Reverse Mortgages, Housing, and Consumption: An Equilibrium Approach

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Abstract

We incorporate reverse mortgages (RMs) into an equilibrium life-cycle model to assess their effects on household decisions, mortgage markets, and housing prices. We show that they increase housing prices and mortgage rates while reducing house price volatility. Households with access to RMs experience lower consumption growth volatility and reduced refinancing needs. Those with the lowest income enjoy the largest consumption-smoothing benefits and welfare gains. We decompose RMs' effects into direct and price feedback effects, with different implications for consumption growth volatility and welfare. Finally, households would require higher social security benefits to attain the same welfare level without RMs.

JEL Classifications: G21, E21, J14

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1 Introduction

Financial instability in late life has become a global challenge in recent decades due to rising life expectancy, growing socioeconomic inequality, and limited public resources for social security systems, which puts pressure on private savings for retirement.[1] And most household wealth accumulates in the form of illiquid housing assets.[2] Moreover, some households make suboptimal pension decisions, such as early withdrawals. This all leads to the phenomenon of "equity-rich and cash-poor" households (Caplin (2000)).

Reverse mortgages (RMs) can address the issue. They allow older homeowners to extract housing equity in order to finance retirement consumption without moving or downsizing. Further, they require no repayment until termination, and they provide non-recourse protection if the outstanding balance exceeds the house value, with government insurance covering any shortfalls. As a result, the RM market has expanded substantially over the past three decades. RM borrowing conditions are closely tied to macroeconomic fluctuations: RM interest rates typically move with adjustable mortgage rates, while housing prices vary over the business cycle, jointly determining borrowing capacity and repayment risk. RM take-up is also disproportionately concentrated among younger retirees and unmarried households, highlighting the role of interest rates, housing conditions, and demographic heterogeneity in shaping demand. However, RMs' institutional design and equilibrium interaction with credit and housing markets complicate the evaluation of their effects on households, financial markets, and public retirement programs, particularly across macroeconomic states.

To assess the effects of RMs, we study four central questions. How does access to RMs affect household behavior over the life cycle? How does introducing them reshape equilibrium outcomes in housing and mortgage markets, including house prices, borrowing costs, and volatility across macroeconomic states? What are the welfare consequences across heterogeneous households, and how are these effects distributed by age, income, and homeownership status? Finally, to what extent can RMs reduce the fiscal burden on public retirement programs?

To address these questions, we develop a general equilibrium model with RMs and conventional mortgages, featuring heterogeneous households, competitive lenders, and endogenous house prices. We also consider different relationships between the interest rate and the exogenous aggregate state. Household decisions influence equilibrium property prices and conventional mortgage spreads, which then feed back on decisions. Based on their expectations about equilibrium house values and mortgage rates, households choose consumption, saving, homeownership, default, conventional mortgage (re)financing, property maintenance, and RM borrowing. The model is calibrated to match loan-level data and life-cycle profiles of wealth, homeownership rates, and loan-to-value (LTV) ratio. The calibrated model generates a relatively low RM take-up rate of 4.5% among eligible homeowners, with a hump-shaped life-cycle profile consistent with the data. It also reproduces several untargeted moments, including household leverage and debt-service burdens.

We find substantial heterogeneity in RM take-up across macroeconomic states, household

[1] The Geneva Association (2024) reports that the world's pension gap is $41 trillion.

[2] For example, according to Chen et al. (2020), on the US household balance sheet, housing estates total 10 times the size of liquid assets.

wealth, and income and savings levels. Take-up is highest during recessions, as households access home equity in response to adverse income and macroeconomic shocks, and is more moderate when liquidity needs are lower or borrowing conditions are tighter. Across housing market conditions, participation varies modestly by house price tercile, with slightly lower rates among the lowest tercile, suggesting limited sensitivity to housing wealth. RM take-up declines sharply with income, as RMs primarily serve income-constrained retirees. Take-up has a U-shaped relationship with savings, suggesting RMs function as both a necessity for liquidity-poor households and a strategic instrument for wealthier households.

In addition, contract choice varies over the life cycle. The share of borrowers selecting fixed-rate RMs increases in early retirement, peaks in the early 70s, then declines, consistent with stronger preferences for payment certainty in early retirement and for flexibility at advanced ages.

To quantify RMs' effects, we compare a baseline economy with RMs to a counterfactual economy without them. Our first finding concerns household welfare. Holding housing supply fixed allows us to isolate their impact on housing markets and household outcomes. RMs raise house prices across macroeconomic states, with the largest increases occurring during recessions with tight credit conditions. With tighter credit, RM availability increases the value of homeownership by expanding access to liquidity. RMs also reduce house price volatility.

Second, refinancing activity is lower in the baseline economy. The difference is modest at younger ages, narrows during middle age, and widens sharply between ages 60 and 64, reflecting anticipation of RM eligibility at age 65. As households approach age 65, the option to extract home equity reduces the incentive to refinance with conventional mortgages, which entail fixed costs, including origination and closing fees as well as the implicit cost of resetting the mortgage term. By contrast, an RM provides liquidity without required periodic repayment. Further, once eligible, homeowners can repay outstanding debt through an RM rather than refinancing with a new loan, thereby avoiding refinancing costs late in life. RMs thus operate as a substitute for mortgage refinancing. By converting illiquid housing wealth into liquid resources, they enable older households to smooth cash flows and consolidate debt without rolling over traditional contracts. Although RMs entail insurance premia and interest accrual, the absence of refinancing frictions makes them an attractive alternative to repeated mortgage renewal, crowding out refinancing among older borrowers.

