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Reverse Mortgage Loans: A Quantitative Analysis*

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Abstract

Reverse mortgage loans (RMLs) allow older homeowners to borrow against housing wealth without moving. In spite of growth in this market, only 2.1% of eligible homeowners had RMLs in 2011. In this paper, we analyze reverse mortgages in a life-cycle model of retirement, calibrated to age-asset profiles. The ex-ante welfare gain from RMLs is sizable at $1,000 per household; ex-post, low-income, low-wealth and poor-health households use them. Bequest motives, nursing-home moving risk, house price risk, and interest and insurance costs all contribute to the low take-up rate. The model predicts market potential for RMLs to be 5.5% of households.

JEL classification: D91, E21, G21, J14
Keywords: Reverse Mortgage, Mortgage, Housing, Retirement, Home Equity Conversion Mortgage, HECM

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1 Introduction

Reverse mortgage loans (RMLs) allow older homeowners to borrow against their housing wealth without moving out of the house, while insuring them against significant drops in house prices. Despite potentially large benefits to older individuals, many of whom want to stay in their house as long as possible, as well as frequent coverage in the media and attempts by the Federal Housing Administration, which administers RMLs, to change the contract to increase the appeal to borrowers, research on reverse mortgages is not extensive. This paper is intended to fill some of the void.

In previous work, Nakajima and Telyukova (2012) found that older homeowners become borrowing constrained as they age, since it becomes more costly to access their home equity, and that these constraints force many retirees to sell their homes when faced with large expense shocks. In this environment, it seems that an equity borrowing product targeted toward older homeowners may be able to relax that constraint and hence potentially benefit many owners later in life. Empirical studies have suggested a similar possibility, though estimates range widely. For example, Merrill et al. (1994) suggest that about 9% of homeowner households over age 69 could benefit from RMLs. Using a less conservative approach, Rasmussen et al. (1995) argue, using 1990 U.S. Census data, that the number is nearly 80%.[1] Despite the apparent benefits, RMLs were used by just 2.1% of older homeowners in 2011, although this represented the highest level of demand to date.

In this paper, we study the determinants of demand for reverse mortgages and their market potential in terms of consumer demand, in the face of complex trade-offs that retirees face in deciding whether to borrow. Specifically, we answer four questions about RMLs. First, we want to understand who benefits from reverse mortgages, and how much, in welfare terms. Second, we ask, given the current available RML contract, what prevents more retirees from taking the loans. Here we focus on retirees' environment, such as the magnitude of risk that they face, and preferences, such as their bequest motives. Third, we study whether and how the existing reverse mortgage contract can be changed to make the RML more attractive. We are motivated here by the frequently advanced argument that the low take-up rate in the data is due to the high fees on reverse mortgages. Finally, we want to understand what the largest potential market size for reverse mortgages may be.

To answer these questions, we use a rich structural model of housing and saving/borrowing decisions in retirement based on Nakajima and Telyukova (2012). In the model, households are able to choose between homeownership and renting, and homeowners can choose at any point to sell their house or to borrow against their home equity. Retirees face idiosyncratic uninsurable uncertainty in their life span, state of health, medical expenses, and house prices, and no aggregate uncertainty. Bad health may force older individuals into nursing homes, which we capture with an idiosyncratic moving shock. The model is estimated to match life-cycle profiles of net worth, housing and financial assets, homeownership rate, and home equity debt, which we construct from the Health and Retirement Study data. Into this model, we introduce reverse mortgages, study their use and value to different household types, and conduct counterfactual experiments to answer

[1] Rasmussen et al. (1995) assume that elderly households with home equity exceeding $30,000 and without mortgage loans in 1990 benefit from having the option of obtaining reverse mortgages. Merrill et al. (1994) assume that households with housing equity of between $100,000 and $200,000, income of less than $30,000 per year, and a strong commitment to stay in the current house (i.e., those who had not moved for the previous 10 years), and who own their house free and clear benefit from reverse mortgages.

the questions posed above.

The model predicts that the ex-ante welfare benefit of reverse mortgages is equivalent to providing a lump-sum transfer of $1,000 per retiree at age 65, or about 5% of median annual after-tax income. The welfare gains double, for example, for low-income retirees who are more likely to use RMLs. Nearly all homeowners value, ex-ante, the option of being able to tap their equity some time during their retirement; however, ex-post, only 2.1% of eligible retirees use RMLs, consistent with the data. Indeed, we estimate the potential market size for reverse mortgages at 5.5% of eligible retirees, which is an increase over the current level of 260% but far from the majority of households. Behind these low numbers is a combination of substantial risks that households face late in life, such as health, medical expense and long-term care risks, house price uncertainty, bequest motives, and significant costs of the reverse mortgage contract, all of which can dampen demand for reverse mortgages. A caveat is that we compute these numbers under the assumption of stationarity, i.e., absent aggregate booms or busts in the housing market, which certainly affect demand as well, as we show in further experiments. A policy takeaway is that demand for reverse mortgages could be boosted by policy aimed either at reducing certain costs of reverse mortgages, or reducing idiosyncratic risk that retirees face. We find, for instance, that absent most idiosyncratic risks that retirees currently face, demand for reverse mortgages could go up to 8.6% of retirees.

In more detail, we find that retirees who use reverse mortgages tend to have low income, low wealth, and poor health, and that they use them primarily to support consumption expenditure in general, or large medical expenses in particular. About 20% of RML borrowers use reverse mortgages to pay exclusively for medical expenses, which allows them to remain in their home, where the alternative in the world without RMLs would have been to sell the house. Bequest motives not only dampen RML demand, but also change the dominant reasons for why homeowners take RMLs; without these motives, retirees take RMLs much more frequently and use them overwhelmingly for non-medical consumption. On the contract side, we find that eliminating upfront costs of the loan increases demand for RMLs to 3.5%. In addition, reverse mortgages are non-recourse loans, meaning that if the price of the collateral falls below the loan value during the life of the RML, the lender cannot recover more than the collateral value. Strikingly, we find that retirees do not value this insurance component of RMLs, due to low borrowed amounts and availability of government-provided programs such as Medicaid, so that making reverse mortgages a recourse loan would increase RML demand by 48%, to 3.1%. In this sense, the oft-heard claim that large contract costs suppress RML demand is supported by our model. However, the HECM Saver loan, which was designed to respond to this claim by lowering the upfront cost of insurance in exchange for lowering the amount of equity accessible to the elderly, reduces demand for reverse mortgages, so that adding it to existing RML contracts is not likely to boost demand. In sensitivity experiments, we show that our results are robust to perturbations in estimated parameter values.

This paper makes three key contributions to the literature. First, we are the first, to our knowledge, to model reverse mortgages in a standard life-cycle environment that incorporates both key sources of risk that retirees face, and aspects of preferences of older households previously deemed important by the literature, such as bequest and precautionary motives. Second, our model allows us to run a rich set of fine-tuned experiments, designed to study all aspects of reverse mortgages relevant to current and potential borrowers and to quantify potential market size for reverse mortgages. Finally, we are able to quantify welfare gains from reverse mortgages on average and the distribution of welfare gains across different household types.

Our paper is related to three branches of the literature. First, the literature on reverse mortgage loans is developing, reflecting the growth of the take-up rate and the aging population. Shan (2011) empirically investigates the characteristics of reverse mortgage borrowers. Redfoot et al. (2007) explore better design of reverse mortgage loans by interviewing reverse mortgage borrowers and those who considered reverse mortgages but eventually decided not to utilize them. Davidoff (2012) investigates under what conditions reverse mortgages may be beneficial to homeowners, but in an environment where many of the idiosyncratic risks that we model are absent. Michelangeli (2010) is closest to our paper in approach. She uses a structural model with nursing home moving shocks and finds that, in spite of the benefits, many households do not use reverse mortgages because of compulsory moving shocks. Our model confirms this, but also takes into account many other important risks that older households face, such as health status, medical expenditures, and price of their house. Moreover, we incorporate into the model the initial type distribution of older households from the data, which allows us to capture crucial empirical correlations between household characteristics, such as wealth, income, home ownership, and health, important to household decisions on whether to borrow. Finally, we model the popular line-of-credit reverse mortgage loan, while Michelangeli (2010) assumes that borrowers have to borrow the maximum amount at the time of loan closing. We find that this distinction in the form of the contract matters.

The second relevant strand of literature addresses saving motives for the elderly, or solving the so-called "retirement saving puzzle." Hurd (1989) estimates the life-cycle model with mortality risk and bequest motives and finds that the intended bequests are small. Ameriks et al. (2011) estimate the relative strength of the bequest motives and public care aversion, and find that the data imply both are significant. De Nardi et al. (2010) estimate in detail out-of-pocket (OOP) medical expenditure shocks using the Health and Retirement Study, and find that large OOP medical expenditure shocks are the main driving force for retirement saving, to the effect that bequest motives no longer matter. Venti and Wise (2004) study how elderly households reduce home equity. In our previous work, Nakajima and Telyukova (2012) emphasize the role of housing and collateralized borrowing in shaping retirement saving, and find that housing and homeownership motives are key in accounting for the retirement saving puzzle, in addition to bequest motives and medical expense uncertainty.

Third is the literature on mortgage choice, particularly using structural models, which is growing in parallel with developments in the mortgage markets. Chambers et al. (2009) construct a general equilibrium model with a focus on the optimal choice between conventional fixed-rate mortgages and newer mortgages with alternative repayment schedules. Campbell and Cocco (2003) investigate the optimal choice for homebuyers between conventional fixed-rate mortgages (FRM) and more recent adjustable-rate mortgages (ARM). We model the choice between conventional mortgages and line-of-credit reverse mortgages, though we focus only on retirees.

The remainder of the paper is organized as follows. Section 2 provides an overview of reverse mortgages. Section 3 develops the structural model that we use for experiments. Section 4 discusses calibration of the model. In section 5, we use the model to analyze the demand for reverse mortgages through a number of counterfactual experiments. Section 6 presents sensitivity analysis, and section 7 concludes.

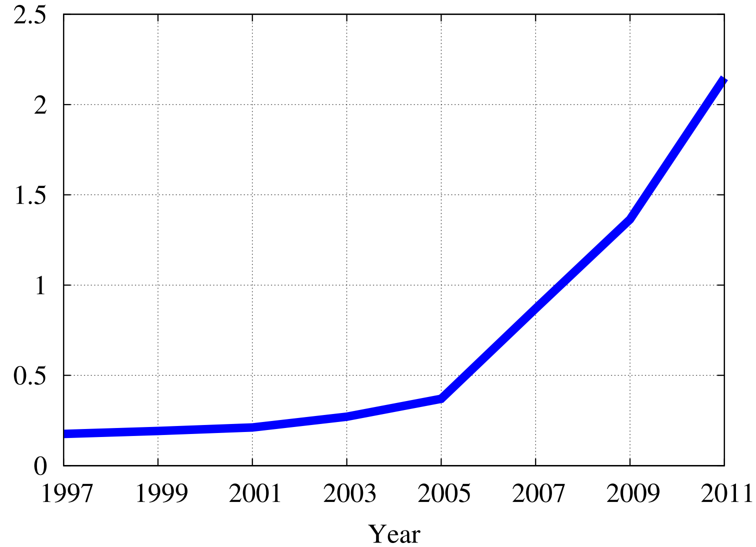


Figure 1: Percentage of Older (age≥65) Homeowners with Reverse Mortgages. Source: American Housing Survey, Various Waves.

