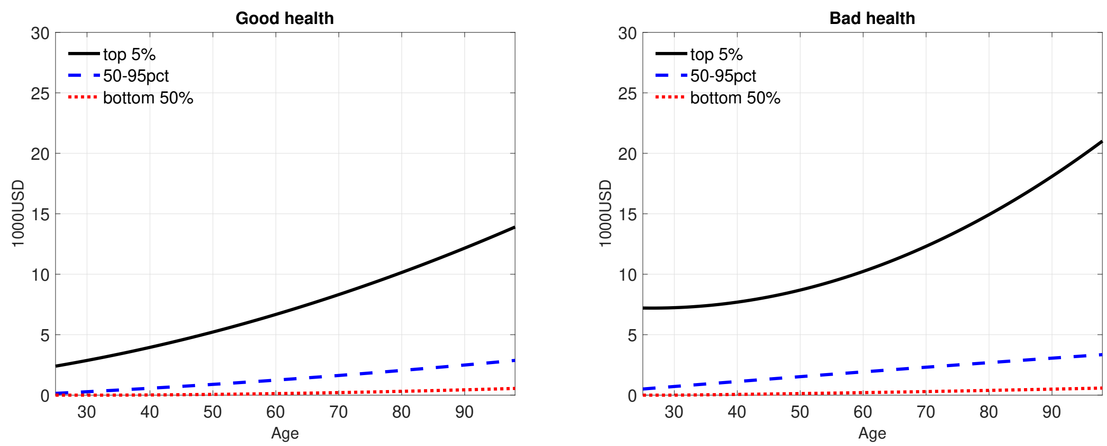
3.1.3 Medical expenses and nursing home shocks

Medical costs in our model correspond to the out-of-pocket medical expenditures in the MEPS dataset. We assume that medical expense shock is a 3-state discrete health- and age-dependent stochastic process. To construct these shocks, we separate people into the following six groups: those with spending below the 50th, 50th to 95th, and above the 95th percentiles of the medical spending distribution, and in good or bad health. For each group, we regress the out-of-pocket medical expenses on a second-order age polynomial.[2]

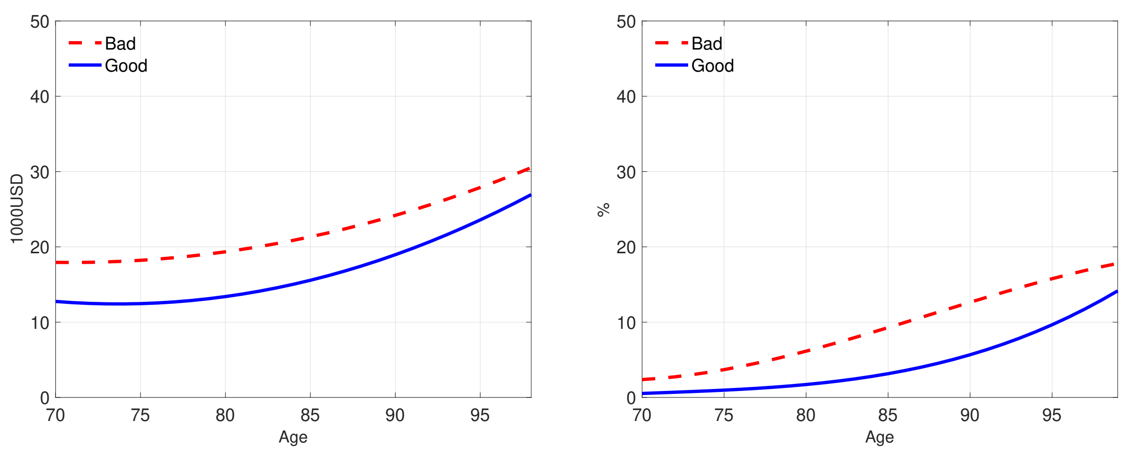
[2]The MEPS underestimates aggregate medical expenditures: the ratio of aggregate medical spending in the National Health Expenditure Account (NHEA) divided by aggregate medical spending in MEPS for people younger and older than 65 years old constitute 1.6 and 1.9, respectively (Pashchenko and Porapakkarm, 2016). The larger discrepancy for the older group is due to the fact that MEPS does not include nursing home expenditures. To bring aggregate medical expenses computed from the MEPS in line with the corresponding statistics in the NHEA, we multiply our estimated medical expenses by 1.60. We use this number because we explicitly account for nursing home spending in our model.

The resulting medical expenses are plotted at the top panel of Figure 2.

To estimate the risk of incurring a nursing home shock, we first compute the percentage of individuals reporting staying in a nursing home in the HRS for the following age groups: 65-69, 70-74, 75-79, 80-84, 85-89, and older than 90. We convert these numbers into annual probabilities by taking a square root. We then interpolate the probability to stay in a nursing home for other ages separately for healthy and unhealthy people. To compute the average nursing home costs, we multiply the number of nights people report staying in a nursing home by the average daily rate for a semiprivate room in a nursing home, which was $158.26 in the MetLife Market Survey of Nursing Home and Home Care Costs (August 2003). The estimated costs of nursing homes and the probability to enter a nursing home are plotted at the bottom panel of Figure 2.



Out-of-pocket medical expenses: x_t^h



Out-of-pocket nursing home costs: xn_t^h

Nursing home probability: pn_t^h

Figure 2: Out-of-pocket medical expenses and nursing home risks

3.1.4 Taxes and government transfers

We specify the progressive income tax function $\mathcal{T}(y)$ following Guner et al. (2016) and Heathcole et al. (2017):

$$\mathcal{T}(y) = y - a_{\tau 0}\ y^{1-a_{\tau 1}}. \tag{17}$$

The progressivity of the tax system is captured by $a_{\tau 1}$. We set $a_{\tau 0}$ and $a_{\tau 1}$ to 0.911 and 0.053, respectively, following Guner et al. (2016) who estimated the tax function for year 2000.

The Medicare and Social Security tax rates are set to 2.9 percent and 12.4 percent, respectively. The maximum taxable income for Social Security ($\overline{y}_{ss}$) is set to \$76,200 (corresponding to year 2000).

3.1.5 Other first-step parameters

We set the consumption share in the utility function χ to 0.5, which is in the range estimated by French (2005). We set the labor supply of those who work ($\bar{l}$) to 0.4. We set the interest rate to 2%.

3.2 Second step estimation

Preference parameters are estimated with the MSM using the data on employment, claiming, and saving decisions. Our 8×1 vector of estimated parameters Δ includes discount factor, IES, risk aversion, disutility from work at ages 25 and 65, bequest parameters, and the consumption minimum floor: $\Delta = \{\beta, \gamma, \psi, \phi^w_{25}, \phi^w_{65}, \eta, \phi, \underline{c}\}$. Our estimated $\widehat{\Delta}$ is the value of Δ that minimizes the difference between our data moments and the simulated moments from our model. We use the simplex search method in our estimation. Following Altonji and Segal (1996), to avoid small sample biases, we use the identity weighting matrix. The moments that we use are:

1. Average, 25th and 75th percentiles of wealth distribution at the following age groups: 35-39, 40-44,..., 85-89 (27 moments);
2. Employment rates at the following ages: 25-29, 30-34,..., 65-69 (9 moments);
3. Fraction of people claiming Social Security benefits at ages 62 (earliest claiming age) and 65 (FRA for our base cohort) (2 moments).

For our wealth moments, we construct the net worth from the PSID (1994, 1999-2017) and normalize it by the OECD household equivalence scale. We regress the resulting normalized variable, nw_{it}, on a set of age and cohort dummy variables:

$$nw_{it} = d_{age}^{nw} D_{it}^{age} + d_c^{nw} D_i^c + \epsilon_{it}^{nw}, \tag{18}$$

where ϵ_{it}^{nw} is the idiosyncratic component, which is orthogonal to age and cohort. Using these estimates, we construct the net worth for our sample after controlling for cohort effects as follows:

$$\hat{nw}_{it} = \hat{d}_{age}^{nw} D_{it}^{age} + \hat{d}_c^{nw}(D_i^c = 1937) + \hat{\epsilon}_{it}^{nw},$$

where $\hat{d}_{age}^{nw}$ and $\hat{d}_c^{nw}$ are the estimated coefficients from the regression in Eq (18), and $\hat{\epsilon}_{it}^{nw}$ is the estimated residual.