Third, RMs smooth consumption over the life cycle. Consumption growth volatility declines for retirees by 5.65% but is largely unchanged for working-age households, reflecting anticipatory dissaving prior to eligibility at age 65. RMs also affect welfare differentially. Homeowners realize substantial welfare gains, while renters experience smaller and mixed effects. Young renters benefit modestly, reflecting the option value of future RM access, whereas retired renters experience welfare losses that grow with age. Overall, RMs improve aggregate welfare primarily through consumption smoothing, with gains largely concentrated among homeowners.

To better quantify the welfare gains and consumption smoothing associated with access to RMs, we also consider an economy in which their price feedback effect is controlled for. RMs' direct (and positive) effect on welfare is 7.92%, and price feedback offsets that effect by 4.70%. RMs causes a direct reduction of 6.65% households' consumption volatility and price feedback

causes an additional 1.17% reduction.

We conduct additional experiments varying financial literacy to assess its implications for RM take-up and equilibrium outcomes. Choinière-Crèvecoeur and Michaud (2023) indicate that financially literate customers are more aware of RMs and more willing to use them. Thus, we examine how financial literacy affects household consumption volatility, welfare benefits, and housing and mortgage market dynamics. We find that financial literacy (measured by the RM awareness rate) reduces consumption volatility across age groups, with retirees accounting for most of the aggregate decline. Along the tenure dimension, the reduction is concentrated among homeowners. Welfare gains for homeowners increase linearly with awareness. Renters' welfare worsens as awareness grows. Housing market performance exhibits positive house price growth across almost all economic states. House price volatility generally (but not always monotonically) declines as awareness increases. RM awareness monotonically lowers mortgage refinancing rates across all age groups. These findings suggest financial literacy plays a key role in advancing RM adoption, which induces welfare gains through consumption smoothing, improving housing market performances, and avoiding unnecessary refinancing.

Our final experiment evaluates the insurance value of RMs through a welfare-equivalence exercise. In the economy without RMs, the government must provide larger transfers to retirees to sustain the same welfare level achieved in the RM economy. RMs therefore operate as a partial substitute for social security by allowing households to self-insure through home equity extraction. The insurance-equivalent value of RMs depends on financial literacy, captured by RM awareness. As awareness increases, take-up rises and the insurance value initially expands, peaking at intermediate awareness levels before declining due to diminishing marginal insurance gains and general equilibrium adjustments.

Our paper contributes to the RM literature. Case and Schnare (1994) examine the expansion of the RM market and highlight regulatory constraints. Rasmussen et al. (1995) and Merrill et al. (1994) identify potential beneficiaries based on age, income, and home equity. Davidoff (2015) characterize the conditions in which RMs improve welfare. Nakajima and Telyukova (2017) show that bequest motive, health and expenditure risk, and loan costs account for low take-up, and Cocco and Lopes (2020) emphasize aging-in-place and maintenance costs. These studies generate low participation rates consistent with the data under exogenous house prices and RM rates. They rely on partial equilibrium life-cycle frameworks that abstract from interactions between housing and credit markets. In contrast, we endogenize house prices, mortgage rates, and RM rates, allowing housing and credit markets, including conventional mortgages and RMs, to clear simultaneously. This framework improves the assessment of RMs' effects on households' balance sheets, decisions, and welfare for both workers and retirees. The model also allows borrowers to endogenously choose between lump-sum withdrawals and credit lines, rather than imposing a single contract form. This is also among the first quantitative life-cycle models to incorporate RMs in a general equilibrium setting with both contract choice and market clearing.

Another key innovation is our use of loan-level data to calibrate the model. Most RM studies rely on public survey data such as the Panel Study of Income Dynamics or Health and Retirement Study (HRS), which require weighting and imputation, but our granular datasets

provide direct information on mortgage balances and refinancing behavior. This is particularly important given the low RM take-up rate, and it allows us to match detailed credit market moments.

Our paper also contributes to the integrated literature on mortgages and housing. Earlier studies typically treat either the mortgage market or the housing market as exogenous. For example, Ortalo-Magne and Rady (2006), Favilukis et al. (2017), and Tim et al. (2014) analyze equilibrium housing markets with stylized or exogenous mortgage structures, while Campbell and Cocco (2015) and Corbae and Quintin (2015) study equilibrium mortgage markets taking house prices as given. More recent work, including Kung (2014) and Guren et al. (2021), jointly endogenizes house prices and mortgage rates in general equilibrium. Building on this framework, we incorporate RMs and model the interaction between conventional mortgages and RMs within a unified equilibrium setting.

Within this literature, refinancing and default have been studied extensively. Empirical evidence shows that default is typically exercised only when borrowers are deeply in the money and that its correlation with unemployment varies across periods and locations (e.g., Campbell (1983), Deng et al. (2000), Elul et al. (2010), Ghent and Kudlyak (2011)). Chen et al. (2020) integrate refinancing and home equity borrowing in a partial equilibrium model and show that liquidity-constrained households refinance even at high borrowing cost following income shocks. We extend this insight to general equilibrium by showing that households use RMs as an alternative to refinancing even when RM interest rates exceed conventional mortgage rates. The model allows for both strategic and forced default and generates refinancing and default patterns consistent with the data across age groups.

Section 2 presents the model. Section 3 describes the calibration. Section 4 analyzes RM take-up and contract choice. Section 5 studies an alternative economy without RMs, holding all other parameters fixed. Section 6 extends the analysis, and Section 7 concludes.

2 The Model

We consider a general equilibrium model with heterogeneous households and competitive mortgage lenders. House prices and mortgage rates are determined in equilibrium. Households have a finite life span divided into two phases: working and retirement periods. While working, households earn labor income and pay taxes. During retirement, they receive retirement income. In each period, households decide whether to rent or buy houses and how much to consume and save. Renters can buy houses, potentially financed through conventional mortgages. Homeowners choose whether to stay in their houses or sell and become renters. They can borrow against their home equity and access RMs during retirement. Homeowners with RMs cannot simultaneously carry conventional mortgages.