2 Reverse Mortgage Loans: An Overview

Currently, the most popular reverse mortgage is administered by the Federal Housing Administration, which is part of the U.S. Department of Housing and Urban Development (HUD), while the private market for reverse mortgages has been shrinking.[2] The government-administered reverse mortgage is called a home equity conversion mortgage (HECM). According to Shan (2011), HECM loans represent over 90% of all reverse mortgages originated in the U.S. market.[3]

The number of households with reverse mortgages has been growing. Figure 1 shows the proportion of homeowner households of age 65 and above that had reverse mortgages between 1997 and 2011. Both the HECM loans and private mortgage loans are included. As the figure shows, the use of reverse mortgages was limited before 2000. In 2001, the share of eligible homeowners with reverse mortgages was about 0.2%. This share increased rapidly since then, reaching 2.1% in 2011. Although the level is still low, the growth motivates our general interest in reverse mortgages and is all the more impressive if one considers that the popularity of RMLs continued to rise even as other mortgage markets remained stagnant through the recent housing market downturn.

Reverse mortgages differ from conventional mortgages in six major ways. First, as the name suggests, a reverse mortgage works in the *reverse* way from the conventional mortgage loan. Instead of paying interest and principal and accumulating home equity, reverse mortgage loans allow homeowners to cash out the home equity they've accumulated. That is why RMLs are targeted to older households.

[2] This section is based on, among others, AARP (2010), Shan (2011), Nakajima (2012), and information available on the HUD website.

[3] Many other reverse mortgage products, such as Home Keeper mortgages, which were offered by Fannie Mae, or the Cash Account Plan offered by Financial Freedom, were recently discontinued, in parallel with the expansion of the HECM market. See Foote (2010).

Second, government-administered HECM loans have requirements different from conventional mortgage loans. These mortgages are available only to borrowers age 62 or older who are homeowners and live in their house.[4][5] Finally, borrowers must have repaid all or almost all of their other mortgages at the time they take out a reverse mortgage. On the other hand, RMLs do not have income or credit history requirements, because repayment is promised not based on the borrower's income but solely on the value of the house the borrower already owns. According to Caplin (2002), RMLs may be beneficial to older homeowners since many of them fail to qualify for conventional mortgages because of income requirements.

Third, reverse mortgage borrowers are required to seek counseling from a HUD-approved counselor in order to qualify for a HECM loan. The goal is to ensure that older borrowers understand what kind of loan they are getting and what the potential alternatives are before taking out a reverse mortgage loan.

Fourth, there is no pre-fixed due date; repayment of the borrowed amount is due only when all the borrowers move out or die. As long as at least one of the borrowers continues to live in the same house, there is no need to repay any of the loan amount. There is no gradual repayment with a fixed schedule, as with a conventional mortgage or line of credit; repayment is made in a lump sum from the proceeds of the sale of the house.

Fifth, HECM loans are non-recourse; borrowers are insured against substantial drops in house prices. Borrowers (or their heirs) can repay the loan either by letting the reverse mortgage lender sell the house, or by repaying. Most use the first option. If the sale value of the house turns out to be larger than the sum of the total loan amount and the various costs of the loan, the borrowers receive the remaining value. In the opposite case, where the house value cannot cover the total costs of the loan, the borrowers are not liable for the remaining amount. The mortgage lender does not have to absorb the loss either, because the loss is covered by government insurance, with the premium included as a part of a HECM loan cost structure.

Finally, there are multiple ways to receive payments from the RML. Borrowers can choose one of five options, and these can be changed during the life of the loan, at a small cost. The first option is a *tenure* RML, where borrowers receive a fixed monthly amount as long as one of the borrowers lives in the house. The second is a *term* RML, where borrowers receive a fixed amount for a fixed length of time. The third option is a *line of credit*, which allows borrowers to withdraw flexibly, up to a limit, during a predetermined drawing period. Finally, *modified tenure* and *modified term* options combine the line-of-credit RML with tenure and term features, respectively. Of the payment options listed, the line-of-credit option has been the most popular. HUD reports that the line-of-credit plan is chosen either alone (68%) or in combination with the tenure or term plan (20%). In other words, it appears that older homeowners use reverse mortgages mainly to flexibly withdraw funds out of accumulated home equity.

How much can one borrow using a reverse mortgage? The starting point is the appraised value of the house, but there is a federal limit for a HECM loan. Currently, the limit is $625,500 for most states.[6] The lesser of the appraised value and the limit is called the *maximum claim amount*

[4]For a household with multiple adults who co-borrow, "age of the borrower" refers to the youngest borrower in the household.

[5]Properties eligible for HECM loans are (1) single-family homes, (2) one unit of a one- to four-unit home, and (3) a condominium approved by HUD.

[6]The limit was raised in 2009 from $417,000 as part of the Housing and Economic Recovery Act of 2008. The

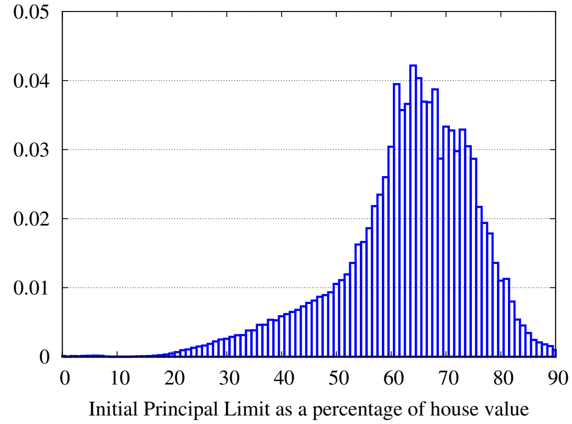


Figure 2: Initial Principal Limit Distribution. Source: Shan (2011).

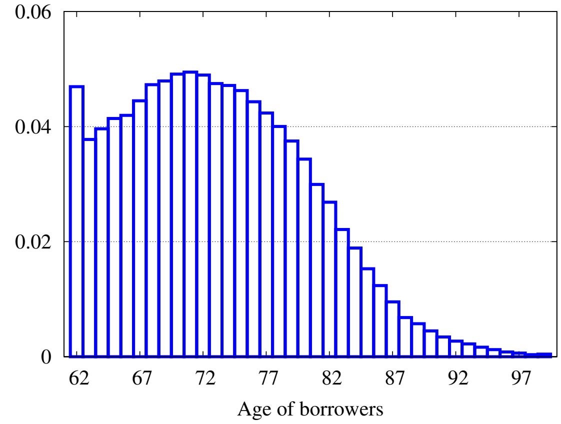


Figure 3: Age at Reverse Mortgage Origination. Source: Shan (2011).

(MCA).[7] Reverse mortgage borrowers cannot receive the full amount of the MCA because there are non-interest and interest loan costs that have to be paid from the house value as well. Moreover, if borrowers have outstanding mortgages, part of the new mortgage loan will be used to pay off the outstanding balance of those other mortgages. Non-interest costs include an origination fee, closing costs, the insurance premium, and a loan servicing fee. The insurance premium depends on the value of the house and how long the borrowers live and stay in the same house. More specifically, the insurance premium is 2% of the appraised value of the house (or the limit, if the value is greater) initially and 1.25% of the loan balance annually.[8] Interest costs depend on the interest rate, the loan amount, and how long the borrowers live and stay in the house. The interest rate can be either fixed or adjustable. In the case of an adjustable interest rate, the borrowing interest rate is the sum of the reference interest rate plus margin charged by the mortgage lender, and there is typically a ceiling on how much the interest rate can go up per year or during the life of a loan. The *initial principal limit* (IPL) is calculated by subtracting expected interest costs from the MCA. The *net principal limit* is calculated by subtracting various upfront costs from the IPL.

The IPL is thus larger the larger the house value, the lower the outstanding mortgage balance, the older the borrower, and the lower the interest rate. Figure 2 shows the distribution of the initial principal limit as a percentage of the underlying house value. It is clear that many homeowners can borrow around 60% to 70% of the appraised house value using reverse mortgages. If the term option is chosen, the total loan amount is divided depending on the number of times the borrower receives payments. With the tenure option, the amount of payment per period is determined by the number of times the borrower is *expected* to receive payments.

To understand who the reverse mortgage borrowers are, Shan (2011) looked at the characteristics of areas with more reverse mortgage borrowers and investigated how those characteristics changed over time. She found that areas with more reverse mortgage borrowers tend to have lower household

$625,500 limit is valid until December 2013.

[7]Private mortgage lenders offer jumbo reverse mortgage loans, which allow borrowers to cash out more than the federal limit. However, borrowers have used jumbo reverse mortgages less and less often as the federal limit has been raised.

[8]The annual mortgage insurance premium was raised from 0.5% to 1.25% in October 2010.

income, higher house value, relatively higher homeowner costs, and lower credit scores. The median house value among reverse mortgage borrowers was $222,000 in 2007, which was about 25% higher than the median house value of all older homeowners ($175,000). Figure 3 shows the age distribution of borrowers at the time of mortgage origination, during 2003-2007. There is a spike at age 62, which is the first eligibility age. Shan (2011) also showed that the distribution is shifting to the left over time, implying that reverse mortgage borrowers were getting younger, with the spike at age 62 becoming more pronounced.

3 Model

We set up the decision problem of retired homeowners and renters, based on our previous work (Nakajima and Telyukova (2012)). Time is discrete and finite, and there is no aggregate risk. Renters choose consumption, saving, and the size of the house to rent each period, subject to uninsurable idiosyncratic uncertainty in health status, medical expenditures, and mortality. We do not allow renters to buy a house. This assumption is motivated by our data (Health and Retirement Study), in which the proportion of retired households switching from renting to owning is small. We also abstract from idiosyncratic rent fluctuations, assuming that rents are constant. We found that adding realistically mild rent fluctuations did not change our results significantly.

Homeowners choose how much to consume and save, and whether to stay in their house or sell and become a renter. Homeowners can borrow against their home equity using conventional mortgage arrangements, but this collateral constraint is age-dependent. In addition to the same shock as renters, homeowners also face idiosyncratic house price and moving shocks. The moving shock forces the homeowner out of her house and is intended to capture the possibility of moving involuntarily into a nursing home as a result of deteriorating health.

Into this benchmark, we introduce reverse mortgage loans for homeowners, which we model as a line of credit, since this is by far the most frequently used option and can be reinterpreted as a term, or, with some assumptions, tenure RML.[9] As we specify later, reverse mortgages offer collateral constraints and cost structure different from conventional mortgages. Finally, homeowners who use reverse mortgages cannot simultaneously borrow using a traditional mortgage, which is a feature of the reverse mortgage contract in reality.

We will characterize the problem recursively. The set of state variables for a household consists of its age i, pension income b, health status m, medical expenditures x, house price p, reverse mortgage indicator k, house size h ($h = 0$ means the household is a renter), and financial asset holdings a. $k = 0$ means a homeowner does not own a reverse mortgage, while $k = 1$ means that he does. Although the states (p, k, h) are irrelevant for renters, we keep them as part of the renters' state space, to keep the dynamic programming problem consistent between renters and owners. Following convention, we omit time subscripts and use a prime to denote a variable in the next period $(t + 1)$.

[9] It is easy to show that the term option, under which a homeowner receives a fixed amount of money every period for a fixed period of time, can be replicated using the line-of-credit option, by drawing a fixed amount of money every period for a fixed period of time. The tenure option adds insurance against longevity and thus theoretically cannot be replicated only by the line-of-credit option. However, it seems that the amount that a borrower can receive every period under the tenure option is calculated with conservatively estimated life expectancy. This implies that a borrower rarely outlives a reverse mortgage, in which case the tenure option can be roughly replicated by the line-of-credit option as well.

