Home Equity Withdrawal in Retirement*

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Abstract

We study empirically and theoretically the patterns of home equity withdrawal among retirees, using a model where retired households are able to own or rent a home, save in a financial asset, and borrow against a housing asset, in the face of idiosyncratic risks regarding mortality, health, medical expenditures, and household size. Using the estimated model, we conduct various counterfactual experiments. There are three main findings. First, the model predicts that a future decline in house prices would reduce home equity borrowing, but increase homeownership rate, as fewer retirees choose to sell their house if house prices are lower. Second, the model implies that costs of increasing home equity borrowing are restricting the borrowing of retirees, and thus future reduction of such costs (for example, lower costs of reverse mortgage loans) might significantly raise home equity borrowing. Third, the model implies that extra utility from owning housing together with costs of home equity borrowing could explain part of the retirement saving puzzle.

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1 Introduction

The majority of the working population in the U.S. retires with a house as a major part of their portfolio, and continue well into their old age as home owners. For many retirees, the house is not only a place to live, but also a source of continued borrowing activity throughout retirement. This has always been the case to some extent, but in recent years, the role of housing as a financial asset has been highlighted as housing values first increased, then dropped dramatically, and at the same time, as it became increasingly easier to borrow against one's home using home equity lines of credit and reverse mortgage loans. While our knowledge of saving behavior among retirees is growing on many dimensions, we do not have a good sense yet of how retirees decide whether or not to be a home owner in their old age and why, and how the home may be used as a source of insurance against uncertainty for retirees. In addition, in light of recent events, we think it particularly important to understand the effect that booms and busts in the housing market may have on retiree behavior, and we evaluate the impact on retirees of a possible continued decline in housing prices going forward, from the perspective of home ownership rates and the amount of borrowing in home equity.

In this paper, we build a model of saving and borrowing in retirement using both financial assets and a house, to answer the following questions. (1) What role do housing assets play in the retirees' portfolio decisions, and accordingly, how do retirees decide whether or not to be a home owner? (2) How is the picture of saving or dissaving in old age affected by considering home ownership explicitly? (3) What are the effects of recent housing price boom and bust on the behavior of retirees? (4) How does the liberalization of mortgage markets - i.e. the increased ease with which one can withdraw home equity - affect home ownership and borrowing decisions?

The model has the following key components. Retirees can choose whether to own a home or rent, and home owners have the choice of selling their home and cashing in on the equity. They consume, and can save in a financial asset, as well as borrow against their housing asset. They have income from social security, and face uncertainty in their health status as well as, accordingly, their medical expenses, their life span (as well as that of their spouse), and the price of their house.

We use the Health and Retirement Study (HRS) to document in detail various facts about retirees' financial and housing asset holdings, their indebtedness, their income, as well as their health status, survival probabilities, and out-of-pocket medical expenditures. Because HRS is a longitudinal survey, we are able to track households over time, which gives us careful measures of various transition probabilities between states, as well as evolution of asset holdings over time. We track several cohorts over time and construct life-cycle profiles of relevant variables. We use this information to estimate the model's parameters and assess its performance along a set of relevant dimensions. While we have not completed the second formal stage of estimation, even this relatively simple model is able to replicate fairly well a set of lifecycle facts for retirees, including home ownership rates, financial and housing asset holding, and proportion of the population in debt. The model comes close, but not for all cohorts, in terms of the total amount of debt held by those who choose to borrow.

We then use the estimated model to conduct a series of experiments regarding the effect of house price dynamics on home ownership decisions and borrowing decisions. We find, by studying different paths for house prices, that a housing price boom of the magnitude seen in the last decade depresses homeownership rates, as rising home values encourage retirees to sell their homes and cash in on the equity. At the same time, holding on to the house allows households to borrow, and we find that rising home prices will encourage borrowing, and conditional on borrowing, retirees will borrow more. The second set of experiments we conduct concerns developments in housing markets that make it easier to borrow against one's home equity; this is meant to capture the advent of home equity lines of credit and reverse mortgages. These kinds of developments tend to elevate the home ownership rate and encourage borrowing against one's home. We also combine housing price dynamics and housing market developments to study the interaction of the two sets of effects. In the data, during the housing boom and bust, we saw home ownership rise; our model predicts that this is the result of the financial market development effect dominating the price increase effect. Using our experiments, we contribute to the resolution of the retirement saving puzzle: owning a house comes with extra utility and an ability to borrow against home equity; both of these motives appear important in our estimated model.

Our main contributions are three. First, our careful documentation of the longitudinal data provides a set of facts regarding equity borrowing behavior in more detail than previously described. Second, our model enables us to describe the tradeoff between using housing and non-housing assets in retirement, and conduct experiments pertinent to recent developments in the housing markets. To our knowledge, we are the first to do this in a estimated model of life-cycle behavior in retirement. Third, our model may contribute a resolution to the retirement saving puzzle.

The remainder of the paper is organized as follows. Section 2 discusses related literature. Section 3 develops the model that we use. Section 4 describes the estimation strategy. Section 5 discusses the data that we use for estimation. Section 6 presents the results of the estimation procedure. Section 7 describes the experiments that we conduct using our estimated model. Section 8 concludes.

2 Related Literature

Our paper is related to a number of papers which study saving decisions and motives in retirement, and those which analyze savings decision with a focus on the role of housing.

An important question regarding the interaction between saving decisions and housing is the wealth effect of house price changes on non-housing consumption. Papers by Campbell and Cocco (2007) and Li and Yao (2007) investigate the issue. Campbell and Cocco (2007) use UK micro data to quantify the wealth effect, and find that the effect is large for older homeowners and insignificant for young renters. Li and Yao (2007) use a calibrated life-cycle model and find that, although the aggregate wealth effect is limited, there is a large degree of heterogeneity: the response of non-housing consumption is stronger for younger and older homeowners than middle-aged homeowners, and the welfare effect is strongest for older homeowners who most likely will not buy a new house.

Since the housing market boom and bust is considered to play an important role in shaping the recent business cycles, especially the recent recession, there is an increasing body of work incorporating housing explicitly into a macroeconomic framework. Fernández-Villaverde and Krueger (forthcoming) and Yang (2009) use the general equilibrium life-cycle model to study the life-cycle profile of housing and non-housing consumption, with the focus on the difference between housing and non-housing consumption. Other related studies of housing using structural models include Davis and Heathcote (2005), who study a business cycle model of housing, and **?**, who investigate the implications of explicitly considering housing in explaining the observed large wealth inequality in the U.S. Ortalo-Magné and Rady (2006) study the impact of income shocks and credit constraint for business cycle dynamics of the housing market. Our paper complements these studies by focusing on the saving and housing decisions of retirees.

Our paper is also related to the studies of mortgage choices, and aggregate implications of mortgage market developments. Chambers et al. (2009a) examine various elements which contribute to the rise in homeownership rates in the U.S. and find that introduction of new mortgage instruments which allow lower downpayment at the time of purchase has a sizable effect on the homeownership rate. They use a life-cycle model capturing rich features of mortgage markets. Chambers et al. (2009b) construct a general equilibrium model with a focus on the optimal choice between conventional fixed-rate mortgages and newer mortgages with alternative repayment schedules, and study macroeconomic implications of having different types of mortgages available for households. Campbell and Cocco (2003) investigate the optimal choice for home buyers between conventional fixed-rate mortgages (FRM) and more recent adjustable-rate mortgages (ARM). Our model is agnostic about specific mortgage options, but complements the literature by focusing on home equity borrowing by retirees both empirically and theoretically.

A big question in the savings literature is why the elderly do not dissave much in the data, while a simple life-cycle model predicts that the elderly should keep reducing savings so that, when death is certain, they leave no saving. There are various answers proposed to solve the "retirement saving puzzle." Hubbard et al. (1995) argue that means-tested social insurance programs provide a virtual consumption floor and thus strong incentives for low income individuals not to save. Hurd (1989) estimates the life-cycle model with mortality risk and bequest motives, and find that the intended bequests is small.

Among the literature of elderly savings, the recent paper by De Nardi et al. (2010) is most closely related to ours. They estimate a life-cycle model of retirees using the subsample of the Health and Retirement Study focusing on the oldest old, which include mortality risk, bequest motives, and out-of-pocket (OOP) medical expenditure shocks, and find that a large OOP medical expenditure shocks is the main driving force for savings of retirees. We use the HRS as well. The key difference between our work and theirs is the focus on housing and home equity borrowing; while they aggregate all the assets in the household portfolio, including housing, and study the profile of the consolidated asset position in retirement, we explicitly model housing choice and specifically focus on the decisions of whether to own a home and whether and when to borrow against one's home equity. To the best of our knowledge, since there is no study which uses structural model with housing to tackle the retirement saving puzzle, our paper contributes to the literature from a new perspective.