Mortgage lenders price conventional mortgages in equilibrium; RM interest rates are instead taken from Home Equity Conversion Mortgage (HECM) data, as Federal Housing Administration (FHA) insurance transfers lenders' credit and longevity risks to the government. For conventional mortgages, lenders receive payments until households default or refinance. For RMs, lenders recover the collateral when households die or leave the property for long-term

care facilities. We consider a real economy in which both mortgages and RMs are inflation indexed.

2.1 Setup

2.1.1 Economy

Our model is discrete, and each period corresponds to one year. In each period t, the economy (θ_t) takes one of five states: crisis, recession with loose credit, recession with tight credit, expansion with loose credit, and expansion with tight credit. We employ an exogenous transition probability matrix (P_θ) to describe the evolution between these macroeconomic conditions.

We assume the financial market has only one asset, a one-period riskless bond with return $r^f(\theta_t)$, in which households can invest. The risk-free real interest rate is exogenous and depends on the economy. That rate is highest in expansions and lowest during crises.

2.1.2 Households

Following the convention in life-cycle models, we assume households start working at age 25, retire at 65, and can live up to 100 ($T = 75$). The probability that households are alive at age $(a + 1)$ conditional on being alive at age a is denoted by p_a (p_{75} equal to 0).

Preferences Following Campbell and Cocco (2015), we assume household i derives utility from housing H_{it}, nondurable consumption C_{it}, and leaving a bequest. Since house size remains fixed over time, we can drop housing from the preference specification. Household i is penalized for default. The recursive utility function of household i in period t can be written as

$$U_{it} = \frac{C_{it}^{1-\gamma_i}}{1-\gamma_i} + u_o D_{it}^o - u_d D_{it}^d + \beta_i \left[p_{a_{it}} \mathbb{E}_t[U_{it+1}] + (1 - p_{a_{it}}) \psi^{bq} \frac{(Q_{it+1} + \xi)^{1-\gamma_i}}{1-\gamma_i} \right], \quad (1)$$

where γ_i is the coefficient of relative risk aversion, β_i is the discount factor, u_o is the utility benefit from owning a house, u_d is the utility penalty from defaulting on mortgages, and D_{it}^o and D_{it}^d are indicator functions for owning a house and defaulting on mortgages, respectively. Q_{it} is terminal wealth, ξ is a bequest-motive shift parameter, and ψ^{bq} is the bequest-motive weight.

Labor Income Before retirement, households' labor income is exposed to both aggregate shocks from the economic state and idiosyncratic shocks. Specifically, the labor income in period t (Y_{it}) is given in logs ($y_{it} = \ln(Y_{it})$) by

$$y_{it} = v_t + \epsilon_{it}, \quad t < R, \quad (2)$$

where v_t is the aggregate component of log labor income determined by the economic state θ_t and where the idiosyncratic labor income shock ϵ_{it} follows a Markov process with transition matrix $P_y(\theta_t)$ as a function of economic state θ_t.

We assume a linear taxation rule: Households' labor income during the working period is taxed at the constant rate τ.

In retirement, the aggregate shock v_t persists but the idiosyncratic shock is absent; the idiosyncratic component is fixed at its last working-period value and reduced by ρ:

$$y_{it} = v_t + \epsilon_{i,R-1} - \rho, \quad t \geq R \tag{3}$$

Here, $R = 45$, corresponding to the retirement age 65.

Government Transfers Households are guaranteed a lower-bound per-period amount of cash on hand, which can be viewed as a subsistence level. When households' wealth and housing value drop below this lower bound, the government provides a consumption floor, which enables them to consume nondurable goods and rent a house.

Health Risk and Medical Cost During retirement, households are exposed to health risks. We introduce a health-status indicator, D_{it}^{med}, to capture this risk. It takes the value of 1 if households are in good health and 0 if they are sick. Once households become sick, they remain in that state till death. We assume the health state D_{it}^{med} of household i in period t follows a Markov process independent of the economic and idiosyncratic states.

A senior household i pays medical expenses of $c_{med}(a_{it}, D_{it}^{med})Y_{it}$, where c_{med} represents the proportion of income and is determined by the health state D_{it}^{med} and age a_{it}.

2.1.3 Housing Market

Our model assumes housing supply is fixed. The real house price P_t^h is determined endogenously in equilibrium and depends on the economic state. In each period, households choose to be homeowners (denoted $D_{it}^o = 1$) or renters (denoted $D_{it}^o = 0$), and housing size H_{it} is fixed for all homeowners.

Homeowners must pay per-period maintenance cost $C_{ma}(H_{it}, P_t^h)$, proportional to the value of the property, to keep the house from depreciating:

$$C_{ma}(H_{it}, P_t^h) = c_{ma} H_{it} P_t^h \tag{4}$$

Here, c_{ma} measures the maintenance cost per unit of total property value. Homeowners unable to pay that cost are forced to sell and become renters.

We assume homeowners face exogenous moving shocks, which force them to leave their houses with probability p_m, incurring moving cost $C_{ms}(H_{it}, P_t^h)$:

$$C_{ms}(H_{it}, P_t^h) = k_{ms} + c_{ms} H_{it} P_t^h \tag{5}$$

Here, k_{ms} captures the fixed cost and c_{ms} quantifies the variable moving cost per unit of total property value.

The literature shows that the rental and owner-occupied markets are segmented. Rental housing can be produced and destroyed at unit cost q, so in equilibrium, renters face rental cost $C_r = q$. We do not differentiate between the owner-occupied house price and the rental property price and focus only on the equilibrium of the owner-occupied housing stock. This

implies that in our model, the price-to-rent ratio varies with the house price.