3.3 Second step estimation results and the model fit

Our estimated preference parameters and the consumption minimum floor are reported in Table 2. Our estimated discount factor is 0.929, which suggests relatively strong degree of impatience. At the same time, our estimated bequest preferences suggest strong bequest motive in which bequests are luxury goods. In particular, the estimated bequest parameters imply the marginal propensity to bequeath (MPB) of 0.9591 and a bequest threshold of \$9,994.[3] In other words, in a deterministic consumption-saving model where an individual dies for sure in the next period, he only leaves bequests if his wealth exceeds \$9,994, and once bequest motive is operational, almost 96% of an additional dollar is bequeathed. These numbers are comparable to bequest preferences estimated in other structural studies.[4]

To jointly identify bequest parameters and the discount factor, we follow the approach developed by Pashchenko and Porapkkarm (2024) by exploiting Social Security claiming behavior. Specifically, we use the fact that decisions when to claim benefits is equivalent to annutiization decisions (see Section 2.1.2). Hence, the distribution of people by claiming age captures the demand for Social Security annuities.

Combining information on wealth accumulation and claiming behavior allows us to identify bequest parameters and the discount factor because these preferences have similar effects on wealth accumulation but differential effect on claiming behavior or demand for public annuities. In particular, more patient people save more and claim Social Security benefits *later*. This is because annuities pay out over long time horizon and more patient people value these

[3] We can find the MPB and threshold as follows:

$$threshold = \alpha\phi, \qquad MPB = \frac{1}{1+\alpha}, \qquad \text{and} \qquad \alpha = \left(\beta\eta^{\frac{1-\gamma}{1-\psi}}\right)^{\frac{1}{\chi(1-\gamma)-1}} \tag{19}$$

[4] See Pashchenko and Porapkkarm (2024) for a detailed comparison of bequest preferences across studies.

long-term payments more. At the same time, people with stronger bequest motives save more but claim benefits *earlier*. This is because people with strong bequest motives have lower annuity demand as annuity payments cannot be bequeathed.

Parameters		value
Risk aversion	ψ	6.80
Discount factor	β	0.929
Inverse of IES	γ	3.41
Bequest parameter	η	22,512,910
"	ϕ	\$234,179
Consumption floor	$\underline{c}$	\$6,501
disutility from work at age 25	ϕ^w_{25}	0.11
" at age 65	ϕ^w_{65}	0.31

Table 2: Preference parameters and the consumption floor.

Our estimated risk aversion is equal to 6.8, and the inverse of the estimated IES is 3.41.[5] Importantly, our estimated risk aversion and the inverse of IES are very distinct from each other. In other words, people's attitude's towards utility fluctuations over time and over states of the world are not as closely linked as implied by the standard CRRA function suggesting people's behavior is more consistent with the non-expected utility preferences. These parameters are primary identified from the shape of wealth profiles over the life-cycle.

Figure 3 compares the data moments we use in our estimation with the corresponding moments simulated from our model: the top panel displays the wealth profiles, and the bottom panel shows moments related to employment and claiming behavior. In each case, our model is able to well capture the salient features of the data.

In particular, the lower left panel in Figure 3 shows that our model can well account for the fact that a large number of people claim benefits as soon as they become eligible (age 62): 39% in the model and 41% in the data. In addition, almost no one claims after the FRA (age 65). The average claiming age in the model is 63.6 years old while in the data it is 63.3 years old (for our base cohort). The prevalence of early claiming is driven by the combination of relatively low discount factor and strong bequest motive uncovered in our estimation.

[5]Note that the parameters ψ and $1/\gamma$ represent risk aversion and IES in relation to consumption-leisure composite $c_t^{\chi}(\widetilde{l_t})^{1-\chi}$. The risk aversion over consumption is $\psi\chi + 1 - \chi = 3.9$, and the inverse of IES with respect to consumption is $\gamma\chi + 1 - \chi = 2.2$.

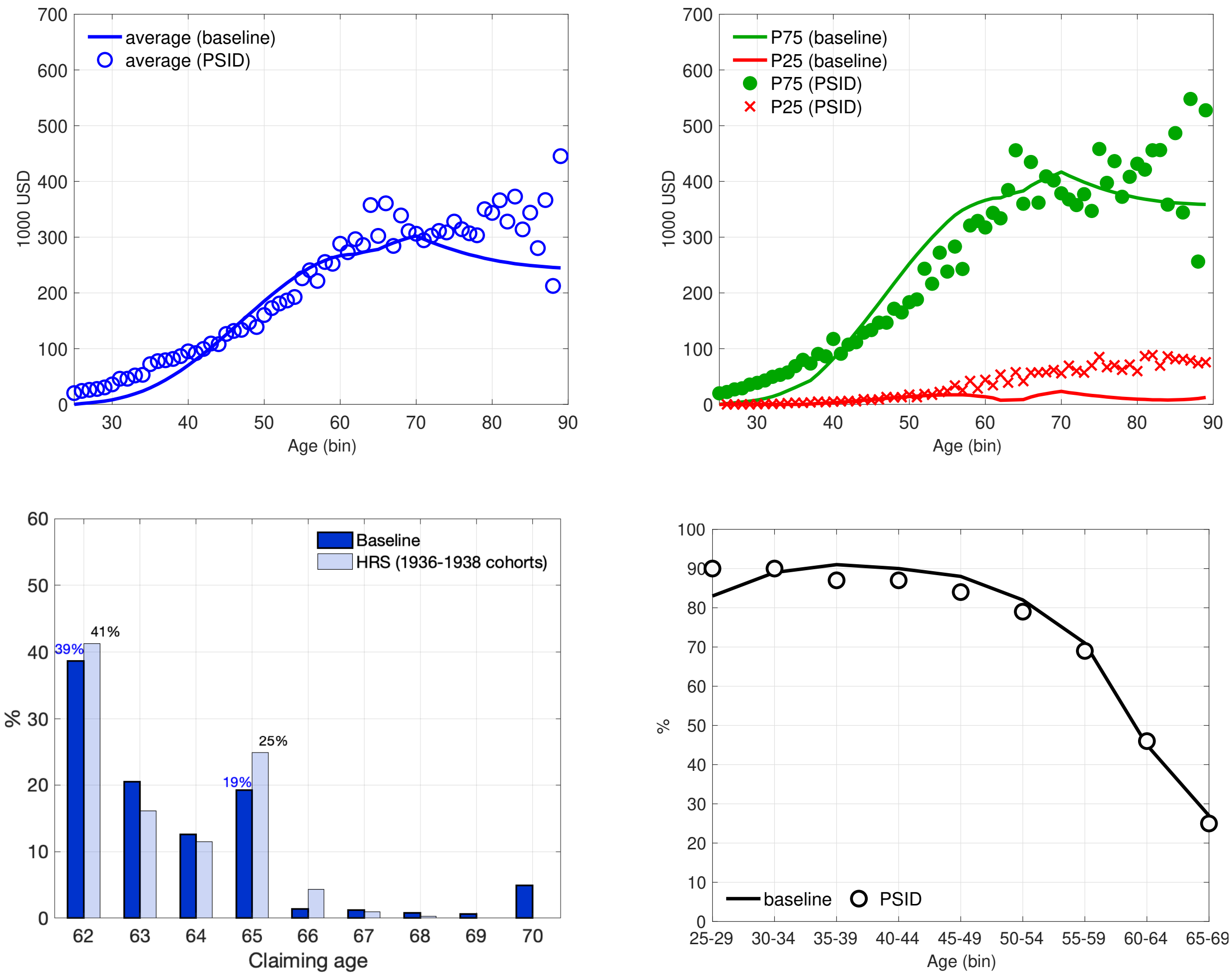


Figure 3: Saving, claiming, and employment decisions, model versus data. Top left panel: average wealth profiles by age. Top right panel: 25th and 75th percentiles of wealth distribution by age. Bottom left panel: distribution of people by claiming age. Bottom right panel: employment by age.