As in De Nardi et al. (2010), in our model, one of the major sources of risks in retirees is the health condition and medical expenditures. Regarding the implications of the health and medical expenditure risks on the decision of retirees, Yogo (2009) studies the portfolio choice decision among retirees.

A natural future direction of our project is to study the implications of retiree's decision regarding saving and housing on social security program and its reform. The influential work using a general equilibrium life-cycle model to analyze social security reform is Auerbach and Kotlikoff (1987). Chen (2010) analyzes the reform of eliminating the social security program in a life-cycle model with housing.

3 Model

We focus on retired households, which allows us to abstract from labor supply decision and retirement decision. Each period, a retired household chooses consumption and saving or borrowing, and makes decision regarding housing. For a homeowner, the choice is whether to move out of the house or to stay in the same house. For a renter, the choice is the size of the rental property in which the household lives in the current period. We abstract from the decision of a homeowner moving to a different, most likely a smaller, house or a renter buying a house. This abstraction is not a serious problem, since in the data, the proportion of households making such moves is small. A household is subject to four types of shocks: (i) health status (including mortality), (ii) out-of-pocket medical expenditure, (iii) household size, and (iv) house price. For the household size shock, we focus on the transition from a two-adult household to a one-adult household, caused by death of a spouse. Since in the data, income is stable over time conditional on household size, in the model income to be constant, conditional on household size.

3.1 Preferences

A household is born as a retiree in age 1. The household potentially lives up to age-I, but dies stochastically; this is discussed more below, together with the health status transition process. The household maximizes its life-time utility. The utility function is time-separable with discount factor β. The period utility function has the following form:

$$u(c,h,s,o) = s\frac{\left(\frac{1}{\mu_s}c^{\eta}(\omega_o h)^{1-\eta}\right)^{1-\sigma}}{1-\sigma} \tag{1}$$

where c is non-housing consumption, h is the size of the house that the household lives in, $s \in \{1,2\}$ is the number of adults in the household, and $o \in \{0,1\}$ is the tenure status. $o = 0$ and $o = 1$ means renting and owning, respectively. Housing and non-housing consumption is aggregated by a Cobb-Douglas aggregator, which is a special case of a more general CES (constant elasticity of substitution) aggregator with the unit elasticity. η determines the relative importance of the two consumption goods. The period utility function is a standard CRRA (constant relative risk aversion) type with the risk aversion parameter σ. μ_s is the effective household size or the household equivalence scale, which captures the externality within a household.[1] In particular, if $\mu_1 = 1$ and $\mu_2 \in (1,2)$, the *household-size multiplier* for a one-adult household is $\frac{1}{\mu_1^{1-\sigma}} = 1$, while

[1]For more detailed discussion on the household equivalence scale, see Fernández-Villaverde and Krueger (2007). Li and Yao (2007) assume a similar assumption with respect to the effect on the household size on utility.

the multiplier for a two-adult household is $\frac{2}{\mu_2^{1-\sigma}} > 1$ for $\sigma > 0$. In other words, the assumption captures the benefits of having multiple adults instead of one adult in the household. ω_o captures the extra utility from owning a house rather than renting, such as the ability to modify the house to the individual taste, the ability to invest in the neighborhood, etc. Additionally, the extra utility of home ownership captures financial benefits of ownership, such as tax exemption of imputed rents of owner-occupied properties and mortgage interest payment deduction, implicitly. Naturally, ω_0 (for renters) is normalized to one, and $\omega_1 > 1$.

As in De Nardi et al. (2010), a household gains utility from leaving bequests.[2] When a household dies with the consolidated wealth of c, the household's utility function takes the form

$$v(c) = \gamma \frac{(c+\zeta)^{1-\sigma}}{1-\sigma}. \tag{2}$$

Here, γ captures the strength of the bequest motive, and ζ captures the marginal utility of bequests.

3.2 Non-Financial Income

Since the main source of non-financial income for retirees are the social security benefits and other pension benefits, and they are typically fixed at the time of the retirement and do not change during the retirement period, we assume that non-financial income is $\psi_s b$, where $b \in B = \{b_1, b_2, b_3, ..., b_B\}$ and ψ_s adjusts the non-financial income according to the number of adults in the household. Naturally, $\psi_1 = 1$. Notice b is different across households, but b for each household does not change over time.

3.3 Health Status and Mortality Shock

$m \in \{0, 1, 2, ..., M\}$ represents the health status of a household. $m = 0$ indicates that the household is dead. A strictly positive m indicates that the agent is alive, and in one of several health states that can vary over time. $m = 0$ is an absorbing state, i.e., $m_j = 0$ for $\forall j \geq i$ if $m_i = 0$. We assume that m follows a first order Markov process. $\pi^m_{i,m,m'}$ is the transition probability from a health state m to m', for an agent of age i. Because of the way we include the death state in the health status, the transition probability $\pi^m_{i,m,m'}$ also includes the survival probability of agents. In particular, the survival probability for an agent of age i and current health status m can be represented as $\sum_{m' \neq 0} \pi^m_{i,m,m'}$.

3.4 Medical Expenditure

Health status introduced in the section above affects two things: (i) survival probability is lower for a household with a worse health status, and (ii) out-of-pocket medical expenses are on average higher for a household with a worse health status. Both are supported by our data (details will be provided in Section 6.1). A household is hit by out-of-pocket medical expenditure shocks $x \in \{x_0 = 0, x_1, x_2, ..., x_X\}$. The probability that a x is drawn is denoted by $\pi^x_{i,m,x}$, where i is

[2] De Nardi (2004) finds that the bequest motive is important in capturing the observed wealth distribution, especially the wealth concentration, using a general equilibrium overlapping-generations model with accidental and intended bequests.

the age of the household and m is the current health status of the household. The specification allows the distribution of the medical expenditures to vary depending on age and health status. We assume that the shock is uninsurable; the medical expenditure shock corresponds to only the out-of-pocket expenses in the data.

3.5 Household Size

We introduce household size transition because a sizable part of the housing tenure transition (to be more precise, transition from a homeowner to a renter) is associated with the transition from two-adult to one-adult households. $s \in \{1, 2\}$ represents the number of adults in a household. One-adult households ($s = 1$) remain the same for the rest of their life. But two-adult households ($s = 2$) stochastically changes to one-adult households. The transition probabilities of the household size is denoted by $\pi^s_{i,s,s'}$, where i is the age of households. By assumption, $\pi^s_{i,1,1} = 1$, $\pi^s_{i,1,2} = 0$ for all i. We assume that the transition from $s = 2$ to $s = 1$ captures death of spouses. We do not consider divorces or remarriages, in order to abstract from consolidation or splitting of assets. According to our data, these events are rare. Household size affects the households' decision in the following three ways. First, two-adult households maximize the sum of the utilities of the two. In order to avoid keeping track of types of each individuals in a two-adult households, we assume that the two adults have the same utility function. In other words, the utility of a two-adult household is basically that of a one-adult household multiplied by two. Second, consumption is split equally in a two-adult households. However, each of the household members can enjoy more than half of the consumption, because of the positive externality within the household. This is captured by the effective household size μ_s, which was introduced in Section 3.1. Finally, two-adult households face a shock that may turn them into a one-adult household.

3.6 Housing

A household is either a renter ($o = 0$) or a homeowner ($o = 1$). A renter chooses the size of the rental property each period. The available size of housing is $h \in \{h_1, h_2, h_3, ..., h_H\}$. The per-period cost of renting h is hpr_h where p is the current house price, and r_h is the rental rate. We will further discuss the house price p in Section 3.8. For a renter, there is no cost of changing the size of the house each period. All rental contracts are one-period. A homeowner with a house h decides whether to move out of the house and become a renter or stay in the same house. In order to simplify the problem, selling a house and buying another is assumed away. This is justified, since we do not observe many such transitions in our data. When the homeowner sells the house, the selling cost is hp. There is a cost of moving out, which is κhp. Besides, homeowner has to pay for a maintenance cost δhp each period. The rental rate r_h is determined as follows:

$$r_h = r + \delta + \iota \quad (3)$$

where r is the interest rate (discussed more in the following section), and ι is an extra cost of renting. Basically, the rental rate is the competitive cost of an intermediating real estate firm to hold housing and rent out to a renter.[3]

[3]See Nakajima (2010) for more careful discussion about the determination of the rental rate.