2.1.4 Conventional Mortgages

When purchasing a house, households may borrow through a conventional mortgage. Let ζ_t^m denote the down-payment ratio, subject to the maximum LTV constraint ϕ_t^m. The initial mortgage balance for household i at the start of period t satisfies

$$M_{it}^m = (1 - \zeta_t^m) P_t H_{it}. \tag{6}$$

A lower down-payment ratio implies a higher LTV ratio, which cannot exceed ϕ_t^m:

$$\zeta_t^m \geq 1 - \phi_t^m \tag{7}$$

We assume ϕ_t^m varies exogenously and depends on the macroeconomic state.

Two main types of mortgage contracts are available on the conventional mortgage market: fixed-rate mortgages (FRMs) and adjustable-rate mortgages. For simplicity, we only model the main type of conventional mortgage: the long-term FRM, which represents more than 90% of mortgages originated in the US. Households with an FRM bear the same mortgage rate $r^m(\theta_t)$ endogenously determined by the economic state θ_t at origination. We assume FRM rates are the same for all households in the same economic state.

With the timing assumption that households pay interest between periods t and $t+1$ in advance at time t, the minimum payment for a household that neither moves nor refinances in period t is given by[3]

$$M_{it}^m - M_{it+1}^m (1 - r^m(\theta_t)) \geq M_{it}^m \frac{r^m(\theta_t) \left(\frac{1}{1 - r^m(\theta_t)} \right)^{T - a_{it} + 1}}{\left(\frac{1}{1 - r^m(\theta_t)} \right)^{T - a_{it} + 1} - 1}. \tag{8}$$

When prevailing mortgage rates fall below a household's origination rate, the household may refinance. Refinancing is subject to the LTV constraint (7) and requires paying refinancing costs

$$C_{re}(M_{it+1}^m) = k_{re} + c_{re} M_{it+1}^m. \tag{9}$$

Here, k_{re} is the fixed refinancing cost and c_{re} is the variable refinancing cost per unit of the mortgage balance. Households can refinance; they pay any refinancing cost at the beginning of each period.

If households default, they suffer a utility penalty of u_d and lose their house immediately. Defaulting households are temporarily barred from credit markets, but their default status may be lifted, allowing them to re-enter the housing market.

[3] We assume the mortgages reach maturity at age 70 for all households.

2.1.5 RMs

RMs allow older homeowners to borrow against their housing wealth without moving out of the house. This option also offers insurance against substantial declines in house prices. However, to obtain RMs, homeowners must have paid off a significant part of their conventional mortgages. We incorporate this feature, following the guidelines established by the HECM program, the most popular RM program in the US.

To borrow against the home value, households must be at least 65 years old and have more than $\phi^{rm}_{own}(\theta_t)$ in home equity. $\phi^{rm}_{own}(\theta_t)$ is the minimum home equity requirement for RMs and is determined by economic state θ_t. Therefore, households must satisfy the following conditions when initiating RMs:

$$1 - \frac{M^m_{it}}{P^h_t H_{it}} \geq \phi^{rm}_{own}(\theta_t) \tag{10}$$

Households are also constrained by the maximum amount of RMs they can borrow, which is determined by the lower value between a constant maximum claim amount (Q^{rm}) and the principal limit based on the home value. According to HECM, the principal limit factor (PLF) ϕ^{rm} is determined by the age of the borrower a_{it} and the RM rate $r^{rm}(\theta_t)$. Let M^{rm}_{it} denote the amount a household chooses to claim. Therefore, M^{rm}_{it} should satisfy

$$M^{rm}_{it} \leq \min\left\{Q^{rm}, \phi^{rm}(a_{it}, r^{rm}(\theta_t))P^h_t H_{it}\right\}. \tag{11}$$

Although HECM provides several repayment options to borrowers, we focus on the two most common types of RM: (1) the lump-sum RM, which is a single large payout at the start of the loan, and (2) the drawdown RM, which is a stream of unscheduled payments at the borrower's request until the line of credit is exhausted. In addition, households can choose fixed-rate RMs (FRRMs) or adjustable-rate RMs (ARRMs). Only the lump-sum option is available for FRRMs.

If households decide to obtain a drawdown RM, they can determine the proportion of the total amount to receive at the start of the loan, denoted by $\alpha^{rm}_{it} M^{rm}_{it}$ at origination, while the remaining amount will be available in the form of a line of credit. Given that the amount M^{rm}_{it} includes the cost c^{rm}_0, which comprises the initial mortgage insurance premium and origination fee, households receive $(\alpha^{rm}_{it} - c^{rm}_0)M^{rm}_{it}$ at the origination. In each period, households decide whether to draw down the credit line if it is not exhausted ($\alpha^{rm}_{it} < 1$). They may also prepay the RM balance. The remaining RM balance and credit line both accumulate with the RM rate $r^{rm}(\theta_t)$ and the annual loan fee rate c^{rm}_a, including annual insurance cost and annual service cost. Specifically, after origination, households face the following constraints:

$$M^{rm}_{it} \leq M^{rm}_{it-1}(1 + r^{rm}(\theta_{t-1}) + c^{rm}_a), \tag{12}$$

$$(1 - \alpha^{rm}_{it})M^{rm}_{it} \leq (1 - \alpha^{rm}_{it-1})M^{rm}_{it-1}(1 + r^{rm}(\theta_{t-1}) + c^{rm}_a) \tag{13}$$

The first constraint indicates how the RM balance accumulates, and the second constraint implies that the remaining line of credit cannot be increased as households prepay the RM balance.

If the household chooses to take a lump sum, α^{rm}_{it} is fixed at 1, indicating that the entire

amount, M_{it}^{rm}, will be received at the beginning. Therefore, these borrowers only face constraint 12.