3.1 Renters

We start with the renter's decision problem, the simpler of the two household types, since renting is the absorbing tenure state by assumption. Every period, the renter solves:

$$V(i,b,m,x,p,k=0,h=0,a) = \max_{\tilde{h}\in H, a'\geq 0} \Bigg\{ u(i,c,\tilde{h},0)$$
$$+ \beta \sum_{m'>0} \pi^m_{i,m,m'} \sum_{x'} \pi^x_{i+1,m',b,x'} \sum_{p'} \pi^p_{p,p'} V(i+1,b,m',x',p',k=0,h=0,a') + \beta \pi^m_{i,m,0} v(a') \Bigg\} \quad (1)$$

subject to:

$$\tilde{c} + a' + r_h \tilde{h} + x\chi_i = (1+r)a + b\chi_i \quad (2)$$
$$c = \begin{cases} \max\{\underline{c}\chi_i - r_h\tilde{h}, \tilde{c}\} & \text{if } a' = 0 \\ \tilde{c} & \text{otherwise} \end{cases} \quad (3)$$

Naturally a renter has no house ($h = 0$) and no reverse mortgage ($k = 0$). A renter, taking the states as given, chooses consumption (c), savings (a'), and the size of the house to rent ($\tilde{h}$). (m, x, p) are the shocks. $\tilde{h}$ is chosen from a discrete set $H = \{h_1, h_2, ..., h_{\overline{H}}\}$, where h_1 is the smallest and $h_{\overline{H}}$ is the largest house available. a' has to be non-negative, i.e., renters cannot borrow. In other words, only home equity borrowing is available in the model. This choice is motivated by the data, where holdings of unsecured debt among retirees are small.[10] $\pi^m_{i,m,m'}$, $\pi^x_{i+1,m',b,x'}$ and $\pi^p_{p,p'}$ denote the transition probabilities of (m, x, p), respectively. $m > 0$ indicates health levels, with a higher m for better health. The transition of m also includes mortality risk; $m' = 0$ implies that the household does not survive to the next period. Note that health shocks are age-dependent, and medical expense shocks depend on the current health, age, and income of the household. Both assumptions are motivated by the data. Finally, consistent with data, pension income b is different across households, but is assumed to be constant throughout the life of a household.

The current utility of the renter depends on non-housing consumption c, services generated by the rental property (which are assumed to be linear in the size of the rental property $\tilde{h}$), and tenure status o. $o = 1$ represents ownership, while $o = 0$ indicates renting. The tenure status in the utility function is intended to capture the differential private value of owned versus rented housing. Age i in the utility function captures the adjustment we make by the age-specific average household size factor, which weighs utility of couples differently from utility of single households. This factor captures the fact that a younger retired household is more likely to be a couple, and we include couples as well as singles in our data sample. The continuation value is discounted by the subjective discount factor β. Following De Nardi (2004), we assume a warm-glow bequest motive with utility function $v(a')$.

Equation (2) is the budget constraint for a renter. The expenditures on the left-hand side include consumption ($\tilde{c}$), savings (a'), rent payment with the rental rate r_h, and the period's medical expenditures x, which are multiplied by age-specific average household size factor χ_i. The right-hand side includes financial asset holdings and interest income $(1+r)a$ and pension income b, again

[10] We discuss some of the model assumptions and their connection to data in more detail in Nakajima and Telyukova (2012).

multiplied by the age-specific household size factor χ_i. The adjustment by χ_i is motivated by the fact that two-adult households tend to have higher pension income and face higher medical expenses. It is assumed to be age-dependent, to capture the changes in the average household size over the life cycle. Following standard practice in the literature, equation (3) represents the consumption floor, which is provided by the government net of the rental payment, and approximates Medicaid in the data. The household qualifies for this program if it runs down its savings ($a' = 0$) and if the sum of $\tilde{c}$ implied in the budget constraint (2) and the rent payment $r_h\tilde{h}$ is lower than the consumption floor adjusted by household size ($\underline{c}\chi_i$).

3.2 Homeowners Without a Reverse Mortgage

Next we describe the problem of a homeowner without a reverse mortgage ($k = 0$). The choice with respect to moving and mortgage is characterized by the following equation:

$$V(i, b, m, x, p, k = 0, h, a) = \pi^n_{i,m} V_0(.) + (1 - \pi^n_{i,m}) \max\{V_0(.), V_1(.), V_2(.)\}. \tag{4}$$

With probability $\pi^n_{i,m}$, the homeowner experiences a compulsory moving shock. In this case, she is forced to sell the house and become a renter in model parlance, with continuation value $V_0(i, b, m, x, p, k = 0, h, a)$. In the data, this shock represents a compulsory move to a nursing home, and hence the probability depends on age and health status. If the owner is not forced into a nursing home, she has three choices: sell the house and rent, stay in the house ($V_1(i, b, m, x, p, k = 0, h, a)$), or stay in the house and take out a reverse mortgage ($V_2(i, b, m, x, p, k = 0, h, a)$).

The component value functions are defined below. For a homeowner with no reverse mortgage, who decides to move out or is forced out by the moving shock,

$$V_0(i, b, m, x, p, k = 0, h, a) = \max_{a' \geq 0} \Bigg\{ u(i, c, h, 1) + \beta \sum_{m'>0} \pi^m_{i,m,m'} \sum_{x'} \pi^x_{i+1,m',b,x'} \sum_{p'} \pi^p_{p,p'} V(i + 1, b, m', x', p', k = 0, h = 0, a') + \beta \pi^m_{i,m,0} v(a') \Bigg\} \tag{5}$$

subject to

$$\tilde{c} + a' + x\chi_i + \delta h = (1 - \kappa)hp + (1 + r + \mathbb{1}_{a<0}\iota^m)a + b\chi_i \tag{6}$$

$$c = \begin{cases} \max\{\underline{c}\chi_i, \tilde{c}\} & \text{if } a' = 0 \\ \tilde{c} & \text{otherwise} \end{cases} \tag{7}$$

Compared to the problem of the renter, the new features here are that the owner, in the current period, may have a different utility function as represented by $o = 1$ in the function $u(i, c, h, 1)$, he has to pay a maintenance cost δh to keep the house from depreciating, and he receives the proceeds from selling his house hp net of the selling cost κhp. In addition, if the homeowner is in debt at the time of house sale, the interest rate has a mortgage premium ι^m on it, but going forward he can no longer borrow. The mortgage premium is represented by $\mathbb{1}_{a<0}\iota^m$, where $\mathbb{1}$ is the indicator function that takes the value 1 if the condition attached ($a < 0$) is true, and 0 otherwise. Finally, the consumption floor does not include a rental payment in the current period because the owner still lives in his house.

The Bellman equation of a homeowner who stays in the house and does not take out a reverse mortgage in the next period is

$$V_1(i,b,m,x,p,k=0,h,a) = \max_{a' \geq -(1-\lambda_i^m)h} \Bigg\{ u(i,c,h,1) + \beta \sum_{m'>0} \pi^m_{i,m,m'} \sum_{x'} \pi^x_{i+1,m',b,x'} \sum_{p'} \pi^p_{p,p'} V(i+1,b,m',x',p',k=0,h,a') + \beta \pi^m_{i,m,0} \sum_{p'} \pi^p_{p,p'} v((1-\kappa)hp' + a') \Bigg\} \quad (8)$$

subject to

$$c + a' + x\chi_i + \delta h = (1 + r + \mathbb{1}_{a<0}\iota^m)a + b\chi_i \quad (9)$$

The differences from previous equations are that this homeowner can borrow on a traditional mortgage with the age-dependent collateral constraint λ_i^m, and, in the event of death, the estate includes the value of the house (hp'), net of the selling cost to liquidate it ($\kappa hp'$). Moreover, as long as he remains a homeowner, he cannot utilize the consumption floor. In other words, we assume that there is no homestead exemption to qualify for the program.[11] Next is the problem of a homeowner who stays in the house and takes out a reverse mortgage going forward:

$$V_2(i,b,m,x,p,k=0,h,a) = \max_{a' \geq -(1-\lambda^r)h} \Bigg\{ u(i,c,h,1) + \beta \sum_{m'>0} \pi^m_{i,m,m'} \sum_{x'} \pi^x_{i+1,m',b,x'} \sum_{p'} \pi^p_{p,p'} V(i+1,b,m',x',p',k=1,h,a') + \beta \pi^m_{i,m,0} \sum_{p'} \pi^p_{p,p'} v(\max\{(1-\kappa)hp' + a', 0\}) \Bigg\} \quad (10)$$

subject to

$$c + a' + x\chi_i + \delta h + (\nu^i + \nu^r)h = (1 + r + \mathbb{1}_{a<0}\iota^m)a + b\chi_i \quad (11)$$

There are three new features. First, the collateral constraint of the reverse mortgage borrower is λ^r, which does not depend on age. Second, in order to take out a reverse mortgage, the household pays upfront costs and insurance premium proportional to the value of the house, ν^r and ν^i.[12] Finally,

[11] Many states allow homeowners to keep their house, below some threshold value, and still qualify for Medicaid. In Nakajima and Telyukova (2012), we model the homestead exemption explicitly. In that paper, we find that Medicaid is not a quantitatively important reason for homeowners to stay in their homes, unless they are in a very advanced age. In addition, in the data, relatively few homeowners receive Medicaid. Finally, in the data it appears difficult to borrow on an RML and claim Medicaid simultaneously, because the RML is likely to violate income requirements for Medicaid. Thus in this model, we abstract from the exemption.

[12] Notice that collateral limit λ^r and upfront costs of reverse mortgages do not depend on p. This is for computational tractability; ideally, we would make them depend on the house price at the time of RML signing, but that requires keeping that price as an additional state variable, which substantially increases the computational burden. Instead, we assume that collateral limit and upfront costs are proportional to the *average house price*, which is 1.

there is a max operator in the utility from bequests. This captures the non-recourse nature of the reverse mortgage; if the homeowner dies, and the consolidated balance of housing assets and reverse mortgage ($(1-\kappa)hp' + a'$) turns out to be negative, the heirs of the household are not liable for the loss.

3.3 Homeowners With a Reverse Mortgage

Similar to the household without a RML, a household with a RML ($k = 1$) makes the following tenure decision, subject to not being forced into a nursing home with probability $\pi^n_{i,m}$:

$$V(i, b, m, x, p, k = 1, h, a) = \pi^n_{i,m} V_0(.) + (1 - \pi^n_{i,m}) \max\{V_0(.), V_1(.)\} \tag{12}$$

where $V_0(i, b, m, x, p, k = 1, h, a)$ and $V_1(i, b, m, x, p, k = 1, h, a)$ are values conditional on moving out of the house and becoming a renter and of staying in the same house and keeping the reverse mortgage, respectively.

The homeowner with a reverse mortgage who chooses to sell solves

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

$$+ \beta \sum_{m'>0} \pi^m_{i,m,m'} \sum_{x'} \pi^x_{i+1,m',b,x'} \sum_{p'} \pi^p_{p,p'} V(i + 1, b, m', x', p', k = 0, h = 0, a') + \beta \pi^m_{i,m,0} v(a') \Bigg\} \tag{13}$$

subject to:

$$\tilde{c} + a' + x\chi_i + \delta h = (r + \mathbb{1}_{a<0}(\iota^i + \iota^r))a + b\chi_i + \max\{(1 - \kappa)hp + a, 0\} \tag{14}$$

$$c = \begin{cases} \max\{\underline{c}\chi_i, \tilde{c}\} & \text{if } a' = 0 \\ \tilde{c} & \text{otherwise} \end{cases} \tag{15}$$

First, the max operator in the budget constraint captures that moving out entails repayment of the reverse mortgage, as per current legislation. Notice that current RML borrowers are likely to have $a < 0$; the max operator captures the non-recourse nature of the loan, where the lender cannot recover more than the value of the house at the time of repayment. Second, the interest payment for the loan includes the reverse mortgage premium (ι^r) and insurance premium (ι^i) that have accumulated during the term of the loan on a flow basis.