3.7 Saving and Home Equity Borrowing

We use a to denote consolidated financial asset balance. In particular, a denotes saving (in case a is positive) or borrowing (in case a is negative). Households can save at the interest rate r. In addition, home equity borrowing is allowed; homeowners can borrow against the value of their housing. In particular, the borrowing limit in period t has the following form:

$$a \geq -(1-\lambda)hp \tag{4}$$

In other words, a homeowner can borrow up to a fraction $1-\lambda$ of the value of the house (hp) in each period. The parameter λ can be interpreted as the downpayment constraint, since a household has to have at least λhp to own a house of size h. The borrowing interest rate is assumed to be $r+\chi$, where χ is an extra cost of home equity borrowing. Moreover, whenever a homeowner increases the amount of home equity borrowing, the homeowner has to pay νhp. Although our general setup of the home equity borrowing leaves us agnostic about the interpretation of the cost, it loosely corresponds to the closing cost of refinancing, the cost of opening a new home equity line of credit (HELOC), or the closing cost of the reverse mortgage loan (RML). We will estimate the parameter from the data. This parameter is important because we found that some of the characteristics of the borrowing behavior of the elderly cannot be replicated without some cost of extra borrowing.

3.8 House Price

The house price p is assumed to have only an aggregate time-varying component; we do not consider heterogeneity of house price change for now. As for the expectation, we assume that households expect the current house price to stay at its current level each period in the future. In other words, in simulations in which we feed the observed house price trajectories, all the changes in the house price are taken as a surprise by households. Accordingly, expectations of future house prices are set at the house price observed in the last period. One of the main experiments that we implement is to feed different future house price trajectories and investigate the response of households, especially regarding their decision with respect to housing and home equity borrowing.

A natural alternative in terms of the expectation of the future house price growth is perfect foresight. However, we found that perfect foresight assumption generates a highly counterfactual outcome: if households know the future path of house prices and this path replicates what we saw in the data in the last 15 years, a substantial proportion of households would choose to sell their house at the peak of the market, i.e. in 2006. As a result, home ownership rates would drop at the market peak as well, which does not appear consistent with the data. Although our main data set ends in 2006 (see below) and thus is silent as to home ownership rates after that year, we do not observe such a large drop in homeownership in other data sources. Thus, based on this evidence, we do not use perfect foresight as our baseline assumption.

3.9 Government Transfers

Following Hubbard et al. (1995) and De Nardi et al. (2010), we assume that the government uses means-tested social insurance which provides a consumption floor. The consumption floor is especially important in our model in which a large out-of-pocket medical expenditure shock could force a household to consume a negative amount in the absence of social insurance. The consumption floor supported by the government is denoted by $\underline{c}$ per adult. Following De Nardi et al. (2010), we assume that the government subsidizes each member of a household up to the consumption floor only when the household sells all of its assets and chooses the minimum rental property available (in case of a renter) but still falls short of the consumption floor.

3.10 Household Problem

We will formalize the households' problem recursively, and separately for homeowners and renters. Following the convention, we use a prime to denote a variable in the next period. In order to save some notation, we use $h = 0$ to represent a renter. $h > 0$ means that a household is a homeowner with house size of h. Let us start from the problem of a renter. The Bellman equation that characterizes the problem of a renter is as follows:

$$V(i,s,b,m,x,p,0,a) = \max_{\tilde{h},a'\geq 0} \Big\{ u(c,\tilde{h},s,0) + \beta \sum_{s'} \pi^s_{s,s'} \sum_{m'>0} \pi^m_{m,m'} \sum_{x'} \pi^x_{i+1,m',x'} V(i+1,s',b,m',x',p,0,a') + \beta \pi^m_{m,0} v(a') \Big\} \quad (5)$$

subject to:

$$\tilde{c} + a' + r_h \tilde{h} p + x = (1+r)a + \psi_s b \quad (6)$$

$$c = \begin{cases} \max\{s\underline{c}, \tilde{c}\} & \text{if } a' = 0 \text{ and } \tilde{h} = h_1 \\ \tilde{c} & \text{otherwise} \end{cases} \quad (7)$$

The type of a renter is represented by $(i,s,b,m,x,p,h = 0,a)$. The renter chooses the assets carried over to the next period (a') and the property that he rents in the current period $(\tilde{h})$ to maximize the sum of three components. The first component is the period utility. The second component is the discounted expected future value conditional on surviving in the next period $(m' > 0)$. Notice that b does not change, the renter expects the house price p to remain the same as the current level p in the next period, and the renter remains a renter $(h' = h = 0)$. The third component of the maximand in the Bellman equation (5) is the utility from bequests. Notice that, for a renter, the only assets left as estate are the financial assets (a'). Equation (6) is the budget constraint of the renter. Equation (7) represents the lowerbound of consumption per adult guaranteed through the social insurance program. Notice that the consumption floor is available only when the renter chooses not to save anything $(a' = 0)$ and chooses the smallest rental property available $(\tilde{h} = h_1)$.

The recursive problem of a homeowner can be characterized by the following Bellman equation:

$$V(i,s,b,m,x,p,h,a) = \max\{V_0(i,s,b,m,x,p,h,a), V_1(i,s,b,m,x,p,h,a)\} \quad (8)$$

$$V_0(i,s,b,m,x,p,h,a) = \max_{a' \geq 0} \Big\{ u(c,h,s,1)$$

$$+\beta \sum_{s'} \pi^s_{s,s'} \sum_{m'>0} \pi^m_{m,m'} \sum_{x'} \pi^x_{i+1,m',x'} V(i+1,s',b,m',x',p,0,a') + \beta \pi^m_{m,0} v(a') \Big\} \quad (9)$$

subject to:

$$\tilde{c} + a' + x = hp(1-\delta-\kappa) + (1+\tilde{r})a + \psi_s b \quad (10)$$

$$c = \begin{cases} \max\{s\underline{c}, \tilde{c}\} & \text{if } a' = 0 \\ \tilde{c} & \text{otherwise} \end{cases} \quad (11)$$

$$\tilde{r} = \begin{cases} r & \text{if } a' \geq 0 \\ r+\chi & \text{if } a' < 0 \end{cases} \quad (12)$$

$$V_1(i,s,b,m,x,p,h,a) = \max_{a' \geq -hp(1-\lambda)} \Big\{ u(c,h,s,1)$$

$$+\beta \sum_{s'} \pi^s_{s,s'} \sum_{m'>0} \pi^m_{m,m'} \sum_{x'} \pi^x_{i+1,m',x'} V(i+1,s',b,m',x',p,1,a') + \beta \pi^m_{m,0} v(hp+a') \Big\} \quad (13)$$

subject to equation (12) and:

$$\tilde{c} + a' + x + hp\delta + z = (1+\tilde{r})a + \psi_s b \quad (14)$$

$$z = \begin{cases} hp\nu & \text{if } a' < 0 \text{ and } a' < a \\ 0 & \text{otherwise} \end{cases} \quad (15)$$

First, equation (8) represents the tenure decision: $V_0(.)$ is the value conditional on moving out and becoming a renter in the next period, and $V_1(.)$ is the value conditional on remaining the same house and thus a homeowner in the next period. Equation (9) is the Bellman equation conditional on a homeowner becoming a renter. There are four differences from the renter's problem shown above. First, the current tenure status is homeowner ($o = 1$) with the house size of h, as can be seen in the period utility function. Second, the budget constraint (10) does not include the rental cost (since the household owns in the current period), but includes income from selling the house, net of the current maintenance cost (δ) and the selling cost (κ). Third, the interest rate is different depending on whether the homeowner is a net saver (in this case the interest rate is r), or a net borrower (the interest rate is $r+\chi$). Fourth, the household is eligible for the consumption floor if $a' = 0$, because there is no decision of choosing rental property for the current period. In other words, the homeowner has to sell the house and exhaust all the savings to be eligible for the social insurance. Also notice that the household begins the next period as a renter (o=0).

Equation (13) is the Bellman equation for a homeowner conditional on remaining a homeowner. Five remarks are worth making. First, since a homeowner can borrow against the house, a' is not constrained from below by zero, but by $-hp(1-\lambda)$. Second, in case the household does not survives to the next period, the estate is the consolidated asset position, which consists of the value of housing (hp) and the financial asset position (a'). Third, the budget constraint (14) includes the maintenance cost ($hp\delta$). Fourth, the budget constraint also includes z, which is the cost of refinancing. z is zero if the homeowner chooses not to borrow ($a' \geq 0$), or to reduce its debt ($a' \geq a$). Otherwise, the homeowner has to pay the cost of borrowing more, and the cost is the fraction ν of the house value hp. Finally, since the homeowner chooses to keep the house, the homeowner does not have access to the consumption floor.

4 Estimation Strategy

Following Gourinchas and Parker (2002) and De Nardi et al. (2010), we use a two-step estimation strategy. In the first step, we estimate the parameters which are taken as exogenous to the model. Parameters associated with all the shocks and prices, as well as the initial conditions, are in this category. In the second step, we estimate the remaining parameters using the simulated method of moments (SMM), taking the estimated parameters in the first step as given. That is, in the second step we pin down parameters so that a set of moments generated from the simulation of the model, given these parameters, is close to the same moments computed from the data, using some criteria of closeness.