RMs terminate whenever the borrowers move to long-term care facilities or decease, and lenders get paid for the roll-up balance or the home value, whichever is lower. Usually, lenders sell the house to recover the loan balance, and the remaining home value is inherited by the borrowers' heirs or returned to the borrowers. A housing market slump could result in a decrease in the property portfolio value of lenders, leading to potential losses on RMs upon termination. However, as borrowers pay insurance premiums annually, the Department of Housing and Urban Development (HUD) insures against these potential losses.

2.2 Household Optimization Problem

Households are price takers who maximize their lifetime utility, given their expectations about future economic states and house prices. We denote the aggregate state as the vector

$$\Theta_t = \{\theta_t, r^f(\theta_t), P_t^h, r^m(\theta_t), r^{rm}(\theta_t), \Pi_t\}, \tag{14}$$

where Π_t is the distribution of households.[4]

Household i's idiosyncratic-state vector at the start of period t is

$$S_{it} = (a_{it}, Y_{it}^{id}, W_{it}, D_{it}^{o}, D_{it}^{mov}, D_{it}^{med}, M_{it}^{m}, r_{it}^{m}, D_{it}^{d}, D_{it}^{rm}, M_{it}^{rm}, D_{it}^{fix}, r_{it}^{rm}, \alpha_{it}^{rm})'. \tag{15}$$

The first six elements capture the household's demographic and financial profile: age, idiosyncratic labor income, savings, homeownership status, moving-shock indicator, and health state. The remaining elements describe the credit position: mortgage balance and its origination rate r_{it}^{m}, default status, RM eligibility D_{it}^{rm}, outstanding RM balance M_{it}^{rm}, FRRM indicator D_{it}^{fix}, accumulated RM rate r_{it}^{rm},[5] and the fraction of the RM credit line drawn α_{it}^{rm}.

In each period t, household i makes decisions $A_{it} = (D_{it}^{H}, W_{it+1}, M_{it+1}^{m}, M_{it+1}^{rm}, D_{it+1}^{fix}, \alpha_{it+1}^{rm})'$ about housing (D_{it}^{H}), saving (W_{it+1}), and mortgage and RM (M_{it+1}^{m}, M_{it+1}^{rm}, $D_{it+1}^{fix}, \alpha_{it+1}^{rm}$) to maximize lifetime utility. The housing decision, represented as D_{it}^{H}, is characterized by a range of values from -2 to 4, each representing a distinct decision. Renters have the option to continue renting ($D_{it}^{H} = 0$), while those without a default flag can choose to purchase a house ($D_{it}^{H} = 3$). Homeowners can retain ownership ($D_{it}^{H} = 1$), default on their mortgage ($D_{it}^{H} = -1$), refinance the mortgage ($D_{it}^{H} = 4$), become renters ($D_{it}^{H} = -2$), or move to a new house ($D_{it}^{H} = 2$). Homeowners who face a moving shock have only two options: move or default.

The optimization problem is

$$V(S_{it}, \Theta_t) = \max_{A_{it}} U_{it}(S_{it}, A_{it}, \Theta_t), \tag{16}$$

[4]The distribution of households affects the equilibrium and, thus, should be included in the aggregate state. The distribution is over the idiosyncratic states of households.

[5]For FRRMs, r_{it}^{rm} depends on the economic state when the RM originated and remains fixed until the RM terminates; for ARRMs, r_{it}^{rm} equals the current-period rate $r^{rm}(\theta_t)$.

subject to

$$
\begin{aligned}
Q_{it}(S_{it},\Theta_t) =& W_{it} - M^m_{it} + D^o_{it}\max(H_{it}P^h_t - \alpha^{rm}_{it}M^{rm}_{it}, 0), && (17)\\
C_{it}(S_{it},A_{it},\Theta_t) =& [Y_{it} - \tau(Y_{it}) - \phi_c(S_{it},A_{it},\Theta_t)] + \left[W_{it} - \frac{W_{it+1}}{1+r^f(\theta_t)}\right]\\
&+ \mathbb{I}(D^H_{it} \neq -1)\left[(D^o_{it} - D^o_{it+1})H_{it}P^h_t - \left(M^m_{it} - (1-r^m_{it})M^m_{it+1}\right)\right]\\
&+ \left[\alpha^{rm}_{it+1}M^{rm}_{it+1} - \alpha^{rm}_{it}(1+r^{rm}_{it}+c^{rm}_a)M^{rm}_{it}\right], && (18)\\
\phi_c(S_{it},A_{it},\Theta_t) =& D^o_{it+1}C_{ma} + (1-D^o_{it+1})q + D^m_{it}C_{ms} + \mathbb{1}(D^H_{it}=4)C_{re}\\
&+ \mathbb{I}(M^{rm}_{it}=0,\, M^{rm}_{it+1}>0)\, c^{rm}_0 M^{rm}_{it+1}, && (19)\\
C_{it}(S_{it},A_{it},\Theta_t) \geq& C_m, && (20)\\
D^o_{it+1} =& \begin{cases} 1, & \text{if} \quad D^H_{it} > 0 \\ 0, & \text{if} \quad D^H_{it} \leq 0 \end{cases}, && (21)\\
D^d_{it+1} =& \begin{cases} 1, & \text{if} \quad D^H_{it} = -1 \\ 0, & \text{if} \quad D^H_{it} \neq -1, D^d_{it} = 0 \\ 0 \quad \text{with probability } p_{md}, & \text{if} \quad D^H_{it} \neq -1, D^d_{it} = 1 \end{cases}, && (22)\\
M^m_{it+1} =& 0, \quad \text{if} \quad D^H_{it} \leq 0, && (23)\\
\text{LTV constraint} \quad & (7), \quad \text{if} \quad D^H_{it} = 2,3,4, && (24)\\
\text{Minimum payment} \quad & (8), \quad \text{if} \quad D^H_{it} = 1, && (25)\\
M^{rm}_{it+1} =& 0, \quad \text{if} \quad D^H_{it} \neq 1, && (26)\\
\text{RM maximum claim} \quad & (11), \quad \text{if} \quad D^H_{it} = 1, a_{it} \geq R, M^{rm}_{it} = 0 \text{ and } (10) && (27)\\
\alpha^{rm}_{it+1} = 1, & \quad \text{if} \quad D^{fix}_{it} = 1 \text{ or } D^{fix}_{it+1} = 1 && (28)\\
\text{RM balance accumulation} \quad & (12), \quad \text{if} \quad D^H_{it} = 1, M^{rm}_{it} > 0 && (29)\\
\text{RM credit accumulation} \quad & (13), \quad \text{if} \quad D^H_{it} = 1, M^{rm}_{it} > 0, && (30)
\end{aligned}
$$