4 Results

This section is organized as follows. We start by illustrating how using data on people's behavior before and after retirement helps us to uncover the key underlying preference parameters. We then provide a decomposition analysis to understand the contribution of different saving motives to asset-holding at each age. Finally, we investigate the role of several institutional features in generating our results.

4.1 Why early-in-life behaviors are important?

One of the challenges in studying saving behavior is how to separate the distinct role of different saving motives, especially savings for bequest versus precautionary reasons. Recently, several studies addressed this identification problem in the context of retirement saving models by combining information on wealth decumulation with moments related to other aspects of post-retirement behavior (e.g., Ameriks et al., 2020; De Nardi et al., 2016; Lockwood, 2018). In this section, we argue that an alternative approach is to exploit information on decisions made before retirement. Specifically, we illustrate that wealth accumulated by age 70, wealth profiles during working years, and claiming behavior are informative about the underlying preference parameters, and hence about the relative importance of saving motives.

To illustrate this, we proceed as follows. We assume that our estimated baseline model represents the true data-generating process (DGP). We then re-estimate the preference parameters but within the context of a retirement saving model. To do this, we construct two partial life-cycle models starting at age 70 and with the initial distribution taken from the baseline model. Both partial life-cycle models have intensity of bequest motive fixed but at different levels. In the first version, we set the MPB at the level 1% lower than the baseline estimate: $MPB = 0.99\,MPB^{BS}$. In the second version, we set the MPB to be 1% higher than the baseline estimate: $MPB = 1.01\,MPB^{BS}$.[6] We refer to these two versions as partial life-cycle models with (i) weak bequest motive, (ii) strong bequest motive, respectively.

We re-estimate the two partial life-cycle models using the same MSM procedure as described in Section 3.2. Specifically, we estimate risk aversion, IES, bequest threshold, and the consumption minimum floor $(\gamma, \psi, \phi, \underline{c})$ targeting the evolution of average, 25^{th}, and 75^{th} percentiles of wealth distribution after age 70 in the baseline model. In both versions, we fix the discount factor at the baseline estimate.

MPB		ψ	γ	β (BS)	Bequest threshold	$\underline{c}$
1% lower	0.9495	8.49	11.74	*0.929*	\$11,009	\$10,232
Baseline	0.9591	6.80	3.41	*0.929*	\$9,994	\$6,501
1% higher	0.9687	1.39	1.19	*0.929*	\$8,345	\$3,472

Table 3: Re-estimated parameters from the two partial life-cycle models targeting baseline wealth evolution after age 70 (β is not re-estimated).

Table 3 reports the re-estimated preference parameters for the two versions of the partial life-cycle model, including estimates of the baseline model as a reference. Figure 4 compares the targeted and simulated wealth profiles for the models with weak (left panel) and strong (right panel) bequest motives. The figure also shows the median wealth profiles, which are not targeted in our estimation procedure.

[6] Since we use the initial distribution at age 70 from the baseline model, if we set the MPB in the partial life-cycle model to the baseline value, MPB^{BS}, the remaining estimated parameters will be the same as the baseline parameters.

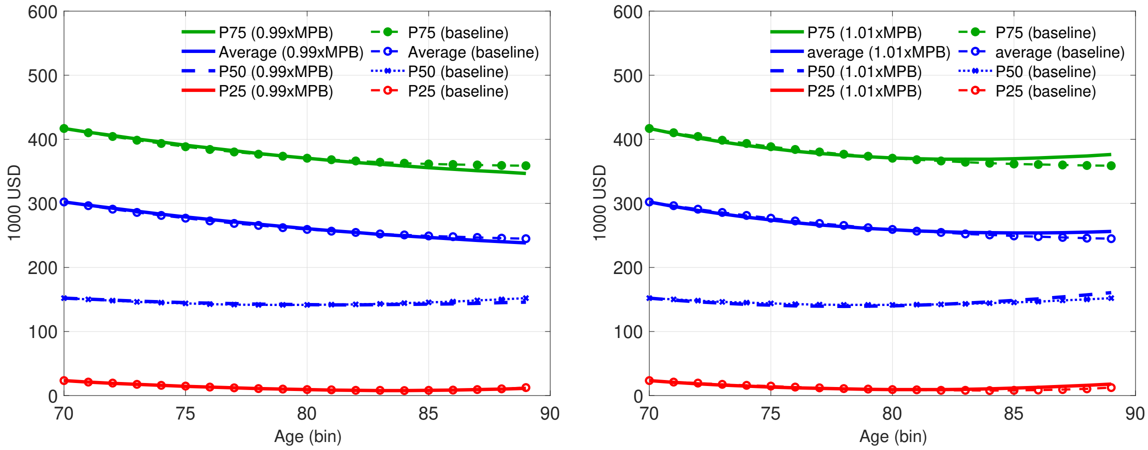


Figure 4: Wealth profiles after retirement from the baseline model and from the re-estimated retirement saving models with fixed MPB. Left panel: model with weak bequest motive (MPB is 1% below the baseline estimate). Right panel: model with strong bequest motive (MPB is 1% above the baseline estimate). Initial distribution at age 70 and β are fixed as in the baseline model.

The key observation from Figure 4 is that the two versions of the model, both with weak and strong bequest motives, capture the targeted wealth profiles after retirement equally well even though the underlying preference parameters are largely different.[7] Table 3 shows that this is achieved by varying the estimates of risk aversion and IES.

In particular, in the model with weak bequest motive, risk aversion is estimated to be 8.49 and the inverse of IES is 11.74. This is because, when the strength of bequest motive is reduced, people save less. To match the targeted wealth profiles, the model now has to feature higher risk aversion to increase saving for precautionary reasons. At the same time, to prevent people from accumulating wealth too fast, IES is lowered, making them less willing to move consumption over time. In the situation with stronger bequest motive, the adjustment of parameters is in the opposite direction. Hence, risk aversion is estimated to be 1.39 and the inverse of the IES is 1.19.

This exercise shows that a model with weak bequest and strong precautionary motives can produce after-retirement wealth evolution which is observationally equivalent to that predicted by a model with strong bequest and weak precautionary motives.[8] This illustrates

[7] There is a small discrepancy in wealth profiles after age 85, especially for the 75^{th} percentile. This is not surprising since we use age-independent parameters to offset the intensity of bequest motive which becomes increasingly important as people age due to the decrease in survival probabilities. The small discrepancy is insufficient to differentiate between the models with weak and strong bequest motives since the targeted wealth profiles of the oldest groups are noisy due to the small number of observations (this can be seen at the top two panels of Figure 3).

[8] Note that in this exercise, we re-estimate models with weak and strong bequest motives while fixing the discount factor as in the baseline model. In Appendix A, we repeat this exercise but instead of fixing the discount factor, we fix the IES and include the discount factor in the set of re-estimated parameters. Our results from this alternative estimation strategy lead to the same conclusions as our results in this section.