5 Data

The Health and Retirement Survey is a biennial longitudinal survey of households of age 50 and above, conducted by the University of Michigan. A total of eight waves are available, from 1992 until 2006. Due to issues with data on assets, we begin our data observation in 1996, see De Nardi et al. (2010).

We consider everyone in the sample of age 63 and above who declares themselves to be retired. We consider both dual and single households. We subdivide the sample into 6 cohorts, of ages 63-67, 68-72, 73-77, 78-82, 83-87, 88-97. We follow these cohorts across the waves of the survey and document their lifecycle patterns of asset holding and health, as described below. As assets are measured in the HRS at household level, while health status and other demographic variables are at the individual level, we adjust the weighting schemes appropriately to construct information for our model households.

The HRS sample is replenished several times over the course of the survey. There are multiple ways to deal with this cohort replenishment: one could only consider those who appear in all six waves of the survey, or include the replenished cohorts. For the time being, we allow the cohorts to be replenished and use household and individual weights as appropriate to ensure that population representation is maintained.

To allow our data measures to map into the model, we measure financial assets as the sum of non-housing assets (excluding businesses and cars) net of all debt, including home equity debt. (We also experiment with using a fuller measure of net worth, separating out only housing assets). We track housing assets separately, including only the primary residence, since other real estate information is not available in all waves of the survey. Below we give more details on the use of the data for the purposes of calibration of our model.

Table 1: Income Levels[1]

	Cohort 1 (age 65)	Cohort 2 (age 75)	Cohort 3 (age 85)
Group 1	4778	5491	5189
Group 2	9329	8598	7600
Group 3	13550	11432	9556
Group 4	19665	15580	12401
Group 5	38562	32480	22917

[1] Annualized income in 1996 dollar.

6 Estimation Results

6.1 First Step Estimation

Since HRS is biennial, we set one period in the model to two years. Each household can live up to 99 years of age, but there is a probability of an earlier death. We look at three cohorts corresponding to ages 65, 75, and 85 in 1996 – the first wave of the survey that we use. We call them cohort 1, 2, and 3, respectively. In order to increase the size of the observations, we define age 65 as capturing the five-age interval of the actual age between 63 and 67. For each cohort, we have six observations, corresponding to years 1996, 1998, 2000, 2002, 2004, and 2006. In simulating and estimating the model, we use the type distribution of the three cohorts of households in 1996 as the input. We also feed in the real national house price indexes between 1996 and 2006 for simulation. All the values that follow in this section are represented in 1996 dollars.

6.1.1 Preferences

There are a variety of estimates for the household equivalence scale. We use the value of 1.34 for a two-adult household. It is the estimate of Fernández-Villaverde and Krueger (2007), which is the mean of existing estimates, ranging between 1.06 and 1.7.

6.1.2 Non-Financial Income

Our definition of non-financial income includes social security, pension, disability, annuity and government transfer income. In each cohort, we sort the households according to the non-financial income in 1996 and classify them into five bins, so that each bin carries approximately one-fifth of the total sample weight in 1996. For a two-adult household, since the average income is about twice as large as the one-adult households, we divide the non-financial income by two. The income representing each of the five income groups is computed by taking the average income of the households in each bin. Table 1 summarizes the resulting income bins by cohort.

Table 2: Health Status Transition

Health status transition (age 65)				
	Dead	Excellent	Good	Poor
Excellent	1.0	71.6	22.4	5.0
Good	1.3	24.7	53.6	20.5
Poor	10.9	6.6	20.3	62.3

Health status transition (age 75)				
	Dead	Excellent	Good	Poor
Excellent	2.4	61.2	27.4	8.9
Good	4.4	22.7	47.0	25.9
Poor	11.3	5.1	18.9	64.7

Health status transition (age 85)				
	Dead	Excellent	Good	Poor
Excellent	10.1	48.2	26.2	15.5
Good	13.0	17.9	40.0	29.5
Poor	27.3	5.7	15.9	51.1

Health status transition (age 95)				
	Dead	Excellent	Good	Poor
Excellent	22.3	32.5	24.0	21.3
Good	28.1	17.7	34.1	20.1
Poor	46.4	4.2	15.4	34.0

6.1.3 Health Status and Mortality Shock

We group the five self-reported health status categories in the HRS (excellent, very good, good, fair, poor) into three categories, combining the top two and the bottom two groups, and leaving the middle group as is. Since the transition among different health and age groups seem stable over the waves of the HRS, we average the transition probabilities across the waves for estimation purposes. In other words, we impose stationarity across time of the health status transitions, though we continue to distinguish transitions by age. We compute the probability that a respondent of health status m (m is 1 (excellent), 2 (good), or 3 (poor)) is of health status m' in the next wave (two years later), conditional on the age of the respondent. Notice that this procedure includes computing a probability of death ($m' = 0$). Table 2 summarizes health transition probabilities for ages 65, 75, 85, and 95. Several points are worth noting. First, as expected, the probability of dying is higher for respondents with a lower health status. Second, probability of death increases with age. Third, health status exhibits persistence. However, fourth, this persistence becomes weaker with age, which corresponds to an increasing probability of death.

6.1.4 Medical Expenditures

We estimate the out-of-pocket medical expenditure shocks from the HRS data, by cohort, again by assuming stationarity across waves. First, we compute the probability that medical expenditures are zero, conditional on age and current health status. After taking out the observations with zero medical expenditures, we fit the distribution of medical expenditures using log-normal distribution. Table 3 and Figure 1 exhibit the estimation results for selected age groups. It is apparent that the probability of zero medical expenses, the log-mean of medical expenses, and the log-standard deviation are all increasing with age. In addition, the probability of zero medical expenses increases as the health condition declines (correlating with the increased probability of death), but conditional on spending on medical services out of pocket, households spend more the less healthy they are, and the dispersion of spending increases as well.

Table 3: Medical Expenditure Distribution[1]

Age	Statistics	Excellent	Good	Poor
65	$\mathbb{P}(x=0)$	0.09	0.10	0.14
	Log-mean	6.72	7.06	7.50
	Log-Stdv	1.38	1.38	1.48
	Exp mean[2]	2147	3035	5194
75	$\mathbb{P}(x=0)$	0.10	0.10	0.13
	Log-mean	6.81	7.13	7.44
	Log-Stdv	1.38	1.33	1.46
	Exp mean[2]	2372	3015	4932
85	$\mathbb{P}(x=0)$	0.12	0.12	0.15
	Log-mean	7.01	7.32	7.62
	Log-Stdv	1.49	1.48	1.56
	Exp mean[2]	3339	4502	6873
95	$\mathbb{P}(x=0)$	0.18	0.16	0.24
	Log-mean	7.35	7.90	8.23
	Log-Stdv	1.90	1.80	1.90
	Exp mean[2]	9685	14048	23365

[1] Out-of-pocket medical expenditures for two-year periods in 1996 dollar.

[2] Assuming log-normal distribution, and conditional on non-zero medical expenditures.

In constructing the medical expenditure shock, we discretize the log-normal distribution using four grid points: the mean, mean plus-minus one log standard deviation, and mean plus three times the log standard deviation. The last grid is chosen to capture the right tail of the distribution, emphasized by French and Jones (2004).