where $\phi_c(S_{it},A_{it},\Theta_t)$ is the total cost of housing maintenance, moving, financial services (refinancing), and RM origination, and we impose the budget constraint and a minimum level of consumption C_m.

2.3 Mortgage Lenders

Lenders operate in perfectly competitive markets and discount mortgage cash flows using a pricing kernel $\Lambda(\theta_t,\theta_{t+1})$. Following Rosenberg and Engle (2002), we project this kernel onto the mortgage-payoff space. The resulting state-dependent discount factor satisfies

$$E_t\left[\Lambda(\theta_t,\theta_{t+1})\right] = \frac{1}{1+r^f(\theta_t)+\kappa(\theta_t)}, \tag{31}$$

where $\kappa(\theta_t)$ is the risk premium lenders require in macroeconomic state θ_t, capturing default risk, liquidity conditions, and macroeconomic uncertainty. Because the risk-free rate $r^f(\theta_t)$ and the risk premium $\kappa(\theta_t)$ both depend only on the current state, the conditional expectation of

the pricing kernel is fully determined by θ_t. We calibrate $\kappa(\theta_t)$ to match observed mortgage spreads; details are provided in Section 3.[6]

Lenders receive payments from borrowers in each period t, which depend on borrowers' endogenous decisions (A_{it}) and the aggregate state (Θ_t). Given the multiperiod nature of mortgage contracts, lenders must recursively compute the net present value of expected cash flows. For a conventional mortgage originated to household i, this value is given by

$$\begin{aligned}\Pi^m(S_{it}, A_{it}, \Theta_t) =& \mathbb{I}(D_{it}^H \in \{-2, 2, 4\}) M_{it}^m + \mathbb{I}(D_{it}^H = -1) \Upsilon H_{it} P_t^h \\ &+ \mathbb{I}(D_{it}^H = 1) \Big[M_{it}^m - M_{it+1}^m (1 - r_{it+1}^m) \\ &\quad + E_t \big[\Lambda_{t,t+1}^m p_{a_{it}} \Pi^m(S_{it+1}, A_{it+1}, \Theta_{t+1}) \\ &\quad + \Lambda_{t,t+1}^m (1 - p_{a_{it}}) \min(M_{it+1}^m, W_{it+1} + H_{it+1} P_{t+1}^h) \big] \Big], \end{aligned} \tag{32}$$

where Υ denotes the foreclosure recovery rate, the fraction of property value recovered by lenders following default. Equation (32) decomposes the lender's expected payoff into three components corresponding to distinct household choices. The first term captures immediate loan repayment when households sell their property, move, or refinance ($D_{it}^H \in \{-2, 2, 4\}$). The second term represents recovery through foreclosure when households default ($D_{it}^H = -1$), with lenders receiving Υ times the current property value. The third term applies when households retain ownership ($D_{it}^H = 1$) and comprises the current period's mortgage payment plus the continuation value. This continuation value accounts for both survival (with probability $p_{a_{it}}$, yielding the recursively determined value Π^m) and death (with probability $1 - p_{a_{it}}$, where lenders recover the minimum of the outstanding balance and the borrower's total wealth including housing equity).

Unlike conventional mortgages, HECMs are insured by the FHA, which guarantees lenders against losses when loan balances exceed home values at termination. This guarantee fundamentally alters the pricing mechanism: Rather than endogenizing RM interest rates through a zero-profit condition, we calibrate them directly using observed spreads from HECM data together with the National Bureau of Economic Research–defined recessions.

2.4 Equilibrium

The economy is characterized by the law of motion for the aggregate state Θ_t. Households choose their consumption and housing decisions (A_{it}) to maximize their expected lifetime utility, given their expectations about future housing prices.

Solving the equilibrium requires households to forecast the law of motion for Θ_t, which includes an infinite-dimensional object Π_t. Except for housing price, the law of motion for the other components of Θ_t depends on θ_t, which follows a Markov process with exogenous transition probabilities. For the law of motion for house prices, we follow Krusell and Smith (1998) and consider a forecasting model in which households use a simple AR(1) forecast rule

[6] Rosenberg and Engle (2002) show that a projected pricing kernel can be uniquely derived from an underlying pricing kernel, conditional on the payoff structure of the asset class.

based on the current and next-period economic states:

$$\ln P_{t+1}^h = f_{(\theta_t,\theta_{t+1})}(\ln P_t^h) \tag{33}$$

We parameterize f as a linear spline

$$f_{(\theta_t,\theta_{t+1})}(x) = b_h + \sum_{i=1}^{n_h} k_{ih}(x - x_i)_+, \tag{34}$$

where $(x - x_i)_+ = \max(x - x_i, 0)$, b_h is the intercept, k_{ih} are the slope increments at each knot, and x_i are the knot values of $\ln P_t^h$; all depend on (θ_t, θ_{t+1}).