Finally, the homeowner with a reverse mortgage who chooses to stay in his house solves the following problem:

$$V_1(i, b, m, x, p, k = 1, h, a) = \max_{a' \geq -(1-\lambda^r)h} \Bigg\{ u(i, c, h, 1)$$

$$+ \beta \sum_{m'>0} \pi^m_{i,m,m'} \sum_{x'} \pi^x_{i+1,m',b,x'} \sum_{p'} \pi^p_{p,p'} V(i + 1, b, m', x', p', k = 1, h, a')$$

$$+ \beta \pi^m_{i,m,0} \sum_{p'} \pi^p_{p,p'} v(\max\{(1 - \kappa)hp' + a', 0\}) \Bigg\} \tag{16}$$

subject to:

$$c + a' + x\chi_i + \delta h = (1 + r + \mathbb{1}_{a<0}(\iota^i + \iota^r))a + b\chi_i \tag{17}$$

Notice that, in our model, households borrowing on a reverse mortgage can flexibly increase or decrease their loan balance at any time. In reality, reverse mortgage lines of credit are typically restricted from partial repayment until the loan is repaid in full. However, in reality households also can save in financial assets simultaneously with borrowing against a RML, which in our model is ruled out. Thus, we think of the flexible adjustment of reverse mortgage balance in the model as capturing this missing additional saving channel. However, we are thus possibly understating the cost of RML borrowing, because the interest rates earned on savings are typically lower than interest and insurance costs of reverse mortgages, a spread that our model does not capture for equity borrowers.

4 Calibration

We perform the baseline calibration on the version of the model without reverse mortgages, and then add RMLs to this calibrated benchmark to understand the role that reverse mortgages play for retirees, as well as the nature of demand for them. To calibrate the baseline case, we use a two-stage estimation procedure in the style of Gourinchas and Parker (2002). In the first stage we calibrate all the parameters that we can directly observe in the data, while in the second stage we estimate the rest of the parameters to match relevant age profiles of asset holdings that we construct from the Health and Retirement Study (HRS). Section 4.1 covers the first stage and section 4.2 the second stage. We base the second-stage estimation on cross-sectional age profiles, rather than cohort life-cycle profiles as in our past work. The cost of doing this is that we cannot account for cohort effects in the data, because our model lacks them due to stationarity. However, we gain the ability to characterize the entire life cycle in the data, which is not possible in the HRS for a single cohort since it has only about 14 years (8 waves) of usable data at this point. We construct the cross-sectional age profiles of homeownership rates, net worth, housing and financial assets, and home equity debt among retirees from the 2006 wave of the HRS, which is a biennial panel survey of households age 50 and above. Our sample of interest is retirees, so that we do not have to account for labor supply decisions; thus, we focus on those in the data who are age 65 and above, and who self-report as retired, and we include both couples and single households.

We do not include reverse mortgages in the benchmark model even though the debt measurements in the HRS include them. The reason for this choice is that we cannot observe reverse mortgages separately from other equity loans in the survey, and hence we cannot identify who in the sample holds them and how much debt they have. This precludes us from calibrating, for example, the initial distribution to include reverse mortgages explicitly. However, this will not matter for our results because, in 2006, the RML take-up rate was just around 0.6% of eligible households, so reverse mortgages in the sample would have no influence on any of the parameter estimates.

To match the HRS, the model period is set to two years. Households are born in the model at age 65 and can live up to 99 years of age. Table 1 summarizes the calibrated parameter values. The first panel of the table covers parameters estimated in the first stage, while the second panel covers the second stage. The third panel of the table covers parameters associated with reverse mortgage loans, which will be discussed in section 4.3. We discuss sensitivity of our results to these parameter estimates in section 6.

Table 1: Calibration Summary: Model Parameters

Parameter	Description	Value
First-Stage Estimation		
r	Saving interest rate[1]	0.040
ι^m	Mortgage interest premium[1]	0.016
δ	Maintenance cost[1]	0.017
κ	Selling cost of the house	0.066
ρ_p	Persistence of house price shock[1]	0.811
σ_p	Standard deviation of house price shock[1]	0.142
Second-Stage Estimation		
β	Discount factor[2]	0.922
η	Consumption aggregator	0.724
σ	Coefficient of RRA	2.068
ω_1	Extra utility from ownership	5.676
γ	Strength of bequest motive	3.926
ζ	Curvature of utility from bequests	13,248
$\underline{c}$	Consumption floor per adult[2]	13,681
λ^m_{65}	Collateral constraint for age 65	0.396
λ^m_{75}	Collateral constraint for age 75	0.789
λ^m_{85}	Collateral constraint for age 85	0.968
λ^m_{99}	Collateral constraint for age 99	1.000
RML-Related		
ν^r	Upfront cost of RML	0.050
ν^i	Upfront cost of RML insurance	0.020
ι^r	Interest margin for RML[1]	0.016
ι^i	RML insurance premium[1]	0.013
λ^r	Collateral constraint for RML	0.200

[1] Annualized value.
[2] Biennial value.

4.1 First-Stage Estimation

4.1.1 Preferences

Households use discount factor β to discount future value. The following period utility function with constant relative risk aversion is used.

$$u(i,c,h,o) = \frac{\left(\left(\frac{c}{\psi_i}\right)^{\eta}\left(\frac{\omega_o h}{\psi_i}\right)^{1-\eta}\right)^{1-\sigma}}{1-\sigma} \tag{18}$$

η is the Cobb-Douglas aggregation parameter between non-housing consumption goods (c) and housing services (h). σ is the risk aversion parameter. ω_o represents the extra utility attached to owning a house. For renters ($o = 0$), ω_0 is normalized to unity. For a homeowner ($o = 1$),

Table 2: Income Levels[1]

Group	Group 1	Group 2	Group 3	Group 4	Group 5
Income	8,028	14,517	21,330	30,273	48,920

[1] Annualized after-tax income in 2000 dollars. Source: HRS 2006 wave.

$\omega_1 > 1$ represents nonfinancial benefits of homeownership, such as attachment to one's house and neighborhood, as well as financial benefits not captured explicitly by the model, such as tax benefits and insurance against rental rate fluctuation. ψ_i is the age-specific adjustment factor for household size. It is constructed by computing the family equivalence scale associated with the average proportion of single and couple households at each age.[13]

A household gains utility from leaving bequests. When a household dies with the consolidated wealth of a, the household's utility function takes the form:

$$v(a) = \gamma \frac{(a+\zeta)^{1-\sigma}}{1-\sigma}. \tag{19}$$

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

4.1.2 Nonfinancial Income

We group nonfinancial income into five bins, summarized in table 2. Our definition of nonfinancial income includes Social Security, pension, disability, annuity, and government transfer income. Because some of our retirees are only partly retired, we also include labor income in this measure. However, labor income plays a small role in our sample, constituting on average about 6% of total income. We compute the nonfinancial income of households of an age between 63 and 67 in the 2006 HRS sample, sort them, allocate them into five bins equally, and compute the median income in each quintile. Recall that we adjust nonfinancial income b using household size adjustment factor χ_i in the budget constraint of the model. χ_i is constructed using the fact that income of couples is 1.5 times larger, on average, than that of single households.[14]

4.1.3 Health Status and Mortality Risk

As in Nakajima and Telyukova (2012), we group the five self-reported health states in the HRS into three categories: excellent, good, and poor. We also add death as one of the health states. Then we compute two-year transition probabilities across health states, including probability of death, using a pooled 1996-2006 HRS sample. Table 3 shows the resulting transition probabilities for people of ages 65, 75, 85, and 95. As expected, mortality rate is higher for older and less healthy households. Health status is generally persistent, but the persistence weakens with age as health deteriorates.

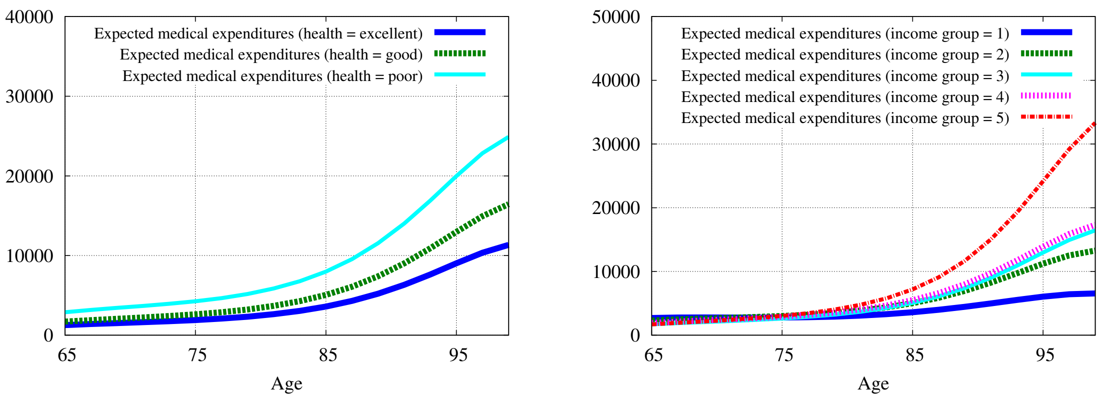
[13] Specifically, ψ_i is computed as $\psi_i = 1.34s_i + 1(1-s_i)$, where s_i is the proportion of single households conditional on age$-i$, and 1.34 is the household equivalence scale for two-adult households (Fernández-Villaverde and Krueger (2007)).

[14] Specifically, χ_i is computed as $\chi_i = 1.5s_i + 1(1-s_i)$, where s_i is the proportion of single households conditional on age i.

Table 3: Health Status Transition (Percent)

Health status transition (age 65)					**Health status transition (age 75)**				
	Dead	Excellent	Good	Poor		Dead	Excellent	Good	Poor
Excellent	1.3	72.8	21.5	4.4	Excellent	3.9	60.1	26.9	9.2
Good	2.2	25.8	53.3	18.7	Good	6.6	21.1	46.9	25.4
Poor	9.6	6.1	20.7	63.7	Poor	16.3	3.8	17.6	62.3
Health status transition (age 85)					**Health status transition (age 95)**				
	Dead	Excellent	Good	Poor		Dead	Excellent	Good	Poor
Excellent	10.5	46.8	27.1	15.6	Excellent	28.5	29.5	19.8	22.3
Good	14.7	17.0	37.8	30.5	Good	32.9	12.9	26.8	27.5
Poor	28.8	5.1	13.2	52.9	Poor	56.9	4.2	13.6	25.3

Source: HRS.



(a) Mid-Income, by Health

(b) Good Health, by Income

Figure 4: Expected Mean OOP Medical Expenditure

4.1.4 Medical Expenditures

We estimate the distribution of log-out of pocket (OOP) medical expenditures by age, health, income quintile, and household size from the pooled HRS sample of retirees. The mean, standard deviation, and probability of zero expenses are estimated as quartics in age and include interaction terms between age and the other three variables. Under the assumption of log-normality of medical expenses, we then compute the expected mean and standard deviation of medical expenses in levels. Figure 4 reproduces expected mean medical expenses for single households in the middle income bin by health, and in good health by income bin. As we would expect, people in worse health pay higher expenses, as do those with higher income. Recall that, in the household budget constraint, medical expenses of each age group are adjusted by the same household size adjustment factor as for income, χ_i.