6.1.5 Household Size

Figure 3 exhibits the proportion of two-adult households conditional on age. Each line corresponds to each of the three cohorts that we use for the estimation, and three additional cohorts (cohorts of age-70, age-80, and age-90 in 1996). The proportion is approximately linearly decreasing with age and there seems to be no cohort effect. Therefore, as with other measures above, we assume that the household size transitions are time-invariant, and estimate the transition probabilities by pooled sample of all six waves of the HRS, by cohort. Moreover, we make two assumptions, for tractability. First, in order to abstract from the division or aggregation of assets by associated with separations and marriages, we only consider transitions from two-adult households to one-adult households. Second, we assume that all the transitions from two- to one-adult households are caused by death of the spouse. The first assumption is supported by the fact that the transitions from one- to two-adult households are rare among the HRS sample; the probability is around 3% for households of age 60s and 70s, and it is less than 1% for older

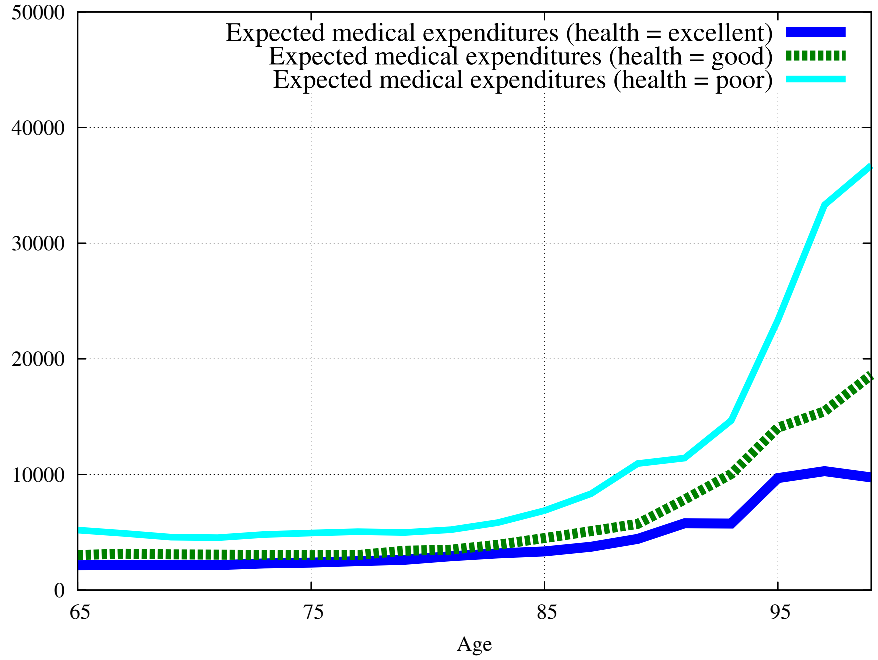


Figure 1: Mean Medical Expenses by Health Status. Source: HRS, various waves.

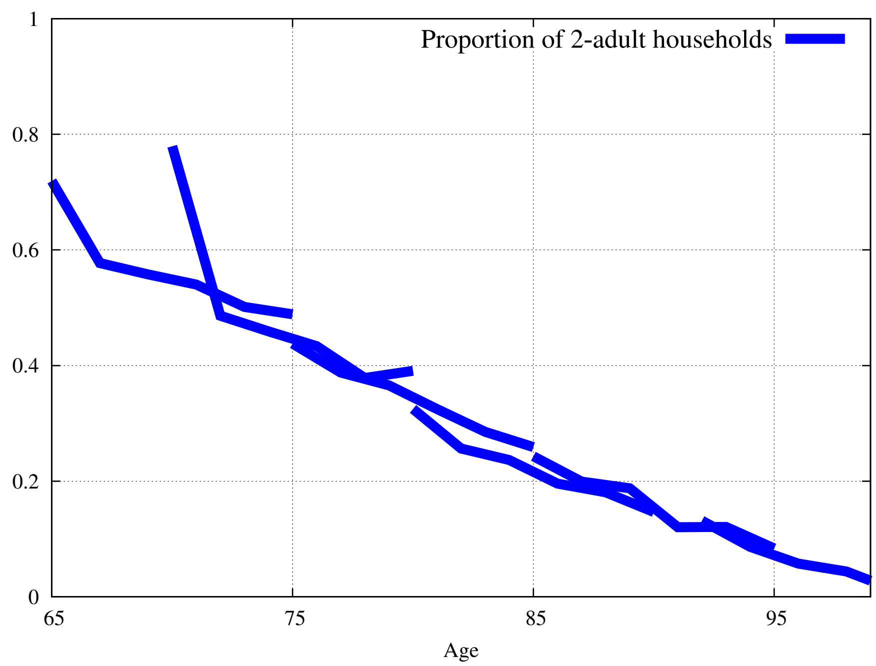


Figure 2: Proportion of Two-Adult Households. Source: HRS, various waves.

households. The second assumption is consistent with a very low probability of divorce in the sample, which appears to be true in our data although we cannot completely cleanly identify the transitions caused by divorces and those caused by death of spouses.

Table 4: **House Size Distribution**[1]

	Cohort 1 (age 65)	Cohort 2 (age 75)	Cohort 3 (age 85)
Bin 1	21792	18291	16781
Bin 2	44977	37924	35743
Bin 3	63613	50801	47699
Bin 4	77839	64390	55112
Bin 5	88087	77613	64175
Bin 6	101358	93641	77510
Bin 7	125114	110422	88651
Bin 8	152107	137455	108380
Bin 9	195244	183215	148655
Bin 10	360683	345206	265221

[1] Value in 1996 dollar.

6.1.6 House Size

For the sake of tractability, we approximate the distribution of house sizes using ten grid points. More specifically, we sort the households in the initial sample year (1996) by cohort and by the value of housing, and classify the households in each cohort into ten bins, so that each bin captures 10% of the sample. The house value representing each bin is computed by taking the average house value within the bin. Table 4 summarizes the house value bins constructed by this procedure. In addition, we restrict the choice of property values for renters to the same set of house bins for each cohort.

6.1.7 House Price

For house price movements in the model, we use the real national house price index. The real house price is constructed by dividing the house price index (HPI) compiled by the Federal Housing Finance Agency (FHFA) by the consumer price index. We use the actual real house price index for the period 1996-2006 for estimation. While we are able to observe heterogeneity regarding the house price growth across households, at this point we do not introduce this heterogeneity into the model, to contain the computational burden. As we show below, using the national house price index is largely sufficient to capture the behavior of the median households.

6.1.8 Initial Distribution

We use the initial distribution constructed from the actual distribution in the 1996 wave of the HRS, and simulate the model starting from the initial distribution and use the outcome of the simulation to estimate structural parameters. Table 5 shows the initial distribution sliced from various dimensions. We do not show the characteristics of the initial distribution with respect to income and housing assets, since we simply construct equal-sized bins for each of these dimensions. The properties of the initial distribution are intuitive. First, the proportion

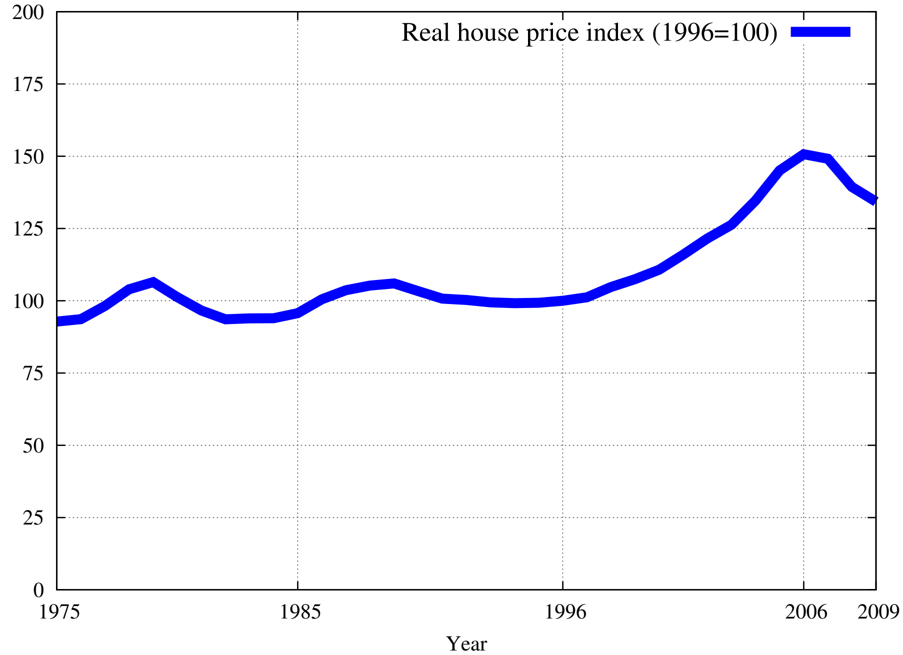


Figure 3: Real House Price Index. Source: FHFA (HPI), BLS (CPI).

Table 5: Selected Characteristics of the Initial Distribution (in 1996)

	Cohort 1 (age 65)	Cohort 2 (age 75)	Cohort 3 (age 85)
Household size			
one-adult	0.28	0.56	0.76
two-adult	0.72	0.44	0.24
Health status			
1 (excellent)	0.48	0.39	0.34
2 (good)	0.29	0.32	0.28
3 (poor)	0.23	0.29	0.38
Tenure			
Homeowner	0.89	0.79	0.61
Renter	0.11	0.21	0.39
Net financial asset position			
Saver	0.82	0.93	0.97
Borrower	0.18	0.07	0.03

of two-adult households is lower for older cohorts. Second, health status is on average worse for older cohorts. Third, homeownership rate is mildly decreasing with age. Finally, the proportion of households with net negative financial assets is lower for older cohorts.