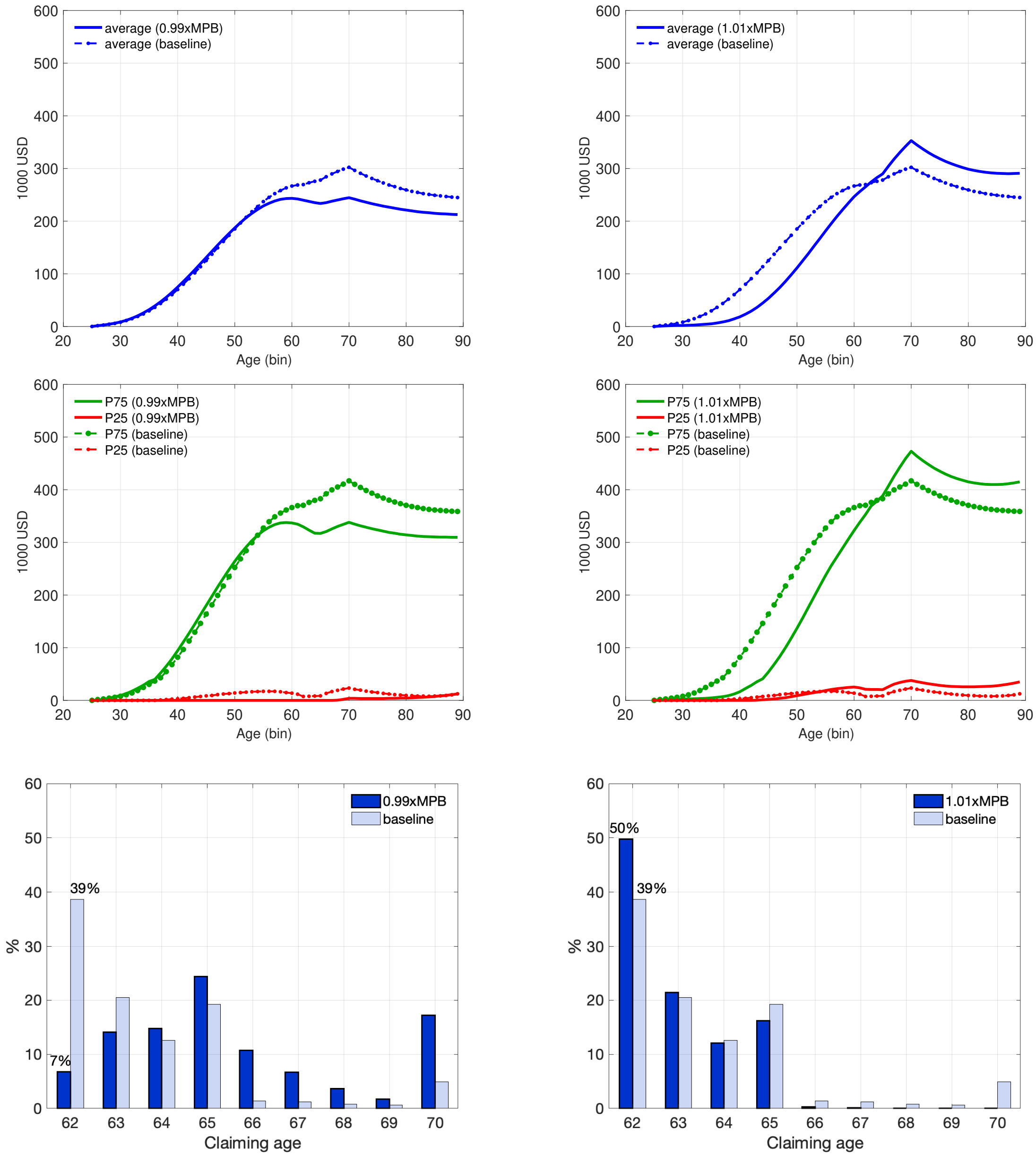


Figure 5: Wealth profiles (top two panels) and the distribution of people by claiming age (bottom panel) predicted by the baseline model and by models parametrized based on the estimates from the retirement saving models with the fixed MPB. Left panel: model with weak bequest motive. Right panel: model with strong bequest motive.

the difficulty of identifying the key preference parameters, namely, bequest intensity, discount factor, risk aversion, and IES from a partial life-cycle model starting at retirement.

We next compare pre-retirement behaviors implied by the two sets of re-estimated parameters from the partial life-cycle models. To do this, we simulate two versions of our full life-cycle model with parameters taken either from the first or third rows of Table 3. In both cases, we set the discount factor and the disutility from work $(\phi^w_{25}, \phi^w_{65})$ at their baseline estimates from Table 2 since these parameters were not re-estimated. Figure 5 displays the results of these simulations, where the left panel corresponds to the model with weak bequest motive, and the right panel - to that with strong bequest motive.

The comparison of the left and right panels of Figures 4 and 5 reveals an interesting observation. While the two partial life-cycle models with different intensity of bequest motives imply almost identical saving behavior after retirement given the same initial wealth distribution (Figure 4), their predictions regarding behaviors earlier in the life-cycle are strikingly different. In particular, three observations are worth noting.

First, in a model with weak (strong) bequest motive, people arrive at retirement with wealth *levels* that are too high (too low). Note that we can account for decumulation of a given amount of wealth in a retirement saving model with weak or strong bequest motive by offsetting it by strong or weak precautionary motive. However, once retirement wealth becomes endogenous in a full life-cycle model, these combinations of motives fail to explain its accumulation.

Second, the two models noticeably differ in the *shape* of wealth profiles. The preference parameters explaining wealth decumulation after retirement when applied to a full life-cycle model fail to account for how people build up their wealth during working life. For example, in the model with strong bequest motive, people save almost nothing early in life due to the combination of weak precautionary motive and strong impatience. Starting from the middle age, they build up wealth at an accelerated rate, which is due to high IES (high tolerance to consumption changes) and desire to amass large wealth to leave for bequests. Since risk profiles in pre- and post-retirement phases are quite different, taking into account the shape of wealth accumulation helps us to distinguish between different model's parameterizations and to uncover the "true" combination of motives that drives savings over the entire life-cycle.

Third, there is a striking difference in the distribution of people by claiming age between the models with weak and strong bequest motives. In the model with weak bequest motive, on average, people claim benefits later compared to the baseline, while in the model with strong bequest motive, much more people claim earlier. For example, the percentage of people claiming at age 62 is 7% and 50% in models with weak and strong bequest motives, respectively (and 39% in the baseline). This is because, as we discuss in Section 3.3, claiming decisions represent an annuitization problem. As bequest motive gets stronger (weaker), people want less (more) annuities and hence claim earlier (later). This result once again highlights that claiming decisions are informative about bequest parameters.

Overall, our results in this section show that looking at saving behavior through the lenses of a partial life-cycle model can misrepresent the composition of underlying saving motives. Taking into account saving decisions both before and after retirement alongside claiming behavior is important to infer the underlying preference parameters.

4.2 Decomposition of saving motives

In this section, we examine the quantitative importance of different saving motives. To do this, we consider a counterfactual exercise when we remove one or more of reasons to save. To take into account the interaction between saving motives, we remove them in varying sequences. Specifically, we first remove bequest motive, then precautionary motive, and compare this to a case where the order is reversed.

The left panel of Figure 6 displays the results of the first sequence of experiments. Removing bequest motive (solid line) results in a substantial reduction in wealth compared to the baseline (dashed line). Not surprisingly, the most dramatic shift is observed at the very end of life: while in the baseline model, on average, people hold a lot of wealth well into their eighties, once bequest motive is removed, people die with almost no assets. Importantly, bequest motive also affects wealth accumulation during working life: due to forward-looking behavior, a non-trivial share of saving among the young is driven by bequest motive.

We next eliminate precautionary motive from the model that already has no bequest motive. To eliminate precautionary motive due to income uncertainty, we remove productivity shocks by replacing z_t^h with its corresponding age-dependent average for each fixed productivity type. Similarly, to eliminate precautionary motive due to uncertain medical expenses, we replace medical and nursing home shocks with their corresponding age-dependent averages for each fixed productivity type.

The resulting average wealth is plotted as a dotted line in the left panel of Figure 6. Precautionary motive against both types of shocks has a large effect on saving behavior: without shocks, people save dramatically less. The resulting saving profile when both bequest and precautionary motives are set to zero represents savings for life-cycle motive.[9] The life-cycle motive plays a minor role in our model: when people face no risk and have no desire to leave inheritances, they hold very little wealth. This is due to two factors: the combination

[9] In our analysis, we consider savings to insure longevity risk as a part of savings for life-cycle motive.

of a relatively high degree of impatience, a moderate IES, and high MPB that we uncover in our estimation; and second, the role of Social Security that replaces labor income after retirement. In Section 4.3.1, we will illustrate the effect of Social Security on life-cycle motive in detail.