Table 4: Probability of Moving to Nursing Home (Percent)

	Health status		
Age	Excellent	Good	Poor
65	0.13	0.16	0.60
75	0.41	1.19	1.89
85	3.99	5.96	8.31
95	22.76	18.28	15.83

Source: HRS.

4.1.5 Compulsory Nursing Home Moves

Using the pooled HRS sample from 1996-2006, we compute the two-year probability that an individual moves into a nursing home *and* simultaneously stops being a homeowner, conditional on the household's age and health status. Table 4 shows the probabilities for age 65, 75, 85, and 95. We interpret the event of moving into a nursing home with loss of homeownership as compulsory moves out of the house, which are important to consider given that reverse mortgages become due when borrowers move out of the house. Not surprisingly, the probability is generally higher for older and less healthy individuals. There are two caveats to these estimates. First, not all elderly move into nursing homes involuntarily. If we take into account that some of the moves are voluntary, the probability that a household is forced to move out is upward-biased. On the other hand, some older retirees might move to their children's homes instead of a nursing home. This consideration implies that the probability of a moving shock might be underestimated. Since the data limit how well we can identify these events, our estimates of the moving shock are the best they can be.

4.1.6 Housing and Interest Rate

We create 10 house size bins, by sorting house values of all homeowners of age 63-67 in the 2006 HRS sample, equally allocating them into 10 bins and computing the median value of each bin. Housing requires maintenance, whose cost is a fraction δ of the house value. δ is set at 1.7% per year, which is the average depreciation rate of residential structures in the National Income and Product Accounts (NIPA). When a household sells the house, the sales cost, which is a fraction κ of the sales price, has to be paid. The selling cost of a house (κ) is set at 6.6% of the value of the house. This is the estimate obtained by Greenspan and Kennedy (2007). Grueber and Martin (2003) report the median selling cost as 7.0% of the value of the house.

The interest rate is set at 4% per year (8% biennially). For conventional mortgage loans, we assume a borrowing premium (ι^m) of 1.6% annually. This is the average spread between 30-year conventional mortgage loans and Treasury bills of the same maturity between 1977 and 2009. Following the arbitrage condition standard in the literature, we assume that rent is the sum of maintenance costs and the conventional mortgage interest rate: $r_h = \delta + r + \iota^m$.

To calibrate idiosyncratic house price shocks, we assume that the house price is normalized to one in the initial period and follows an AR(1) process thereafter. Contreras and Nichols (2010) estimate the AR(1) process of house prices for nine Census regions as well as the U.S. as a whole. Their estimate of the persistence parameter associated with the Census regions varies between 0.704 and

Table 5: Selected Characteristics of the Initial Distribution, Age 65, 2006

Health status		Tenure status		Financial asset position	
1 (excellent)	0.46	Homeowner	0.88	Saver	0.79
2 (good)	0.32	Renter	0.12	Borrower	0.21
3 (poor)	0.22				

Source: HRS.

0.940. Their estimate for the national sample is 0.811, which we use as our persistence parameter. Their estimates for the standard deviation of the shocks from Census regions varies between 6.5% and 9.3%, while the estimate from the national sample is 7.9%. On the other hand, Flavin and Yamashita (2002) estimate the standard deviation of individual house prices using Panel Study of Income Dynamics (PSID) and obtain the standard deviation of 14.2%. We use 14.2% as our standard deviation to house price shocks, since the shock in our model is associated with individual house value. The AR(1) process is discretized into a first-order Markov process. Since one period in the model spans two years, while the house price shocks constructed above are at annual frequency, we square the obtained Markov process to make it into a biennial process.

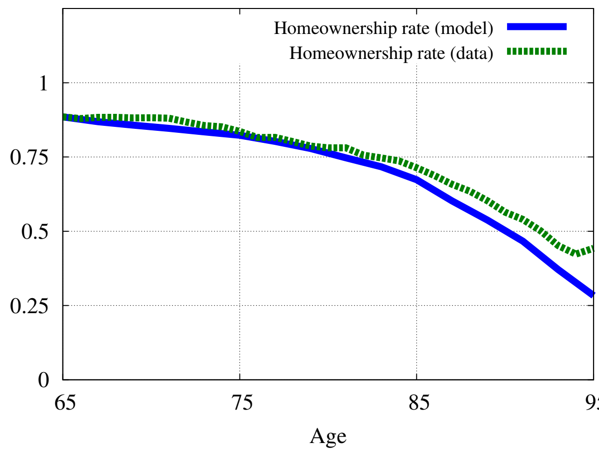
4.1.7 Initial Type Distribution

The type distribution of age-65 households is constructed using the HRS 2006 wave. By taking the initial distribution directly from the data into the model, we capture perfectly in the model empirically relevant correlations across household characteristics, e.g., the correlations between income, housing and financial wealth, health, and homeownership. Table 5 exhibits the dimensions of the initial distribution that we have not already discussed. Half of the households are in excellent health. Homeownership rate is close to 90%. All retirees in the sample are net savers; however, in the language of the model, the financial asset position includes secured debt. By this measure, 79% of the households in our sample are in a net positive financial position at age 65 and the remaining 21% are in a net negative position.

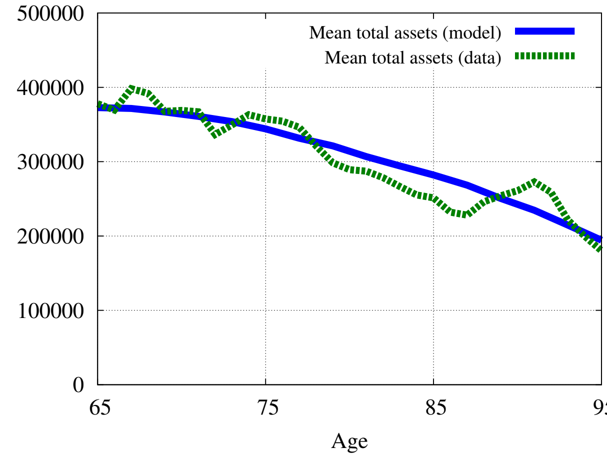
4.2 Second-Stage Estimation

In the second-stage estimation, we match the cross-sectional age profiles of the homeownership rate, mean total, housing and financial asset holdings, and the proportion of retirees in debt. Figure 5 shows the model fit. First, it is valuable to examine the data profiles: dashed green lines in the figure. The homeownership rate is 88% at age 65 and declines smoothly to about 40% by age 95. Mean total assets show a similarly smooth, but slow, decline, from about \$375,000 to about \$200,000. This high mean amount even at age 95 is the statement of the classic "retirement saving puzzle." We analyze in detail the reasons for the lack of dissaving late in life in Nakajima and Telyukova (2012); there we show that housing plays a crucial role in the flatness of this profile.

Financial asset holdings do not decline much over the life cycle for two reasons. First, many households sell their house toward the end of life, as seen in panel (a), which increases financial asset holdings at the expense of housing asset holdings. Second, there is a mortality bias; those with relatively lower wealth die earlier. Therefore, if we look at the average asset holdings of surviving households (balanced panel), the bias tends to push the life-cycle profiles upward. This bias exists

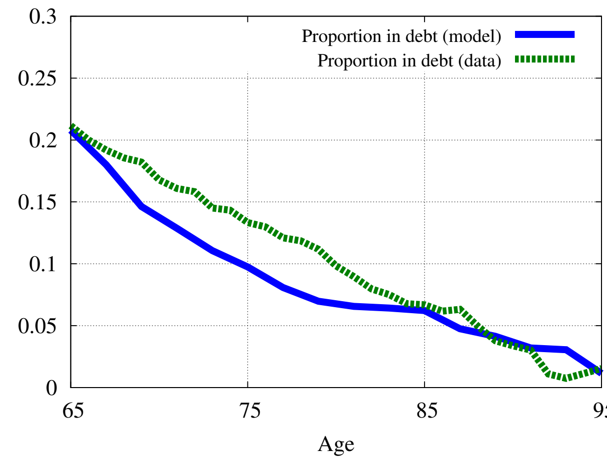


(a) Homeownership rate



(b) Mean total assets

(c) Mean housing and financial assets



(d) Proportion in debt

Figure 5: Model Fit – Age Profiles without RML, Model and Data

both in the data and in the model, since the correlation of health and wealth is built into the initial conditions.

Finally, the proportion of households in debt declines smoothly from 20% at age 65 to nearly 0 at age 95, as households repay the existing collateralized loans or sell their house and become renters. This profile is what primarily pins down the age-specific collateral constraint on traditional mortgages in the model.

The age profiles implied by the model, solid blue lines in the figure, fit the data profiles well. The model slightly underpredicts the homeownership rate toward the end of life, which could be due to an overestimate of compulsory move probabilities late in life, and predicts a smoother mean housing asset profile than appears in the data. The proportion of agents in debt is matched perfectly at later stages of life, but is slightly underpredicted by the model in the earlier years of retirement. The fit presented here yields the smallest sum of weighted squared residuals from the moment condition that compares the model and data moments, with equal weights.

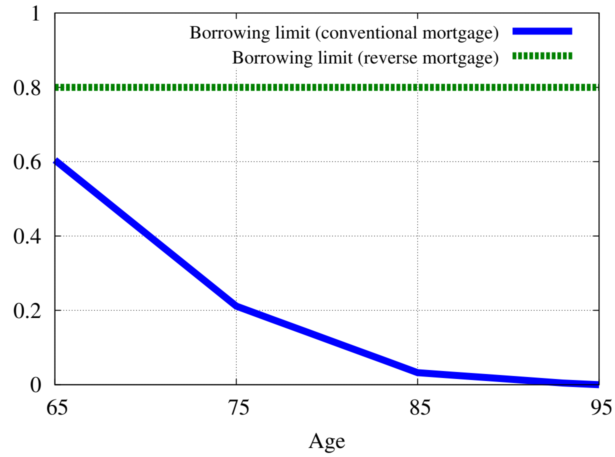


Figure 6: Borrowing Limit as a Proportion of House Value.

Based on this distance criterion, the model produces the following parameter estimates, seen in the second panel of table 1. The estimated discount factor β is 0.92 in biennial terms, which is within the accepted range of estimates in models of this kind, particularly models that account for debt rates in the data. The coefficient of relative risk aversion is just above 2, which is in the middle of the spectrum in the literature. The extra utility from homeownership, at 5.68, suggests that homeownership yields nearly six times the utility benefit of renting in retirement. This estimate captures both financial and nonfinancial benefits of ownership. In Nakajima and Telyukova (2012), we modeled the housing boom and some tax benefits of ownership, absent in this model, explicitly, such as capital gains taxation if one sells the house. In that model, this parameter was lower at 2.5, giving an indication that financial benefits of ownership are significant. The strength of the bequest motive is 3.92, and the preference shifter ζ is 13,248. The consumption floor $\underline{c}$ supported by the government through welfare programs such as Medicaid is estimated to be $13,681$ in 2000 dollars, which aligns with empirical estimates of such program benefits (Hubbard et al. (1994)), once adjusted for inflation.