Table 6: Parameter Estimates

Parameter	Description	Baseline estimates
β	Discount factor[1]	0.90
η	Consumption aggregator	0.85
σ	Coefficient of RRA	2.00
ω_1	Extra-utility from ownership	2.00
γ	Strength of bequest motive	2.00
ζ	Curvature of utility from bequests[2]	1000
$\underline{c}$	Consumption floor per adult[2]	5000
ι	Rental premium[1]	0.00
χ	Debt premium[1]	0.02
ν	Cost of increasing debt	0.03

[1] Biennial value.
[2] Biennial value in 1996 dollar.

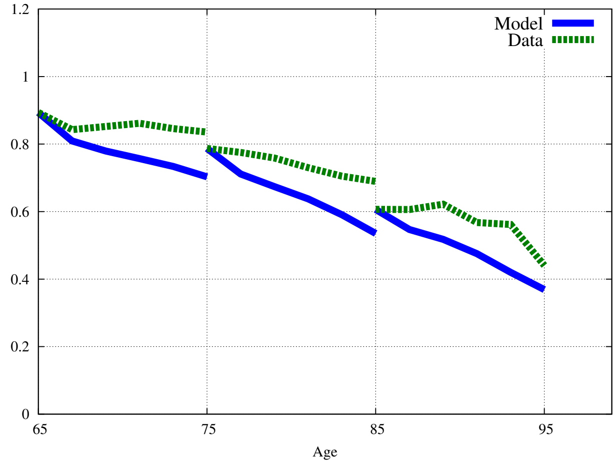
6.2 Second Step Estimation

At this stage, we have not yet implemented second-step estimation with formal distance criteria. As a preliminary step, we have been searching for a combination of parameter values to give us a reasonable starting point for the estimation procedure, based on the targets of choice, described below. Table 6 summarizes the parameters obtained in the second-step estimation to date.

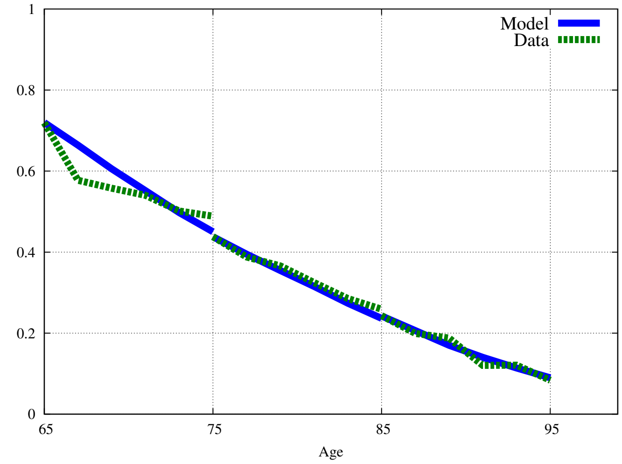
Figure 4 compares homeownership rate of three cohorts in the data and the corresponding outputs of the model. Since the homeownership rate is lower for one-adult households, and the proportion of one-adult households increases with age, the observed decline of the homeownership rate with age can be attributed to (i) an increase in the share of one-adult households (death of spouses), and (ii) a decline in homeownership rates conditional on household size. As panel (a) makes clear, the model over-predicts the decline in the homeownership rate. This is due to element (ii): the model captures the decline of the two-adult households with age in the data, but over-predicts the decline in home ownership conditional on the type of households.

Figure 5 compares the median profiles of housing, financial, and total assets of three cohorts in the data and the corresponding outputs of the model. Median housing assets held (panel (a)) and median financial assets held (panel (b)) in the model replicate the corresponding data quite well. The median total assets held (panel (c)) in the model are slightly under-predicted relative to the data counterpart.

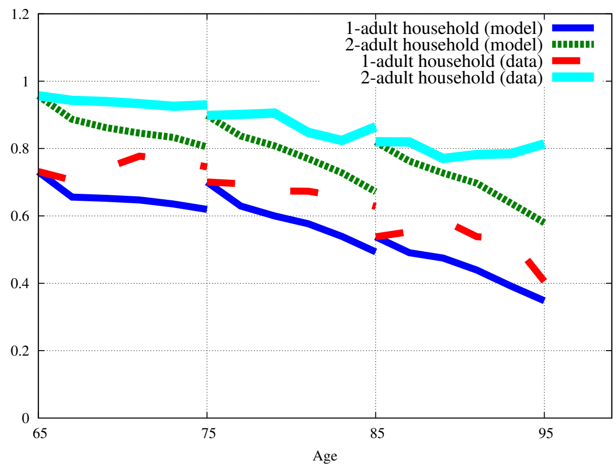
The model is slightly less successful in capturing the proportion of debtors and the amount of debt held by the debtors. Notice that since we define the financial asset in the model as the consolidated balance of all the non-housing assets net of debt, the proportion of debtors in the current definition is not the same as the proportion of households who own *some* form of debt simultaneously with owning positive assets. Let us start from panel (a), which exhibits the proportion of debtors among each cohort and each age. The model replicates the profile of the second cohort (those age 75 in 1996) quite well, but the model is less satisfactory for



(a) Homeownership Rate, All Households



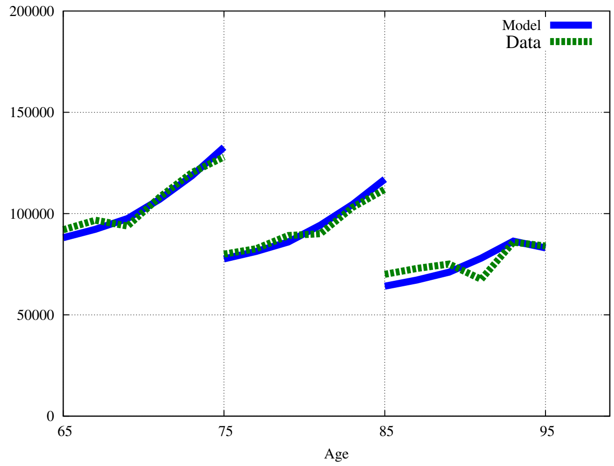
(b) Proportion of Two-Adult households



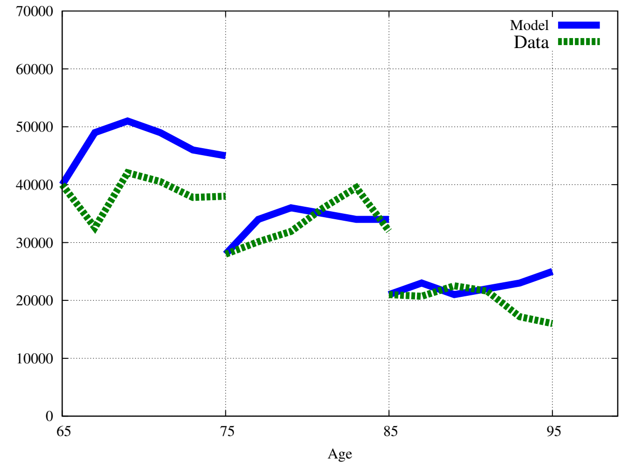
(c) Homeownership Rate, One- and Two-Adult Households

Figure 4: Estimation Results - Homeownership Rate

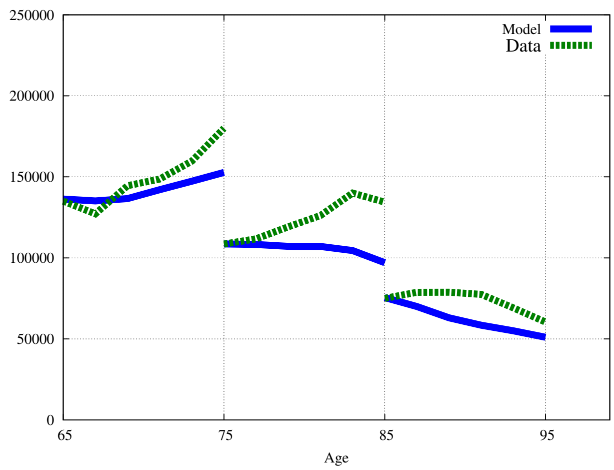
other cohorts. Why? For example, we could slow down the decline in the proportion of debtors among the first cohort (those age 65 in 1996), by slowing down the decline in the homeownership rate or by weakening the saving motive, but that would further increase the borrowing by the oldest cohort, unless there is a substantial cost of borrowing for these older cohorts. This trade-off suggests that there may be a strong restriction against borrowing by older cohorts. Alternatively, this problem might be related to the assumption that all households experience the same house price dynamics; there is no household which experience house price growth substantially higher than the national average by assumption. We will investigate this channel later on. The same problem is menifested for the profile of median debt among debtors. The youngest cohort reduce their borrowing too much compared with the data.