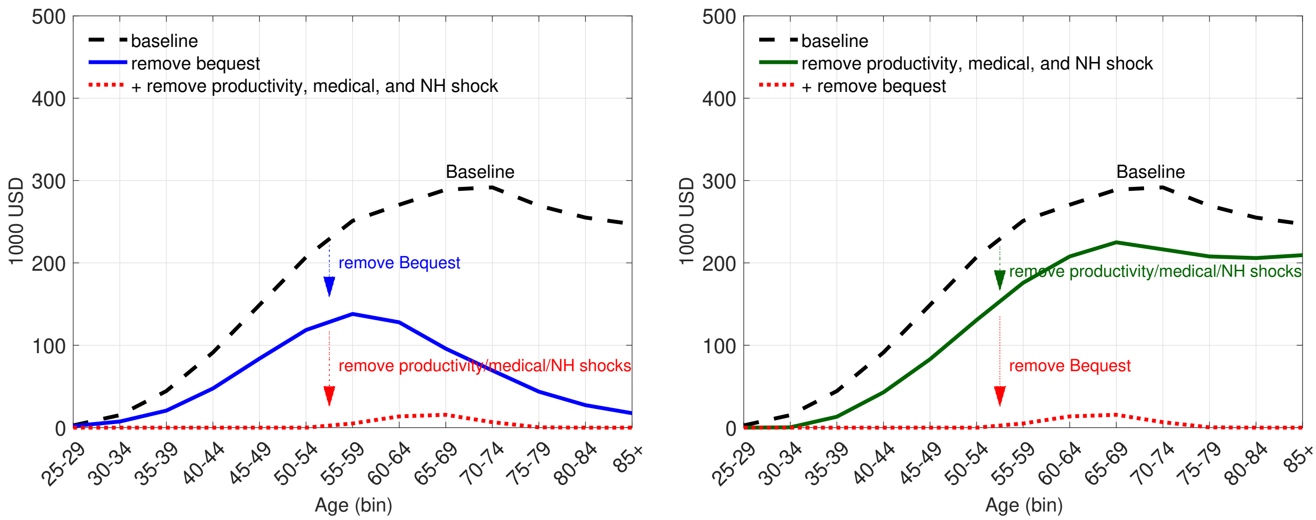


Figure 6: Average wealth profiles after removing saving motives in different order. Left panel: removing bequest motive first. Right panel: removing precautionary motive first.

We next repeat our decomposition exercise by first removing precautionary motive, and then removing bequest motive. The results are displayed in the right panel of Figure 6. The removal of precautionary motive from the model that still features bequest motive lowers savings throughout the entire life-cycle: the resulting wealth profile tracks the baseline profile but at the lower level.

The comparison of the left and right panels of Figure 6 suggests that bequest motive is the key driver of savings in our model. It becomes operational relatively early in life, and is responsible not only for slow decumulation of wealth after retirement, but also for a large part of wealth accumulated during working life.

We complement our graphical analysis above with a formal decomposition exercise by computing the contribution of each saving motive to asset-holding at each age. Because of the interaction between saving motives, the order in which the motives are removed matters. To address this, we remove saving motives in different sequences and then average out the contribution of each saving motive over all the sequences.[10]

To illustrate this, we denote average asset-holding at age t in the baseline economy as $\overline{k}_t$. We denote asset-holding in counterfactual cases as k with the combination of superscripts B, L, and M to denote whether the bequest motive, labor productivity shock, and

[10]This can be thought of as a simplified version of Shapely-Owen decomposition.

medical/nursing home shocks are removed, respectively. For example, k_t^B,k_t^{BL}, and k_t^{BLM} denote average assets when only bequest motive is removed, both bequest motive and labor productivity shock are removed, and all three components are removed, respectively.

There are six possible sequences in which bequest, labor productivity shock, and medical/nursing home shocks can be removed. With this notation, the contribution of each motive to asset-holding of age-t agents is computed as follows:

$$contr^B = \frac{1}{6}\left(2\times\frac{\bar{k}_t - k_t^B}{\bar{k}_t} + \frac{k_t^L - k^{BL}}{\bar{k}_t} + \frac{k_t^M - k_t^{BM}}{\bar{k}_t} + 2\times\frac{k_t^{LM} - k_t^{BLM}}{\bar{k}_t}\right)\times 100\%,$$

$$contr^L = \frac{1}{6}\left(2\times\frac{\bar{k}_t - k_t^L}{\bar{k}_t} + \frac{k_t^B - k^{BL}}{\bar{k}_t} + \frac{k_t^M - k_t^{LM}}{\bar{k}_t} + 2\times\frac{k_t^{BM} - k_t^{BLM}}{\bar{k}_t}\right)\times 100\%,$$

$$contr^M = \frac{1}{6}\left(2\times\frac{\bar{k}_t - k_t^M}{\bar{k}_t} + \frac{k_t^B - k^{BM}}{\bar{k}_t} + \frac{k_t^L - k_t^{LM}}{\bar{k}_t} + 2\times\frac{k_t^{BL} - k_t^{BLM}}{\bar{k}_t}\right)\times 100\%.$$

The contribution of life-cycle motive is calculated on a residual basis by subtracting $contr^B$, $contr^L$, and $contr^M$ from 100%.

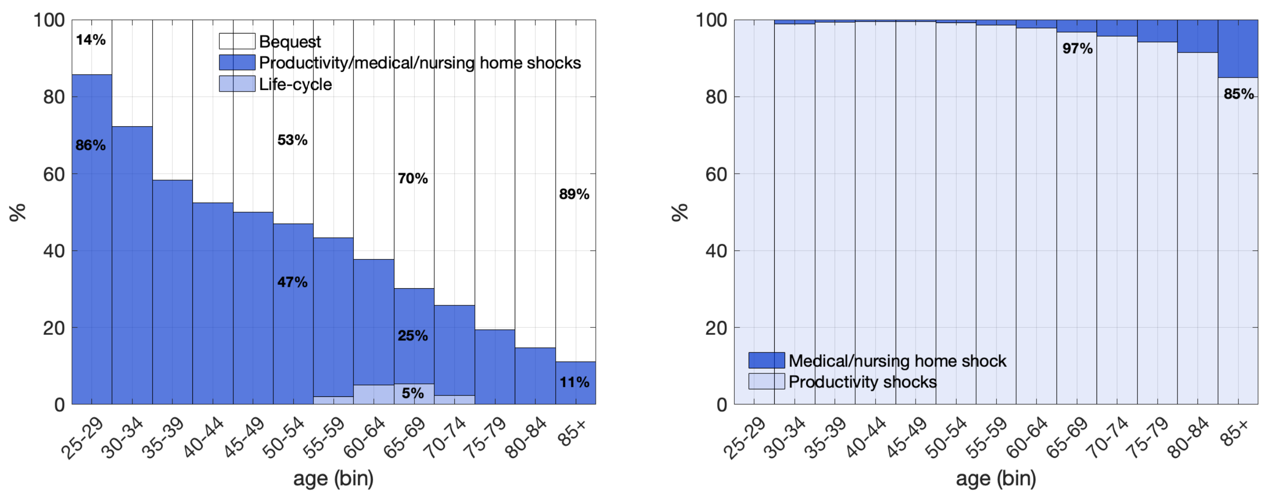


Figure 7: Left panel: Contribution of each saving motive to average asset-holding at each age. Right panel: Contribution of productivity shocks and medical/nursing home shocks to precautionary savings.

The left panel of Figure 7 plots the contribution of bequest motive (white bars), precautionary motive against both labor productivity and medical/nursing home shocks (dark-shaded bars), and life-cycle motive (light-shaded bars) for each age. Not surprisingly, the contribution of different motives varies dramatically by age. For the youngest group, aged between 25 and 29, 86% of savings are due to precautionary motive. It is worth noting that this group does not save for life-cycle motive, which is due to the no-borrowing constraint. If borrowing were allowed, this group will have negative life-cycle saving by borrowing against their future higher income.