Competitive conventional mortgage lenders break even in expectation on newly originated loans:

$$E_{\theta_t=\theta_i}\left[E_{S_{jt}\sim\Pi_{m,t}^{orig}}\left[\Lambda_{t,t+1}^m \Pi^m(S_{jt+1}, A_{jt+1}, \Theta_{t+1}) - (1 - r^m(\theta_t))M_{jt+1}^m\right]\right] = 0, \forall\theta_i \tag{35}$$

Here, $\Pi_{m,t}^{orig}$ is the distribution of newly originated conventional mortgages in period t.

Given the optimal decisions, the housing market clears at P_t^h. Since the supply of houses is fixed, the equilibrium is achieved when the supply from movers, defaulters, and investors who bought last period equals the demand from renters, homeowners who are moving, and investors:

$$\int D_{it}^o d\Pi_t = \int D_{it+1}^o d\Pi_{t+1} \tag{36}$$

Household expectations for housing prices can be verified in equilibrium. We solve the equilibrium numerically; details of the algorithm are in the Appendix.

3 Calibration

3.1 Model Parameters

Aggregate State Variables We first choose aggregate and idiosyncratic shocks that mimic the dynamics of modern business cycles in the US. Then we exogenously calibrate a set of parameters to widely accepted values in the macroeconomic and housing literatures.

Following Guren et al. (2021), we calibrate the Markov transition matrix between macroeconomic states such as crisis, recession, and expansion based on the frequency and duration of such states as defined by the National Bureau of Economic Research (NBER).[7] If the NBER peak of the previous expansion takes place in the first half of a given year, that year is classified as the first year of the new recession, whereas if the peak happens during the second half of a year, the recession is recorded in the subsequent year. The ending date of a recession is defined as the year following the start year of the expansion announced by the NBER because the unemployment rate is a lagging variable and does not immediately fall after NBER troughs. Moreover, we assume crises happen every 75 years, and all other NBER recessions are regular, cyclical recessions.

To determine the risk-free rate, we follow Guren et al. (2021), which uses the historical

[7] See the Appendix for the full transition matrix.

Table 1: Baseline Calibration Parameters

The table shows calibrated parameters for the baseline model. Panel A shows the preference parameters. Panel B shows the mortgage-related parameters, and Panel C shows the parameters associated with reverse mortgages. Panel D shows the parameters for the labor income process. Panel E presents the remaining parameters.

Description	**Parameter value**
Panel A. Preference parameters	
Years in life (T)	75
Risk aversion (γ)	3.0
Discount factor (β)	0.98
Utility from homeownership (u_o)	6
Bequest-motive shifter (ξ)	0.5
Bequest-motive multiplier (ψ^{bq})	250
Default penalty (u_d)	10
Panel B. Mortgages	
Max LTV, tight credit (ϕ^m)	0.8
Max LTV, loose credit (ϕ^m)	0.9
Variable refinance cost rate (c_{re})	1.0%
Fixed refinance cost (k_{re})	0.04
Prob. of default flag removed (p_{md})	0.1
Foreclosure sale recovery (Υ)	0.654
Risk premium (κ) in expansion	95bps
Risk premium (κ) in recession/crisis	385bps
Panel C. Reverse mortgages	
Min equity req. in crisis/recession, RM (ϕ^{rm}_{own})	0.60
Min equity req. in expansion, RM (ϕ^{rm}_{own})	0.50
Initial fee of RM (c^{rm}_0)	0.02
Annual fee of RM (c^{rm}_a)	0.01
Awareness rate of RM	19%
Panel D. Labor income	
Retirement age (R)	65
Log income decline in retirement (ρ)	0.35
Tax rate (τ)	0.1
Aggregate income ($Y^{(agg)}$)	$[0.0976, 0.1426, 0.1776]$
Panel E. Other parameters	
Homeownership rate (H_r)	0.65
Risk-free rate (r^f)	$[0.26\%, 1.32\%, 3.26\%]$
Medical cost rate (c_{med}) (Age $[65, 75)$)	0.05 (good), 0.10 (bad)
Medical cost rate (c_{med}) (Age $[75, 100)$)	0.10 (good), 0.15 (bad)
Rent cost (q)	0.20
Maintenance cost rate (c_{ma})	0.04
Variable moving cost rate (c_{ms})	3.0%
Fixed moving cost (k_{ms})	0.1
Prob. of moving, working (p_{ms})	0.1
Prob. of moving, retiring (p_{ms})	0.02
Lower bound per-period cash-on-hand	0.1

real interest rate observed between 1985 and 2022. Specifically, during recessions, the risk-free rate is set at 1.32%, reflecting the lower economic activity and market conditions. During expansions, when the economy is performing well, the risk-free rate is set at 3.26%. For crises, we assume a significantly lower risk-free rate of 0.26% to account for the heightened uncertainty and economic instability.

Labor Income Process We set the log income decline during retirement to be 0.35, and for income shocks in the working period, we rely on the estimates in Guvenen et al. (2014) and Shen (2023), which calibrate a quantitative labor income model using a large and confidential US dataset. The parameters regarding the mixture of normal distributions during expansions and recessions can be calibrated. We then follow Guren et al. (2021) to discretize the distributions. The tax rate is assumed to be 10%, which is around the average of the current US tax scheme.

Health Status and Medical Cost We calibrate health status and medical costs using the HRS. More specifically, we estimate transition probabilities of household health status, conditional on age and current health. We find that health status is generally persistent, especially for households that are in poor health. Therefore, we assume that once households become sick, they remain sick. Using the HRS, we estimate the annual probability of transitioning from good to bad health to be 0.20, consistent with the average across permanent-income groups reported in the Appendix of Cocco and Lopes 2020, which also draws on the HRS. We then estimate the parameters of the distribution of medical costs, conditional on age and health status. Medical costs are higher for older and less healthy households.