The age-dependent collateral constraint for conventional mortgages is characterized by $\{\lambda_i^m\}$. We pin down λ_i^m for ages 65, 75, 85, and 99, bounding it above by 1, and linearly interpolate the values between these ages. The result is depicted by the solid line in figure 6. Our estimates are 0.40, 0.79, 0.97, and 1.00, respectively. The profile implies that the collateral constraint tightens quickly for the elderly, which should not be taken literally as a continuously expanding downpayment requirement, for example. In our model, λ_i^m simply captures overall costs of borrowing in a parsimonious way, and the estimates are consistent with the fact that retired households fail income requirements inherent in most conventional mortgage and equity loan contracts (Caplin (2002)).

4.3 Calibration of Reverse Mortgage Parameters

To conduct our experiments, into the baseline calibrated above we introduce reverse mortgage loans. In order to calibrate parameters that characterize RMLs, we rely on the terms of reverse mortgage contracts in the data. The upfront and per-period costs associated with insurance against house price shocks are $\nu^i = 0.02$ and $\iota^i = 0.0125$ per year, respectively. Reverse mortgages are further characterized by the triplet $\{\lambda^r, \iota^r, \nu^r\}$, which captures the collateral constraint, the interest premium, and the upfront cost. We set the interest premium of reverse mortgages to be the same as conventional mortgages: $\iota^r = 0.016$ annually. We set the borrowing limit at $\lambda^r = 0.2$, implying that any older household can borrow up to 80% of the value of their house through reverse mortgage loans. This is in line with the equity limits we see in the data. According to AARP, a 65-year-old RML borrower can take a loan of up to 50% of their home value, while a 90-year old borrower can access up to 75%. These numbers do not include interest and insurance costs, while, in the model, households pay these costs using the proceeds of the loan. Therefore, our borrowing constraint, which is not age-dependent, is slightly looser than the borrowing limit for a 90-year old, under the assumption that the expected interest cost for a 90-year-old borrower is not too big. In figure 6, the dotted line depicts the borrowing limit of reverse mortgages in the model. It is easy to see that reverse mortgages allow homeowners, especially older ones, to borrow more out of the value of their house, at various additional costs.

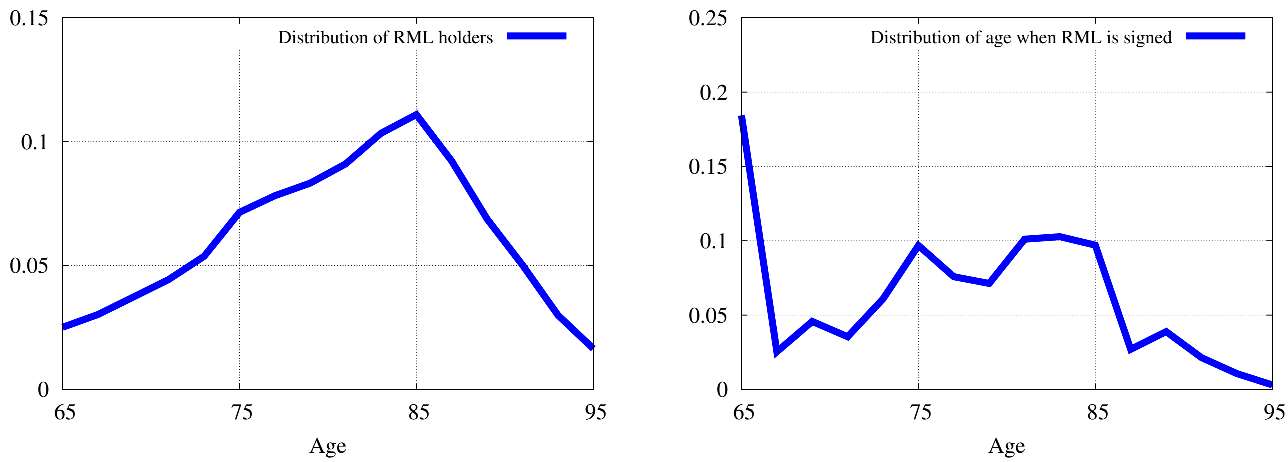
The upfront cost ν^r comes from the data as well. While, in the data, terms of reverse mortgages vary, the typical upfront costs appear to be about 5% of the house value. The origination fee is typically 2% of the house value up to $200,000 and 1% above it, with a cap of $6,000 and a floor of $2,500. Considering that most house values in the model, as in the data, are below $200,000 but half are below $100,000, where the floor of $2,500 binds, 2.5% is reasonable. The closing cost is typically around $2,000 to $3,000. Dividing the amount by the median house value in the sample, we get 2.5% as well. Adding these together, we get $\nu^r = 0.05$; with this value, the model matches the 2011 RML take-up rate of 2.1% perfectly.

5 Results

In this section, we first describe relevant age distribution and life-cycle properties of the model with reverse mortgages and study welfare implications and distribution of gains of reverse mortgages. Then we turn to counterfactual experiments to quantify, in turn, how risk, bequest motives, and the terms of the current RML contracts affect demand for reverse mortgages. Finally, we use the model to quantify market potential for reverse mortgages.

5.1 Distribution of Reverse Mortgage Borrowers

Figure 7 shows two aspects of the age distribution of households who hold a reverse mortgage loan in the model. Panel (a) shows the distribution of the *current age* of reverse mortgage borrowers. Not surprisingly, it is hump-shaped; many of the households who have signed a reverse mortgage earlier survive into their 70s and 80s. Between age 85 and 95, the proportion declines as households with a reverse mortgage die or sell their house, voluntarily or involuntarily, and become renters. Panel (b) is the distribution of age *at which a reverse mortgage loan is signed*, among all households who currently hold a reverse mortgage loan. This figure is a direct counterpart of figure 3. Four points stand out in the comparison. First, the levels are different, partly due to different age bins in the model and data. Each point in panel (b) of figure 7 captures two years of age, while each bar in figure 3 captures only one year of age. Second, the general shape of the distribution – initial spike and a hump shape after the initial spike – is quite similar between the two figures. Third, the initial spike in the data is at age 62, while it is at age 65 in the model. This is obviously because the initial age in the model is 65, while RMLs become available when a household (the youngest member of it) becomes 62 years old. The initial age in the model is not set at 62 because a large proportion of households are still working and earning labor income and thus do not fit our sample of retirees.



(a) Age Distribution of RML Borrowers

(b) Age Distribution at RML Origination

Figure 7: Distribution of RML Borrowers

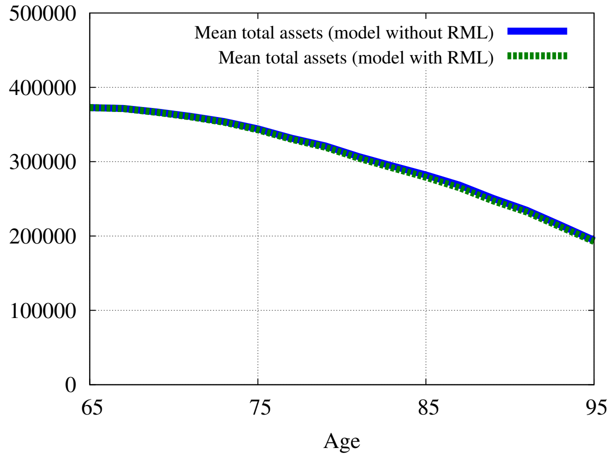
Fourth, our model correctly predicts the drop-off of households who take a reverse mortgage later in their life. However, in the model, the peak of the distribution after the initial spike is between ages 75 and 85, while in the data the peak is around ages 67 to 77. Some of this mismatch is mechanical and due to the missing ages 62-64 in the model. This necessarily shifts the graph to the right. In addition, the data have a trend in reverse mortgages, which produced a "cohort effect" over time: As the take-up rate rose, it rose disproportionately among younger retirees, which shifted the distribution to the left. Since the model is stationary, this cohort effect is absent in the model. Shan (2011) confirms this.

5.2 Life-Cycle Profiles in Model with Reverse Mortgages

Figure 8 shows the life-cycle profiles, discussed previously, in the model with reverse mortgages relative to the benchmark without. The aggregate effect for mean assets, be it total (panel (a)), financial or housing (panel (b)), is small, which is to be expected given the low take-up rate of reverse mortgages. Notice that reverse mortgages enable people to stay in their house longer, which slightly raises the homeownership rate in the model with RMLs (panel (c)). The most observable difference between the two models is in the proportion of households who are in debt (panel (d)): this proportion is clearly higher in the model with reverse mortgages, where retirees acquire a relatively flexible, if costly, means of borrowing against their home equity, compared with the more restrictive conventional mortgage.

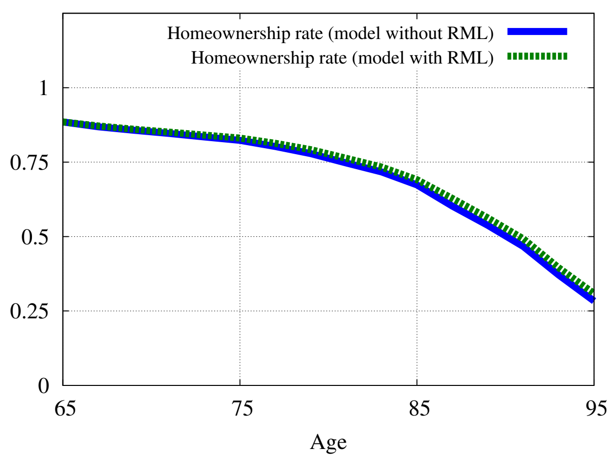
5.3 Take-Up and Benefits of Reverse Mortgage Loans

Table 6 compares the take-up rate of reverse mortgages in the model and in the data. As previously discussed, the model nearly perfectly matches this rate, at 2.12% of retired homeowners in the model and 2.15% in the data. The table also shows the breakdown of RML take-up by household type. Reverse mortgages are far more popular among homeowners with outstanding mortgages (12% take-up rate, versus 0.17% of those with no mortgage debt), low income (7.6% versus 0.5% for highest income group), and in poor health (2.8% against 1.6% for households in excellent health).

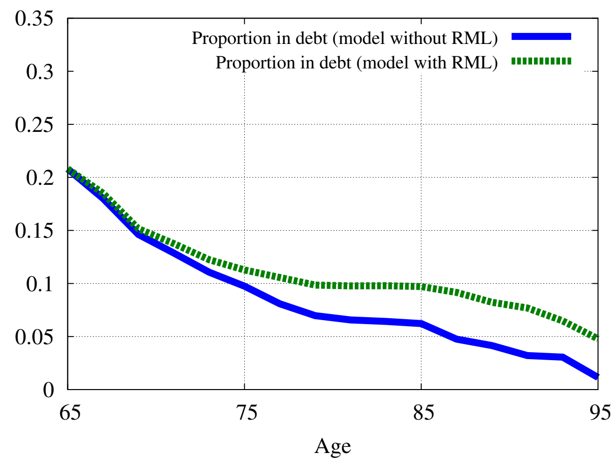


(a) Mean total assets

(b) Mean housing and financial assets



(c) Homeownership rate



(d) Proportion in debt

Figure 8: Age Profiles in Models with and without RMLs

These characteristics of RML borrowers are qualitatively consistent with the data, although we lack necessary micro-data on reverse mortgages to compute direct comparisons. For example, Redfoot et al. (2007) find that households are likely to use RMLs to repay outstanding mortgage debt and to pay for medical expenses, when their income is insufficient to cover these needs in other ways.