(a) Median Housing Assets



(b) Median Financial Assets



(c) Median Total Assets

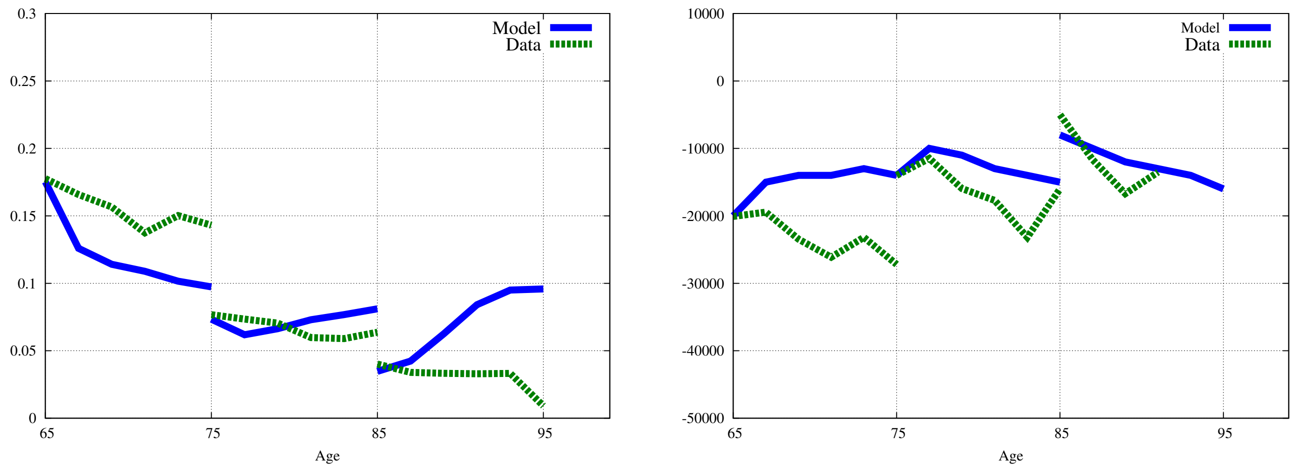
Figure 5: Estimation Results - Asset Holding Profiles

7 Experiments

In this section, we use the model estimated above to implement a variety of counterfactual exercises. We focus on cohort 1 (65 years old in 1996) to clearly show the changes over the life-cycle.

7.1 House Price, Home Equity Borrowing, and Homeownership

How does the house price dynamics affect households' behavior regarding homeownership and home equity borrowing? This question is important not only theoretically, but also empirically: we want to understand the effects of a housing market crisis just seen in the last few years, especially as it impacts retirees, as well to predict what would happen if housing prices continue to stagnate going forward.



(a) Proportion in Debt

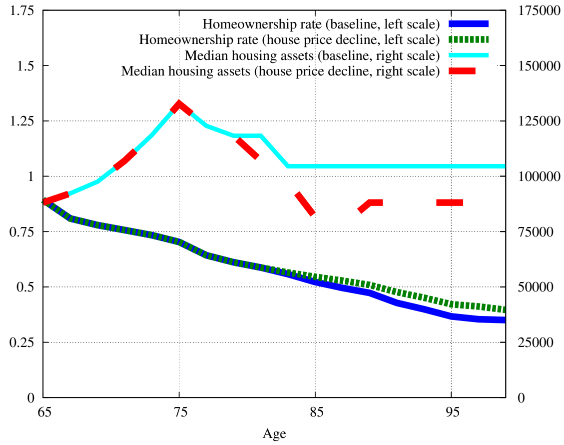
(b) Median Debt among Debtors

Figure 6: Estimation Results - Borrowing Profiles

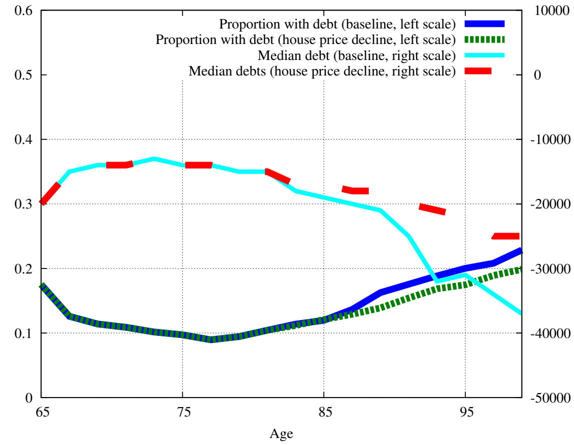
In the benchmark model described above, we assumed that house prices after 2009 remain at the 2009 level. In the data, national average real house price index increased by about 50% between 1996 and the peak of 2006, and dropped since then, but remains about 35% higher than the level of 1996. We now implement two experiments. First, instead of assuming that future house price level remains at the level of 2009, we now assume that the house price drops back to the 1996 level, and investigate how retirees' homeownership rates and borrowing are affected. Panels (a) and (b) of figure 7 show the results. Notice that, since we look at cohort 1, which is of age 65 in 1996, they see the same price profile as our benchmark model until they are age 79 (year 2010). The graphs reflect this. Panel (a) shows that the median housing asset holding declines by about 25% due to the decline in the future house prices. More interestingly, the simulation predicts that homeownership rate would increase if the average housing price were to drop further than the 2009 level going forward. The difference in homeownership rate would be as large as 5 percentage points for households in their 80s and 90s. Why? As house prices continue to decline, retirees would find the benefits of selling their house increasingly less attractive.

In addition, panel (b) shows how the decision regarding borrowing is affected by the difference in the house price dynamics relative to the benchmark case. If future house prices decline further, the model predicts that fewer households would take out home equity later in their life, and the median debt would also decline. The amount of debt taken out by retirees would decline mainly because the value of housing assets decline, which tightens the borrowing constraint against the house. An additional reason is the negative income effect. Although many of the retirees do not sell their house during their lifetime, a lower expected estate (bequest) has a negative income effect on the retirees, reducing consumption and borrowing. The decline in the proportion of debtors among 80- and 90-year-olds is mainly the result of the income effect.

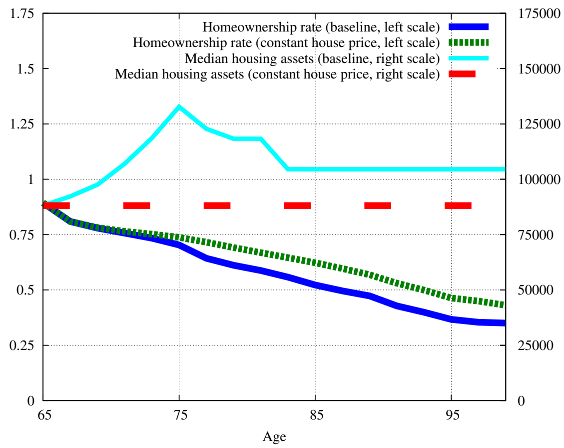
In the second experiment, we make a counterfactual assumption of eliminating the house price boom and bust between 1996 and 2009, and keeping the house price constant at the 1996 level. Once again, we investigate the effect of the house price boom and bust on the rate of



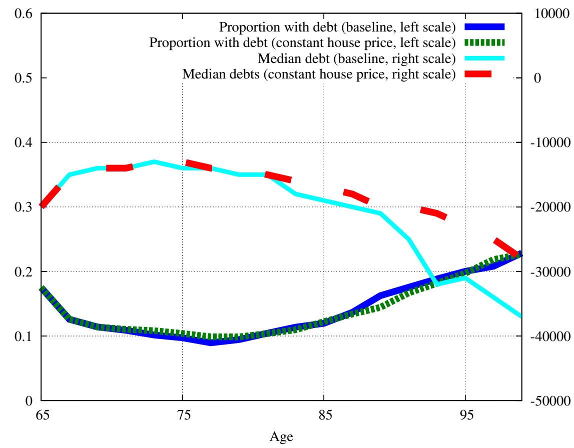
(a) Median Housing and Homeownership Rate (House Prices Decline Post-2010)



(b) Proportion in Debt and Median Debt (House Prices Decline Post-2010)



(c) Median Housing and Homeownership rate (House Prices Constant Since 1996)

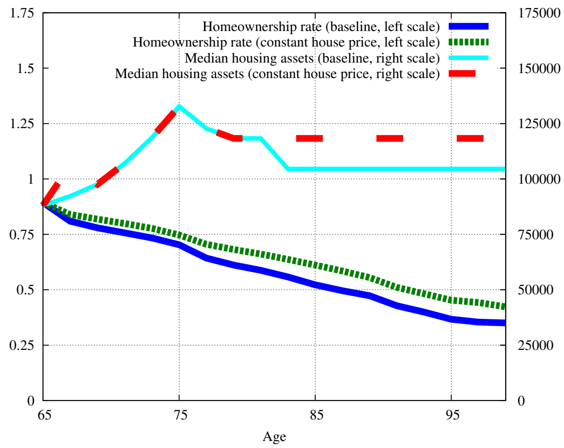


(d) Proportion in Debt and Median Debt (House Prices Constant Since 1996)