	Contribution toward retirement wealth
Baseline model	
- life-cycle motive	5%
- bequest motive	70%
- productivity shock	24%
- medical/NH expense shock	1%
Baseline model without Social Security	
- life-cycle motive	44.8%
- bequest motive	34.4%
- productivity shock	20.4%
- medical/NH expense shock	0.4%
Baseline model without health insurance	
- life-cycle motive	5%
- bequest motive	63%
- productivity shock	24%
- medical/NH expense shock	8%
Baseline model with $\underline{c}$ =$100	
- life-cycle motive	5%
- bequest motive	66%
- productivity shock	25%
- medical/NH expense shock	4%
Baseline model without health insurance and $\underline{c}$ =$100	
- life-cycle motive	3%
- bequest motive	26%
- productivity shock	19%
- medical/NH expense shock	52%

Table 4: Decomposition of wealth accumulated by the start of retirement (65-69 age group)

The contribution of precautionary motive steadily declines with age: for 65-69 age group, precautionary motive contributes only 25% to average asset-holding, and for those above the age of 85, its role is only 11%. The declining role of precautionary motive is accompanied by the increased importance of bequest motive, which becomes a dominant force to save after the age of 50.

We next ask how different sources of risk, namely, labor productivity and medical expense risks, contribute to precautionary savings. The right panel of Figure 7 shows that the primary driver of precautionary savings is labor productivity shocks. Medical spending risk plays a minor role except at the very end of life. This result is consistent with Kopecky and Koreshkova (2014) who find that medical expense uncertainty contributes around 3% to aggregate saving.

Our results in this section are summarized in the first panel of Table 4. The table reports the contribution of each saving motive to pre-retirement wealth, i.e., wealth held by people aged 65-69. For this group, 70% of accumulated wealth is due to bequest motive, and 24% is due to precautionary motive against productivity shocks. The contribution of precautionary motive against medical shocks and life-cycle motive are very small, constituting 1% and 5%, respectively. In the next section, we explore the reasons for these small effects.

4.3 The role of the institutional environment

In this section, we evaluate how existing institutions influence our assessment of the importance of different saving motives. Specifically, we study the role of Social Security, state-contingent savings, and the means-tested transfer that guarantee each agent the minimum consumption level.

4.3.1 Social Security and life-cycle saving motive

One interesting result from the previous section is a small contribution of life-cycle motive to wealth accumulation. The primary role of savings for life-cycle motive is to replace earned income after retirement. Therefore, income replacement provided by Social Security can suppress the intensity of this motive.

To assess the magnitude of this crowding-out effect, we repeat our decomposition exercise but in the environment where Social Security is eliminated: people do not pay payroll taxes during their working life, and they do not receive pension benefits after they retire. The left panel of Figure 8 displays average wealth profiles in the economy without Social Security (solid line). Not surprisingly, people save much more over their working life compared to the baseline (dashed line with circles).

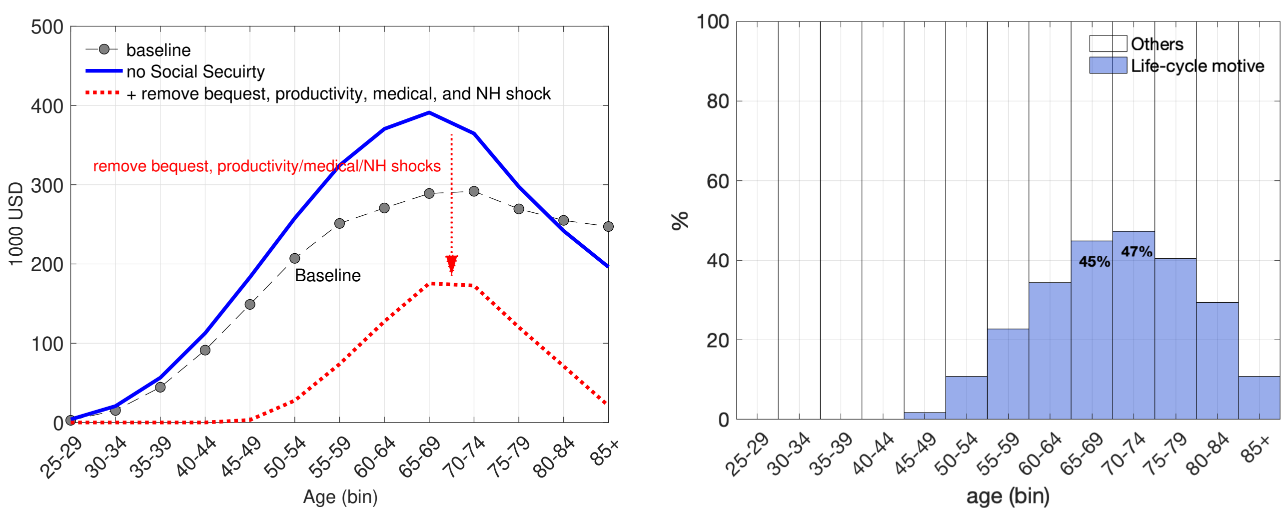


Figure 8: Left panel: Average wealth profiles when Social Security is removed. Right panel: Contribution of life-cycle saving motive to average asset-holding at each age in the economy without Social Security.

We then consider the case when people save only for life-cycle motive by eliminating both precautionary and bequest motives. The results are shown with the dotted line. In sharp contrast to Figure 6, now people accumulate substantially more wealth for life-cycle motive. The life-cycle savings starts at around age 45, reach the peak at the beginning of retirement, age 65-74, and steadily decline after that, in line with the theoretical predictions of Modigliani and Brumberg (1954).

The right panel of Figure 8 displays the contribution of life-cycle motive to savings at each age when Social Security is removed (see also the second panel of Table 4). At its peak, life-cycle motive contributes 47% to average wealth, which represents nine-fold increase compared to the baseline case. This result highlights that the crowding-out effect of Social Security on savings for life-cycle motive is very large.

4.3.2 State-contingent savings and the means-tested transfers

Another interesting result from our decomposition exercise in Section 4.2 is the small contribution of medical expense uncertainty to wealth accumulation. In this section, we examine to what extent this result is due to the institutional environment. We start by noting that two factors influence the size of precautionary savings in response to a particular risk: the availability of state-contingent savings and the utility level in the worst-case outcome.

State-contingent assets, if available, absorb part of precautionary savings. To illustrate this, we use a simple example. Consider an individual who lives for two periods; in the second period with probability π he experiences a shock to his budget constraint equal to x. Suppose an individual wants to insure a fraction μ of this shock. Assuming zero interest rate ($r = 0$) this requires savings in the amount μx. This represents precautionary savings in regular assets.

Assume next that an actuarially fair insurance is available against this shock x. To insure the shock to the same extent, an individual needs to buy an insurance that covers a fraction μ of the shock. Given the assumption of actuarial fairness and zero interest rate, the cost of this insurance is $\pi\mu x$. This represents precautionary savings in state-contingent assets, while there are no precautionary savings in regular assets.

This example illustrates that the size of precautionary savings, commonly measured as the amount of wealth accumulated to insure a particular risk, crucially depends on the availability of state-contingent assets that provides insurance against this risk.

We next turn to the utility level in the worst-case outcome. In our model, this utility level corresponds to the minimum consumption floor. People relying on the means-tested transfers are typically those with the highest realized medical shocks, thus the consumption minimum floor can be thought of as the last-resort insurance against catastrophic medical shocks.

To understand the role of state-contingent savings and the means-tested transfers for precautionary savings against medical expense risk, we consider several counterfactual exercises.

In our first counterfactual exercise, we construct the environment without state-contingent savings, i.e., without health insurance. To do this, we substitute out-of-pocket medical shocks x_t^h with total medical shocks X_t^h estimated from the MEPS dataset. We compensate each individual for the absence of health insurance by an age- and fixed productivity type-dependent lump-sum transfer $comp_t(\xi)$ representing the difference between average total and average out-of-pocket medical spending for people at age t and of fixed productivity type ξ, $comp_t(\xi) = \overline{X}_t^h(\xi) - \overline{x}_t^h(\xi)$. We then repeat our decomposition exercise by evaluating the contribution of different saving motives to asset-holding at each age in this counterfactual setup.