Table 7 quantifies expected welfare gains from the availability of reverse mortgages. This is measured as a one-time transfer at age 65, in 2000 U.S. dollars, that would make households in the economy without reverse mortgages indifferent, in expected terms, to being in the economy with RMLs. Note that no household in the model is worse off by having the option to take a reverse mortgage. Moreover, only homeowners gain from the introduction of reverse mortgages. However, we also compute the gain by averaging it across all households, owners and renters, in the economy. The welfare gain to households of living in a world with reverse mortgages is equivalent to a one-time transfer of \$1,000 per person, or 4.6% of median annual after-tax income, and 87% of all the retirees (i.e., almost all the homeowners) value, ex-ante at age 65, the option of taking out a reverse

Table 6: Take-up Rate of RMLs, Share of Homeowners

	Take-up rate (percent)
Data[1]	
All homeowners	2.15
Model	
All homeowners	2.12
No outstanding mortgages	0.17
With outstanding mortgages	11.99
Low income	7.55
Medium income	1.11
High income	0.51
Poor health	2.81
Good health	2.07
Excellent health	1.58

[1] 2011 American Housing Survey.

mortgage at some point in the future, though most do not, ex-post. The welfare gain is higher for homeowners ($1,130), and higher still among those who have outstanding traditional mortgages ($1,465 per person), because the RML gives them the ability to keep borrowing against the value of their house while the collateral constraint on a conventional mortgage would tighten. Low-income households value the option more than high-income households ($1,963 versus $369) and those in poor health more than those in excellent health; in both cases, the ability to take a reverse mortgage at some point in the future is valuable for the purpose of relieving liquidity constraints, either due to low income or to large medical shocks. Welfare gains are increasing, in absolute terms, in the value of the house, which is not surprising, since a more expensive house entails more equity for the potential borrower; those with the largest house have a welfare gain of $3,330. The percentage of those who gain, ex-ante, from introduction of RMLs in each line of the table reflects the proportion of homeowners in each group. Overall, our findings are consistent with those of Shan (2011).

5.4 The Role of Bequest Motives and Uncertainty for Reverse Mortgage Take-Up

In the first set of experiments, we investigate how the risks that retirees face, as well as bequest motives, affect RML take-up, since these are the factors that determine more generally how households (dis)save in retirement. Table 8 shows the take-up rate among homeowners in the model with several counterfactual experiments, as well as the associated welfare gains for all households, measured as before. First, we evaluate the model without medical expenditure shocks; to do this, we assume that all households have to pay the mean of the medical expenditure distribution, conditional on the current household type (age, income, and health status). In this case, the take-up rate drops to 1.97%, all other things equal. If we shut off medical expenditures altogether, even fewer households take a reverse mortgage (1.73%). These experiments demonstrate that, in the baseline specification,

Table 7: **Welfare Gain from Reverse Mortgages**

	Welfare gain[1]	Proportion with gain
All households	1,000	0.874
All homeowners	1,130	0.987
Among homeowners		
No outstanding mortgages	1,027	0.996
With outstanding mortgages	1,465	0.958
Low income	1,963	0.945
Medium income	1,022	0.999
High income	369	1.000
Poor health	1,165	0.981
Good health	1,180	0.989
Excellent health	1,077	0.989
With smallest house	509	0.989
With largest house	3,330	0.976

[1] Welfare gain is measured by the one-time income at age 65 that would make expected life-time utility of those with access to reverse mortgages equal to expected life-time utility without. Measured in 2000 dollars.

about 20% of households use reverse mortgages to pay exclusively for medical expenses, especially larger ones, while staying in their homes. In fact, we find that an average 6% of model households who experience a large medical expense shock in a given period take out a reverse mortgage in that period. As a result, without the medical expense risk, the welfare gain from RMLs falls to $706 per household, and the share of those who gain falls to 44%.

Nursing-home move risk dampens demand for reverse mortgages, as does house price risk. Removing compulsory nursing-home move shocks increases the RML take-up rate to 2.5% of homeowners. This result echoes the result in Michelangeli (2010). The worst outcome for RML borrowers is to face a compulsory moving shock shortly after paying the large upfront cost of a reverse mortgage but before utilizing the line of credit. Eliminating this possibility makes these loans more attractive as a way of relieving possible liquidity constraints while staying in the house longer. In this case, the welfare gain rises to $1,418 per household. Similarly, removing idiosyncratic house price uncertainty increases the take-up rate to 2.9% of retired homeowners. This increase might seem counterintuitive at first, because one of the benefits of RMLs is their non-recourse nature. However, temporary house price shocks work in the same way as moving shocks. If a household observes a temporary increase in house value, it may want to sell the house for the capital gain, though it trades off against extra utility that holding the house yields. This implies that the expected duration of tenure as a homeowner is shorter with house price shocks, and thus the value of

Table 8: Impact of Uncertainty and Bequest Motives on RML Demand

		Take-up rate, homeowners	Welfare gain, all households[1]	Prop. with gain, all households
1	Baseline model	2.12	1,000	0.874
2	No medical expense risks	1.97	759	0.560
3	No medical expenses	1.73	706	0.442
4	No moving shocks	2.52	1,418	0.874
5	No house price shocks	2.85	766	0.841
6	Expected house price boom (+4.5%)	8.32	7,145	0.882
7	Expected house price drop (−4.5%)	0.83	177	0.839
8	No bequest motive	16.29	9,616	0.878
9	No moving shocks, no medical expenses	2.24	998	0.449
10	No house price shocks, no medical expenses	2.80	661	0.259
11	No bequest motive, no medical expenses	23.41	11,331	0.879

[1] See note 1 of table 7.

reverse mortgages is lower. The welfare gain in the world without house price shocks is $766 per household, reflecting a reduction of risk.

Next, we add to the model an expectation of deterministic house price growth of 4.5% per year, which is the average real house price appreciation rate between 1996 and 2006. The result is a fourfold increase in demand, to 8.3%. The increase is intuitive: When households expect house price growth, they want to front-load consumption by borrowing more. In this case, the welfare gains for RML borrowers rise significantly, to $7,145 per household. This result is consistent with the observed rapid increase in the RML take-up rate in the period 2000-07, shown in figure 1, which may thus have been the result of house price appreciation expectations.

We also run the symmetric experiment of assuming that households expect house prices to drop, deterministically, by 4.5% per year. This has the opposite, though smaller in magnitude, effect of the expected housing boom, dampening the demand for reverse mortgages to less than half of the benchmark level. Even though expected price is dropping, some households will still use reverse mortgages for medical or non-medical consumption. This result may seem to contradict the rise in RML demand after 2007. The clue lies partly in the predictable nature of the decline in the model: It is hard to argue that the recent collapse of the housing market was predicted by homeowners, and expectations matter for this result. In addition, the housing market bust coincided with a wider recession that is not in the model, forcing more households to rely on reverse mortgages for consumption than the model predicts and countering the dampening effect described above. Full analysis of this hypothesis is beyond the scope of this paper, as it would require a set-up with aggregate dynamics.

Next, we recompute the model without the bequest motive, setting $\gamma = 0$. In this scenario, the RML take-up rate increases nearly eight times, to over 16% of homeowners. It is intuitive that bequest motives significantly dampen RML demand, since retirees want to keep their wealth in order to pass it on to heirs. Instead, without bequest motives, older homeowners are happy to decumulate wealth more quickly, and reverse mortgages allow them to do so without moving out of the house. Notice that, in this case, the magnitude of the welfare gain to households from the availability of reverse mortgages is also very large compared to the benchmark case, at $9,616 per household.

Finally, we investigate in more detail how households in the model use reverse mortgages. As we established, many model homeowners use RMLs to pay for medical expenses. However, we also showed that some features of the environment dampen RML demand significantly and may change the purpose of RML borrowing. In the last three rows of table 8 , we examine these possible changes by shutting off medical expenses in the versions of the model without house price shocks, moving shocks, and bequest motives. In the world without moving shocks, 2.2% of homeowners use RMLs for non-medical consumption; without house price shocks, 2.8% do. The dramatic result is in the world without bequest motives, where 23% of households use RMLs for non-medical consumption. This explains the large welfare gains from RMLs that we documented above.

Notice, incidentally, that while medical expenses boost RML demand in the model with bequest motives (lines 1 versus 3 in the table), in the model without bequests, medical expenses dampen RML demand (lines 8 versus 11). This results from differing reasons for saving in the two models, as well as differing consumption uses of reverse mortgages. In the model with no bequest motives, many households spend down their housing wealth for non-medical consumption. However, if medical expense risk does exist, then it creates a precautionary motive that dampens the desire to dissave. If, instead, households have a bequest motive, since they have precautionary savings, they use reverse mortgages only when they are truly constrained (for example, by existing mortgage debt). In this setting, medical expenses exacerbate that constraint for more households, thus boosting the take-up rate of the loans.

In sum, the model suggests that, conditional on the existing RML contract, households do not take out reverse mortgages for the same reasons that they do not decumulate their assets rapidly in retirement, i.e., due to precautionary motives in the face of risks that they face, and to the bequest motive. Next we examine the RML contract itself.

5.5 The Impact of Reverse Mortgage Terms on RML Demand

In this section, we explore how demand for reverse mortgages is affected by their current terms, in response to the popular claim that the high costs of RMLs are to blame. Table 9 summarizes the results. First, we consider the impact of a change in RML terms introduced in October 2010 by the Federal Housing Administration. The FHA introduced a new type of RML known as the HECM Saver. In order to reduce the oft-criticized upfront costs of reverse mortgage loans, the HECM Saver only requires upfront insurance premium of 0.01% of house value, down from 2%. However, since a lower insurance premium exposes the government, i.e., the insurer, to larger house price risk, the amount of equity that a borrower can extract using HECM Saver has been lowered as well. The AARP states that this amount decreases by 10-18 percentage points, depending on borrower age.

We compute RML demand in a counterfactual model economy where the HECM Saver, instead of the regular reverse mortgage, is available. To do this, we reduce the upfront insurance premium,

Table 9: Reverse Mortgage Loans with Alternative Terms

		Take-up rate, homeowners	Welfare gain, all households[1]	Prop. with gain, all households
1	Baseline model	2.12	1,000	0.874
2	HECM Saver[2]	1.92	1,196	0.872
3	Lower (0.01%) upfront insurance premium	2.57	1,315	0.874
4	Lower (65%) borrowing limit	1.53	893	0.872
5	No insurance (recourse)	3.11	1,596	0.874
6	Zero upfront cost	3.50	1,928	0.876
7	Recourse and zero upfront cost	5.50	2,859	0.876

[1] See note 1 of table 7.
[2] Upfront cost down to 0.01% of house value, but the borrower can access only up to 65% of equity.

to $\nu^i = 0.0001$, and allow reverse mortgage borrowers to extract only 65% of their equity, down from the 80% in the benchmark, reflecting the AARP estimate. The first two rows of table 9 compare the baseline model and the counterfactual model with HECM Saver RMLs. We find that the take-up rate of reverse mortgage loans falls, from 2.1% to 1.9% of homeowners. The model thus predicts that homeowners value access to additional equity more than lower insurance costs up front. On the other hand, interestingly, the average welfare gain of having the option to purchase the HECM Saver is higher ($1,196) than the welfare gain in the model with the standard RML ($1,000). This implies that those who do utilize the HECM Saver benefit more than from the standard RML through the lower upfront insurance premium. To disentangle the above experiment further, we compute in rows 3 and 4 the effect on RML demand of lowering the upfront insurance cost separately from lowering the borrowing limit, by the same amounts as the HECM saver. As expected, lowering the upfront insurance premium in isolation raises the take-up rate somewhat, to 2.6%, but the impact is quantitatively stronger from lowering the borrowing limit, which reduces the take-up rate to 1.5% of homeowners.