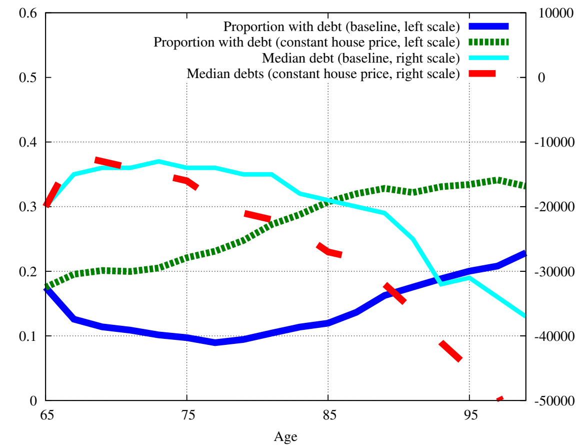
Figure 7: Experiments - House Prices

home ownership and the debt of retirees. Panels (c) and (d) of Figure 7 show the results. Panel (c) clearly shows, based on housing assets, that the housing price boom and bust has been eliminated from the model. The effect of these house price dynamics on homeownership is again that absence of a house price boom induces retirees to stay with their house instead of cashing out and becoming a renter. The effect on borrowing behavior is also similar to the above experiment. The lack of house price boom induces retirees to avoid borrowing, and those who do borrow borrow less - once again, a manifestation of a combination of borrowing constraints that are tighter than in the benchmark, together with an income effect.

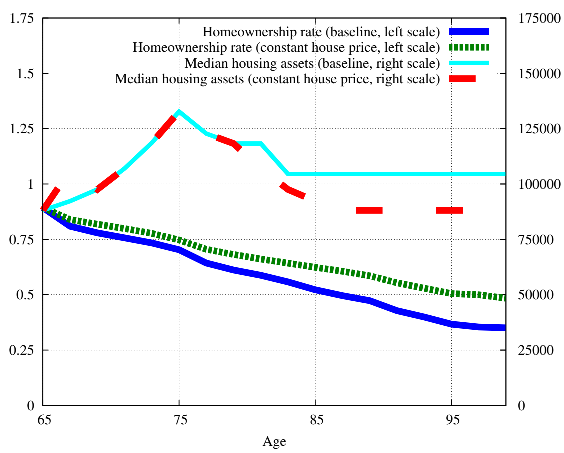
If a lower house price weakens demand for home equity borrowing, the demand for the reverse mortgage loans would be negatively affected, other things equal. We discuss this issue in more detail in the next section.



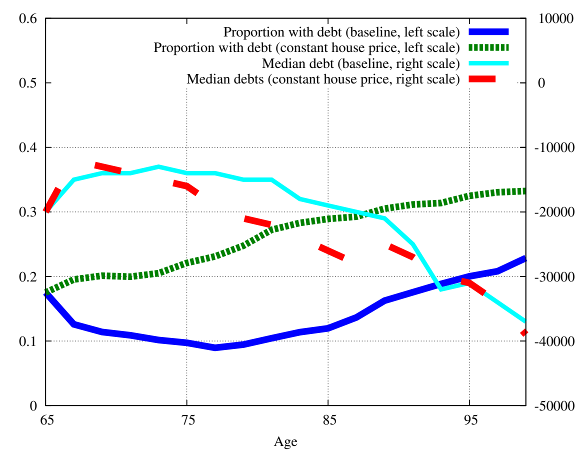
(a) Median Housing and Homeownership rate ($\nu = 0$, Baseline House Price)



(b) Proportion in Debt and Median Debt ($\nu = 0$, Baseline House Price)



(c) Median Housing and Homeownership rate ($\nu = 0$, Lower House Price)



(d) Proportion in Debt and Median Debt ($\nu = 0$, Lower House Price)

Figure 8: Experiments - Lower Cost of Home Equity Borrowing

7.2 Mortgage Market Innovation, Home Equity Borrowing, and Welfare

The last decade saw rapid innovations in the mortgage markets: many new instruments appeared which enabled homeowners to extract home equity more flexibly. Furthermore, reverse mortgage loans (RMLs) rapidly increased in popularity, although the number of RML borrowers is still small. How did this kind of innovation in the mortgage markets affect homeownership patterns and equity borrowing of retirees? Recall that in the benchmark model, the parameter that controls the cost of increasing the debt balance, ν, is estimated to be fairly large at 3% of the house value each time a retiree wants to extract home equity. (This value is broadly consistent with our reading of the institutional details of equity borrowing contracts.) We run a counterfactual experiment with $\nu = 0$; that is, we set the cost of equity extraction to zero as an approximation of what would happen in a hypothetical world with extremely flexible mortgage markets.

The top two panels of Figure 8 shows the homeownership pattern (panel (a)) and borrowing behavior (panel (b)) under the counterfactual assumption of $\nu = 0$, compared with the results under the baseline assumptions and estimated parameters. It is apparent more retirees remain homeowners because the value of owning a home increases as it becomes a cheaper means of borrowing. Homeownership rate for those in 80s and 90 increases more than 10 percentage points. The median housing asset holding increases under the hypothetical assumption, for the same reason as the rising homeownership rate. Home equity borrowing would increase dramatically, in both extensive margin (proportion of households in debt) and intensive margin (median debt of debtors). For example, proportion in debt among 75 years old would increase from 10% in the baseline to 23% under the hypothetical. For those of age 85, the proportion would increase from 12% to 31%. Especially because the effect is larger for older households, further decline in costs of RMLs, which we consider is captured by this counterfactual experiment, could affect the homeownership pattern and home equity borrowing of the elderly significantly.

Notice that our experiments imply that absent financial market innovation, home ownership would be depressed by a housing price bubble. This is offset by the type of mortgage market innovation that we have seen in the data in recent years. As in the data, we have seen an increase in home ownership rates between late 1990s and early 2000s, this increase could be attributed then primarily to the innovation in the mortgage market, which offsets to some extent the dampening effect of the housing bubble.

Similarly, absent financial innovation, a housing price increase would loosen borrowing constraints against housing, while a decline in prices would tighten it. Financial innovation makes it easier to borrow against the home, increasing retiree borrowing significantly.

We investigate these points further by studying the interaction of the price dynamics and market innovation: how would the rate of home ownership and level of indebtedness be affected if mortgage market innovation were dampened by dropping housing prices going forward from 2009? To answer the question, we combine the two counterfactuals: (i) $\nu = 0$, which we investigate in this section, and (ii) house price decreases to the level in 1996, instead of remaining at the 2009 level. The bottom two panels of Figure 8 show the implications of the counterfactual. As can be seen in panel (c), median housing asset holding declines, reflecting the declining trend of the house price. Homeownership rate would be even higher in this case relative to the case with constant prices and financial market innovation; low house price discourages some homeowners from selling their house and cashing out. If the two counterfactual events studied here would happen, homeownership rate of retirees would be lifted. Panel (d) shows that the effect of the reduced costs of increasing home equity borrowing on debt would be mitigated if house prices would have a declining trend.

7.3 Elderly Saving Puzzle Revisited

To be completed.

8 Conclusion

In this paper, we estimate the consumption-savings model of retirees, with the focus on the decision of withdrawing home equity. Homeowners can cash out of housing to finance life in retirement by taking home equity debt, or by selling their house. We use the estimated model to answer three questions. First, we ask how a declining trend of house prices affect future housing and borrowing decision of retirees. The model predicts that home equity borrowing would decline, in terms of both intensive (median amount of debt) and extensive (proportion in debt). This is a direct consequence of a lower value of housings and a negative wealth effect. More interestingly, the model implies that homeownership rate would be higher, because cashing out by selling the house becomes a less attractive option. Second, we ask how future decline of costs of home equity borrowing affects housing and borrowing behavior of retirees. Since the model implies that costs of increasing home equity debt constrain borrowing by retirees, a reduction of the costs increases both indebtedness and homeownership rate of retirees. The intuition is simple. A lower cost of increasing home equity borrowing allows retirees to take home equity borrowing more flexibly, and increases the collateral value of housing. Finally, we ask whether we can shed light to the retirement saving puzzle by explicitly considering housing. The model can be used to quantify the importance of utility of owning housing, and costs of taking home equity borrowing, on retiree's savings decision.

A natural future extension is to use use the model for policy analysis. In particular, the model can be used for positive and welfare analysis of the effect of social security reform. We are also interested in using our framework, where health and medical expenditure risks play an important role, to analyze effects of the health care reform on retirees' housing and saving decision and welfare.

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