The results are displayed at the top left panel of Figure 9 and the third panel of Table 4. Compared to the baseline, two differences are worth noting. First, the contribution of medical risk is now larger: overall, it is responsible for 8% of total pre-retirement savings compared to 1% in the baseline economy. Second, it plays an important role at every age and not just at the very end of life.

In our second counterfactual exercise, we reduce the generosity of the means-tested transfers, thus making the worst-case outcome more punishing in terms of consumption level. Specifically, we decrease the consumption minimum floor to \$100 (compared to \$6,501 in the baseline economy). Our new decomposition results regarding the role of different saving motives are displayed in the right top panel of Figure 9 and the fourth panel of Table 4.

Reducing the generosity of the consumption minimum floor results in the increase in the contribution of medical spending risk to total savings, which is smaller in magnitude compared to that observed in the previous exercise (no state-contingent assets): medical shocks now account for 4% of pre-retirement wealth. The effects are also unequal by age with the youngest and the oldest groups seeing the largest increase in precautionary savings due to medical shocks.

In our last counterfactual scenario, we simultaneously remove state-contingent assets and reduce the minimum consumption guarantee to \$100. The results are shown in the bottom panel of Figure 9 and the fifth panel of Table 4.

In this case, the role of medical spending risk in savings increases dramatically. Now this risk is the key driver of savings, especially for the youngest and the oldest group. This is because the former group starts their model life with no assets and needs to quickly build up wealth to buffer themselves against large medical expense shocks, and the latter group faces additional risk of entering a nursing home.

The last row of Table 4 shows that in sharp contrast to the baseline case, removing uncertainty in total medical spending reduces average pre-retirement wealth by more than 50%. This reveals an important interaction between the means-tested transfers and state-

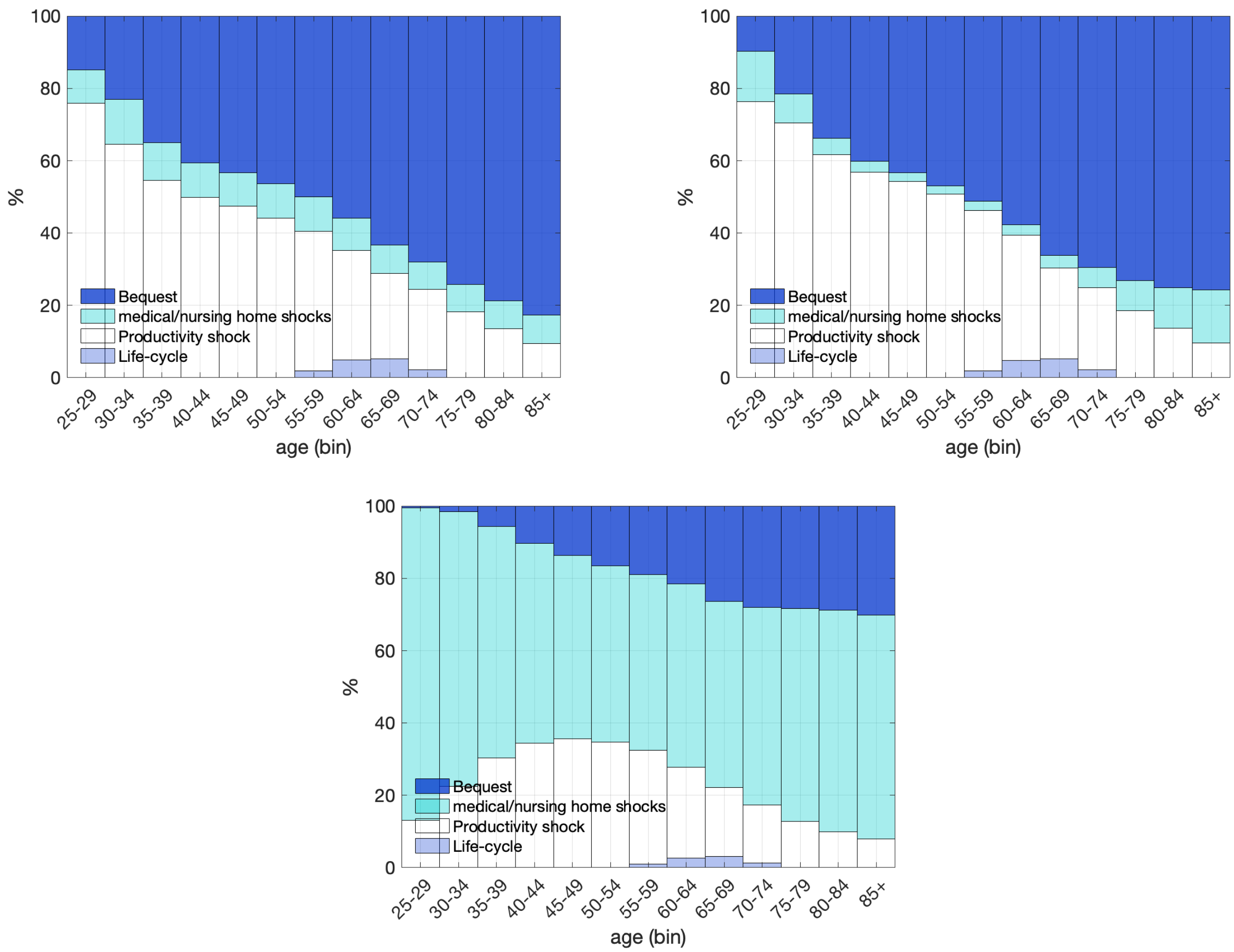


Figure 9: Contribution of different saving motives in several counterfactual economies. Top left panel: no health insurance. Top right panel: the minimum consumption guarantee is set to \$100. Bottom panel: no health insurance and the minimum consumption guarantee is set to \$100.

contingent assets. When health insurance is removed, many people can still rely on the consumption minimum floor as an alternative way to protect themselves against high medical shocks. When both insurance options are eliminated, they have to self-insure through regular savings, which dramatically changes the contribution of medical expense risk to wealth accumulation. Overall, this shows that the small contribution of medical shocks to savings in the baseline economy is not because this risk is unimportant but due to the available insurance options.

5 Conclusion

In this paper, we evaluate the quantitative importance of the three major reasons to save: life-cycle, precautionary and bequest motives. We do so in the unified framework that allows for flexible preferences, accounts for many features of the data, and addresses the challenge of disentangling the effects of different motives on one's decisions.

We estimate our model using several micro datasets and use it to deliver several interesting results. We start by illustrating that combining information on people's behavior both before and after retirement is important when estimating the key preference parameters. In particular, we show that partial life-cycle models with varying strength of bequest and precautionary motives can equally well account for decumulation of a given amount of (fixed) retirement wealth. Accounting for the accumulation of this wealth helps to distinguish between these alternative models. Another aspect of pre-retirement behavior that is very informative about the strength of bequest motive are decisions when to claim Social Security benefits. This is because these decisions are equivalent to an annuitization problem, and bequest motive has an opposite effect on the decisions to save and to annuitize.

We then use our model to decompose the contribution of the three key motives to save to asset-holding at each age. We show that, overall, bequest motive is the most important saving motive contributing more than 50% to total wealth accumulation after the age of 50. In contrast, the contribution of life-cycle motive and precautionary motive against medical shocks are very small.

Our investigation of the latter results reveals that much of it is due to the existing institutions. In particular, we consider the role of Social Security, health insurance and the means-tested transfers. In the counterfactual economy without Social Security, life-cycle motive to save contributes 47% to retirement wealth. Similarly, removing health insurance and reducing the generosity of the means-tested transfers will make medical expense risk the key driver of savings contributing more than 50% to retirement wealth.

Understanding the relative importance of different saving motives is the key pre-requisite for analyzing many policies such as Social Security reforms or changes in the setup of health-saving accounts. Our results also highlight that there is a close interaction between saving motives and the existing institutions. In particular, while we find that precautionary savings against medical shocks are small, this is not because this risk is unimportant, but because people have access to other insurance mechanisms.