This result does not mean that the HECM Saver is hurting retired homeowners, because the Saver is available on top of the standard reverse mortgages in reality while it replaces the regular reverse mortgage in the model. But the lower take-up rate in the model with the HECM Saver suggests that providing it in addition to the standard reverse mortgage loans would not create a substantial increase in the demand for reverse mortgage loans.

As we discussed, reverse mortgages offer a combination of benefits. First, borrowers can access more of their home equity. Second, reverse mortgage loans offer (mandatory) insurance against house price declines, through their non-recourse nature. In the next experiment, we disentangle the relative magnitude of the benefits by shutting off the insurance part of reverse mortgages. We do so by setting insurance costs (ι^i and ν^i) to zero and making the RML a *recourse* loan. That is, we change the terms so when the borrower dies or moves out and the RML is consolidated, the borrower is liable for any excess loan amount. One point to note in this experiment is that

Table 10: RML Market Potential of a Recourse Reverse Mortgage

	Take-up rate, homeowners	Welfare gain, all households	Prop. with gain, all households
Basic deterministic life cycle[1]	31.44	15,310	0.860
Basic stochastic life cycle[2]	37.50	26,461	0.879
Basic stochastic life cycle + bequest motive	8.59	3,504	0.541

[1] Life-cycle model with deterministic life span, no bequest motives, no idiosyncratic risks.
[2] Life-cycle model with stochastic life span, no bequest motives, no idiosyncratic risks.

households can always accumulate the RML balance and then default, using the consumption floor, when they sell the house; hence the loan cannot be made a perfect recourse loan. However, this likely mirrors the possibility of default in the data as well.

Row 5 of table 9 shows that changing the RML to be a recourse loan boosts the take-up rate by 47%, to 3.1% of homeowners. Notable also is the resulting increase of nearly 60% in the welfare gain from reverse mortgages. Thus our model predicts that retirees do not value the insurance aspect of the RML. There are three reasons for this. First, most RML borrowers in the model carry relatively small balances of reverse mortgages when the loans become due, and thus the probability of being unable to repay is small. Second, borrowers have access to the publicly provided consumption floor, which captures welfare programs such as Medicaid. This makes the additional insurance in the RML contract less valuable to older households. Third, since we do not model the big swings in housing prices that have been observed since the mid-2000s, we could be underestimating the house price risk that households face and, hence, the insurance benefit from reverse mortgages.

Row 6 of the table shows the experiment where we arbitrarily reduce the upfront costs to zero, for a non-recourse RML. In this case the take-up rate increases significantly relative to the benchmark, to 3.5%, demonstrating that high upfront costs do play a role. To summarize, the largest gains in RML demand would be made from making the reverse mortgage a recourse loan, or from eliminating upfront costs. In this case, the model predicts a 50% or greater increase in demand. This begs the question of the potential market size for reverse mortgages. We turn to this next.

5.6 Market Potential of Reverse Mortgages

In this set of experiments, we quantify market potential for reverse mortgages in our model in two different ways. The first way is the most feasible in the current environment; this result is in row 7 of table 9. Following our discussion above, we compute the demand for a hypothetical recourse reverse mortgage with zero upfront costs. In this case, we get an increase in demand of 260%, to 5.5% of retirees. We interpret this as the largest potential market size for reverse mortgages absent drastic policy intervention and in the absence of large house price swings.

In table 10, we show experiments designed to gauge the broadest scope for reverse mortgages in the life-cycle setting we use, with more drastic, though perhaps less practical, policy implications. Here, we model again the recourse reverse mortgage with zero upfront costs, and apply it to three stripped-down versions of the benchmark model. First, we remove from the benchmark all the idiosyncratic risk, including longevity uncertainty, as well as the bequest motive, which yields a basic deterministic life-cycle model, the most counterfactual case but theoretically interesting. Second, we add back longevity risk, making the life span stochastic. Finally, we add back the bequest motive. Our idea here is that policy intervention could possibly dramatically reduce the nature of risk that retirees face by providing more public insurance, but it cannot easily remove bequest motives or longevity risk.

The striped-down models without the bequest motive produce high take-up rates of 31% and 38%, respectively. Uncertain longevity increases demand for the loans because when retirees live deterministically to age 99, they need to finance their consumption for longer, which induces them to borrow less using reverse mortgages. When we add the bequest motive to the model with longevity risk, the take-up rate goes down to 8.6%. We interpret this to be the largest potential size for the reverse mortgage market, in the case of recourse reverse mortgages, and policy being set to target a large reduction of existing health, medical expense, and nursing home risks through measures like universal health care and long-term care.

As we discussed before, Merrill et al. (1994) and Rasmussen et al. (1995) each compute the proportion of homeowners who would benefit from having the RML option, obtaining 9% and 80%, respectively. Although these and other studies estimate a broad range of numbers for this market potential, all seem to agree that the market for reserve mortgages can be larger than the 2.1% take-up rate in 2011. It is often argued that one of the main reasons that the market falls short currently is that, in addition to high costs that households face, they do not know, or do not know enough, about reverse mortgages. Our experiments in a *stationary* economy, taken together, suggest that even when all households understand the benefits of RMLs, and absent large swings in housing prices, the take-up rate of reverse mortgages could be increased to around 5.5%, if policy or private lenders were to lower existing insurance and upfront costs, which is a substantial increase over the current take-up rate, but far from the majority of older households. Even in the most extreme case of a significant reduction in existing risks that retirees face, the take-up rate of reverse mortgages increases only to 8.6%.

6 Sensitivity Analysis

The results presented above are all subject to the benchmark model calibration. One of the key mechanisms by which retirees decide how much to save or borrow in retirement is the interplay of the precautionary motive and the bequest motive. The identification of the relevant parameters (σ and γ) is difficult to ascertain formally in this setting, as we discuss extensively in Nakajima and Telyukova (2012); this is a shortcoming of most life-cycle models with a warm-glow bequest motive. Thus, in this section we perturb the calibration to demonstrate sensitivity of our results.

In this experiment, as in our previous work, we nearly double our estimated coefficient of relative risk aversion from our value of 2.07 to 3.81, which is the point estimate from a life-cycle model of retirement similar to ours, albeit without housing, in De Nardi et al. (2010). Then, we re-estimate the model to match the same targets that we use in the benchmark. The fit of this model, measured by the weighted squared distance between data and model moments, deteriorates relative to the benchmark, particularly for the homeownership profile and the age profiles of total and financial assets, but still produces reasonable age profiles. With this parameter specification, we have an increase in the strength of the bequest motive γ, but ζ, the preference shifter for bequests, also increases, which makes bequests more of a luxury good. The result of this perturbation is

Table 11: Alternative Calibration and Results

Parameter	Description	Model with $\sigma = 3.81$
β	Discount factor[2]	0.907
η	Consumption aggregator	0.732
σ	Coefficient of RRA	**3.810**
ω_1	Extra utility from ownership	4.926
γ	Strength of bequest motive	4.697
ζ	Curvature of utility from bequests	24,218
$\underline{c}$	Consumption floor per adult[2]	14,663
λ^m_{65}	Collateral constraint for age 65	0.301
λ^m_{75}	Collateral constraint for age 75	0.720
λ^m_{85}	Collateral constraint for age 85	0.936
λ^m_{99}	Collateral constraint for age 99	1.000
Results:	Take-up rate, homeowners	2.31
	Welfare gain, all households	1,562
	Proportion with gain, all households	0.84
	Recourse + zero upfront cost, take-up rate	4.73
	Basic stochastic life cycle + bequest motive, take-up rate	11.80

[1] Annualized value.
[2] Biennial value.

a very similar reverse mortgage take-up rate of 2.3%, which is comforting given that we do not target the empirical take-up rate in the calibration process. Taking again the two market potential experiments, we get the take-up rate of 4.73% for a recourse RML with zero upfront costs, and 11.8% in the model with no idiosyncratic shocks except longevity risk. The numbers are, respectively, below and above the benchmark rates of 5.5% and 8.6%, but the overall message remains the same.

This message is also robust to other, more arbitrary, perturbations of the model calibration, although the specific take-up rates can be made to increase. For example, if we set $\sigma = 3.81$ as above, but arbitrarily *only* allow the strength of the bequest motive to adjust, we get $\gamma = 0.5$, and in this case, the baseline take-up rate of reverse mortgages increases to 3.6% (not in the table). This model is a worse fit to the targets, as measured by squared weighted distance and obviously does not replicate the RML take-up rate either. However, it is instructive to observe that, in this extreme theoretical case, the striped-down stochastic life-cycle model with bequest motives predicts the upper bound of the reverse mortgage market to be 21%. This is higher than the baseline result of 8.6%, because precautionary savings decrease significantly more in the absence of most idiosyncratic risk. Still, this number is far from the majority of retirees.

7 Conclusion

In this paper, we analyze reverse mortgage loans using a calibrated structural model of life in retirement where older households make decisions about consumption, saving, housing, and reverse mortgages. We find that the expected welfare gain of reverse mortgages is sizable – equivalent to $1,000, or nearly 5% of median annual after-tax income, in a one-time transfer for all households and even higher for homeowners. Our model indicates that under the current environment and RML terms, reverse mortgages are used by about 20% of the borrowers to pay for medical expenses while allowing them to remain in their home. The model also predicts that RMLs are particularly popular among lower-income and lower-wealth households, as well as households in poor health, which is consistent with RML use in the data.

Through counterfactual experiments, we identify that, conditional on the existing RML contract in the data, bequest motives, compulsory nursing-home moving shocks, and house price fluctuations all dampen RML demand to various degrees. However, not surprisingly, we also find that the costs of the RML contract are an important determinant of demand. In particular, the insurance costs inherent in the current contract dampen RML demand because households do not value this insurance, owing to relatively low borrowed amounts and government-provided insurance such as Medicaid. Along these lines, the model predicts a 50% increase in demand if the reverse mortgage were made a recourse loan. On the other hand, the HECM Saver loan of 2010, which lowers the upfront insurance costs in exchange for lowering the total amount of equity accessible to the borrower, actually lowers RML demand among homeowners, which suggests that adding this option to the already existing RML contract is not likely to boost demand significantly. Finally, by lowering upfront costs of RMLs and making RMLs recourse, the loan could reach the market size of 5.5%, which is still far from the majority of retirees. One possible interpretation of these results is that, given the risk that lenders have to take on to offer the RML and given retiree preferences and risks, the resulting contract is too expensive to be desirable to the majority of homeowners, so that many are better off selling their homes in the event of needing to liquidate their home equity, as detailed in Nakajima and Telyukova (2012).

The above results come from the model where households do not face aggregate trends in house prices. In experiments, we find that if households expect a housing boom of the magnitude of 2000-06, this quadruples demand for reverse mortgages because households would want to front-load consumption by borrowing, then repay from the capital gains. In the data, we have observed a run-up in RML demand during the housing boom consistent with this story, as it could be postulated that households continued to expect price growth throughout those years. However, we have also observed this increase continuing in the data through the housing bust. This can still be consistent with the findings of the model. The decrease in house price growth in and after the Great Recession could dampen the take-up rate of reverse mortgages, in a mechanism opposite to the one just described, as long as it is perfectly predicted. At the same time, some homeowners might be using reverse mortgages more extensively in response to the downturn, in order to relax the increased borrowing constraint that they face, particularly if the downturn was a surprise. Our model cannot be used to formally evaluate these possibilities because we do not model aggregate dynamics and expectations about them. We leave this issue for future research.

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