It is worth mentioning that in our framework, we abstract from several factors that can also affect savings, for example, housing wealth, educational expenses, or saving to support one's family members. We consider incorporating these factors and understanding their quantitative importance as a very important avenue for future research.

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Appendix

A Estimation of the partial life-cycle model with fixed IES

In this section, we repeat the same exercise as in Section 4.1 in the main text but with the following modification: instead of fixing the discount factor we fix IES. That is to say, when we re-estimate the partial life-cycle models with weak and strong bequest motives, we include β in our set of parameters to be estimated, but fix the IES at the level estimated in the baseline model. As in Section 4.1, we use wealth profiles after age 70 generated by our baseline model as the targeted moments.

The fit of the partial life-cycle models to the targeted moments is displayed in Figure 10, and the estimated parameter values are shown in Table 5. The implications of the re-estimated parameters regarding the behaviors over the entire life-cycle are displayed in Figure 11. Overall, our strategy of fixing IES results in the same conclusions as the strategy of fixing the discount factor: we can well account for wealth decumulation after retirement with different combinations of saving motives. However, the re-estimated models differ in their predictions regarding pre-retirement behaviors.

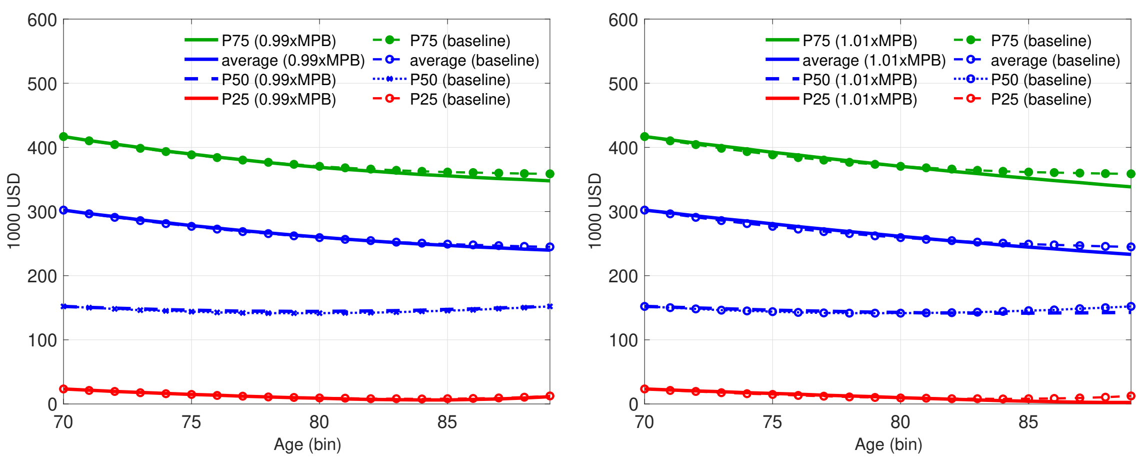

Figure 10: Wealth profiles after retirement from the baseline model and from the re-estimated retirement saving models with fixed MPB. Left panel: model with weak bequest motive (MPB is 1% below the baseline estimate). Right panel: model with strong bequest motive (MPB is 1% above the baseline estimate). Initial distribution at age 70 and the inverse of IES (γ) are fixed as in the baseline model.

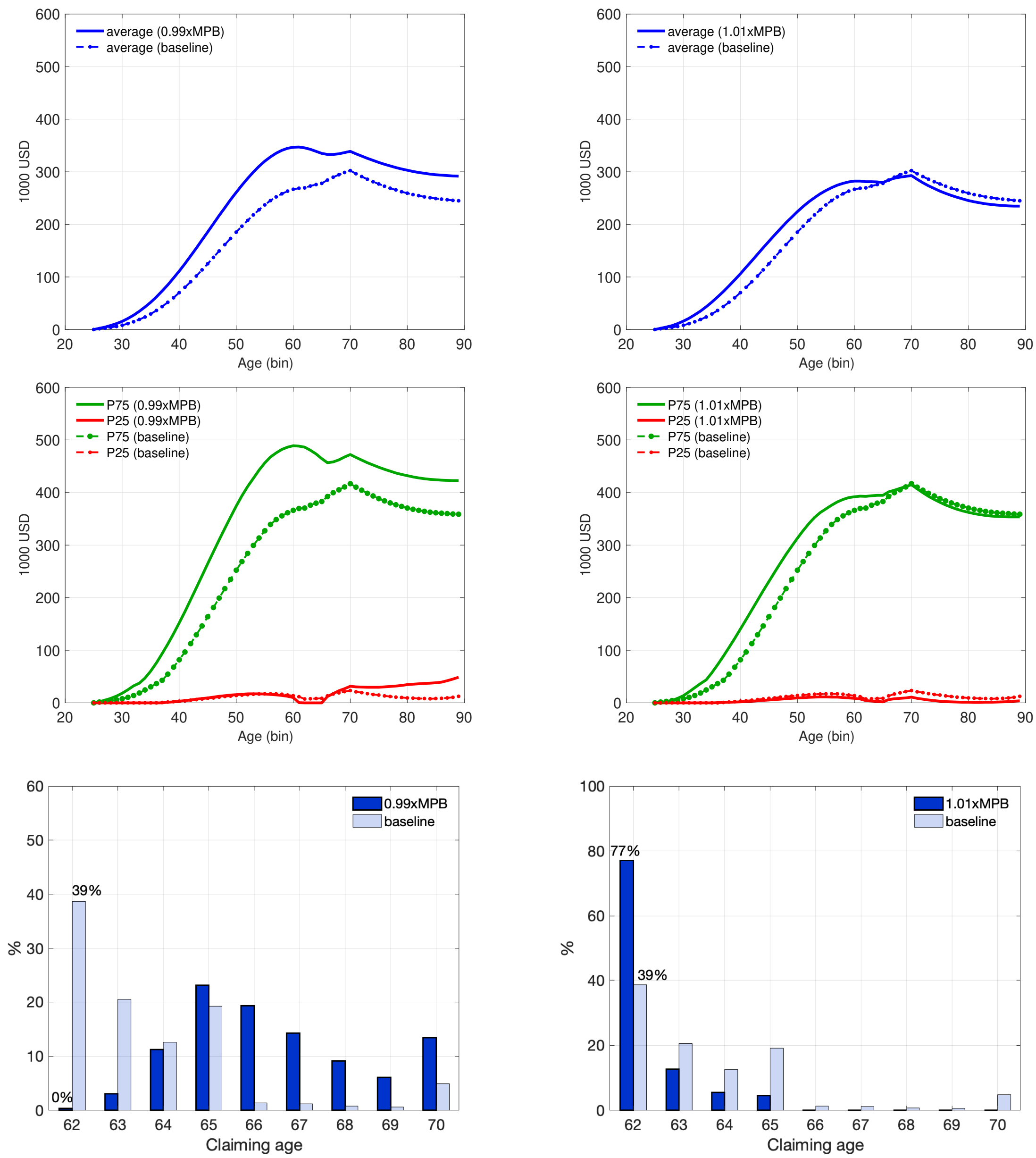

Figure 11: Wealth profiles (top two panels) and the distribution of people by claiming age (bottom panel) predicted by the baseline model and by models parametrized based on the estimates from the retirement saving models with the fixed MPB. Left panel: model with weak bequest motive. Right panel: model with strong bequest motive.

MPB		ψ	γ (BS)	β	Bequest threshold	$\underline{c}$
1% lower	0.9495	12.72	*3.41*	0.957	\$9,881	\$8,092
Baseline	0.9591	6.80	*3.41*	0.929	\$9,994	\$6,501
1% higher	0.9687	8.29	*3.41*	0.769	\$8,457	\$3,936

Table 5: Re-estimated parameters from the two partial life-cycle models targeting baseline wealth evolution after age 70 (IES is not re-estimated)