Maintenance and Moving We take the annual maintenance cost from Guren et al. (2021) and assume it is the same for both workers and retirees for simplicity, although we acknowledge that retirees usually face relatively lower maintenance costs.[8] We study the moving decisions of workers using the Panel Study of Income Dynamics and of retirees using the HRS data. We estimate probabilities of moving and find that workers are more likely to relocate compared to retirees, perhaps due to stronger career opportunities, more flexibility, and weaker preference for aging in place. Following Guren et al. (2021), we set the fixed cost of moving to be equivalent to 10% of the average household annual income, or approximately $5,000. Additionally, proportional costs, incurred by both buyers and sellers, are set at 3% of the house value to account for expenses such as closing costs and realtor fees.

Reverse Mortgages Except for the RM rates, we calibrate all other RM-related parameters and age-dependent collateral constraints based on the existing RM contracts from CoreLogic and HECM.[9] We find that the annual fee is 1%, of which 0.5% is the insurance premium and the remaining 0.5% is the annual service fee. The minimum equity requirement during crises and recessions is 60%, which is higher than that during the expansion, 50%. Table 2 shows the

[8]For example, Nakajima and Telyukova (2017) calibrate the annual maintenance cost for retirees at 1.7%, based on the depreciation rate of residential capital.

[9]Unlike conventional mortgages, RM rates are directly observed from HECM spreads. See Table 3.

PLF for various RM interest rates taken from HECM.[10] For example, for age 65 and an RM rate of 3%, homeowners can borrow a maximum of 52.4% of their home value. Unlike conventional mortgages, the loan amounts granted in RMs depend on the borrowers' ages, increasing as they age. The rationale is that as borrowers grow older, the projected interest expenses decrease, and the anticipated future house price appreciation diminishes, reducing the risk for the lenders. Generally, the collateral constraint related to conventional mortgages becomes more stringent as the borrower ages. However, RMs provide a more relaxed collateral constraint that eases with age, resulting in a more favorable borrowing environment across all life stages.

In addition to contract terms, we model financial literacy as an exogenous participation friction captured by the share of households aware of RMs. In the baseline calibration, 19% of households are aware of the RM option, consistent with survey evidence. Only aware households can include RMs in their choice set. We vary this awareness rate in counterfactual experiments to study how financial literacy affects take-up and welfare outcomes.

Table 2: Principal Limit Factor for Reverse Mortgages

This table states the reverse mortgage (RM) rates and principal limit factor (essentially the ratio of loan to home values) that lenders are willing to lend to RM borrowers by age group, at three different RM rates: 3%, 4%, 6%.

	Age						
RM rate	65	70	75	80	85	90	95
3%	52.4%	57.6%	60.9%	64.2%	68.5%	73.0%	75.0%
4%	47.0%	52.2%	54.7%	58.5%	63.6%	69.1%	75.0%
6%	35.7%	41.5%	44.3%	48.8%	54.9%	61.8%	70.1%

Risk Premia We calibrate the state-dependent risk premium $\kappa(\theta_t)$ entering equation (31) to match observed mortgage spreads. We target the historical spread between 30-year FRM rates and 10-year Treasury yields, which averages 169 basis points during expansions and 225 basis points during crises and recessions. Our calibration yields $\kappa(\theta_t) = 95$ basis points in expansions and $\kappa(\theta_t) = 385$ basis points in recessions and crises. These values reflect the heightened default risk, reduced liquidity, and increased macroeconomic uncertainty lenders face during downturns. Combined with the state-dependent risk-free rates $r^f(\theta_t)$, the calibrated premia generate equilibrium mortgage rates that closely track the cyclical patterns observed in the data.

Preferences We estimate the preference parameters related to households' consumption, financial, and housing decisions using the method of simulated moments. In particular, we use the data from the American Housing Survey and the Survey of Consumer Finances (SCF), and we search for the set of parameters that produce simulated life-cycle decision profiles closely aligning with those observed in the empirical data. The mechanics of our method-of-simulated-moments approach are fairly standard. We compute life-cycle histories for many artificial households.

[10] See HECM guidelines for the complete table. We assume for simplicity that the expected interest rate in HECM is the same as the RM rate.

Each of these households is endowed with a specific value for the state vector, and a series of idiosyncratic shocks are assigned to them in a manner consistent with the stochastic processes explicated in Section 2.

To facilitate the computational process, we discretize the state space and employ value-function iteration to solve the model numerically. This iterative procedure enables us to derive decision rules that govern the choices made by households. By combining these rules with the simulated endowments and shocks, we can simulate various aspects of household behavior, including wealth accumulation, housing decisions, refinancing, and the decision to take up RMs. Subsequently, we compute age profiles based on the artificial household histories, employing the same methodology used to analyze the actual data. We adjust until the difference between the data and simulated profiles is minimized as follows:

$$(\hat{m} - m)' W (\hat{m} - m) \tag{37}$$

Here, $\hat{m}$ refers to the simulated moments, m the targets, and W the inverse of the covariance matrix of the empirical moments, which is estimated by bootstrapping the true data.

Our target moments are the age profiles of homeownership rates, LTV, payment-to-income (PTI), and overall wealth profiles. The estimated discount factor β is 0.98, and the coefficient of relative risk aversion γ is 3, which both fall within the reasonable range in the literature.[11] Moreover, utility from homeownership u_o is 6. To match the ratio of total net worth at age 60 to net worth at age 45 in the SCF, we calibrate the bequest-motive shifter to 0.5 and the bequest-motive multiplier to 250.

Mortgage and RM Interest Rates Table 3 presents the equilibrium mortgage and RM rates across economic states. The mortgage rate is endogenously determined under the lenders' zero-profit conditions (equation 35), given projected pricing kernels calibrated to match observed spreads, while the RM rate is calibrated to match HECM spreads.

Several patterns emerge from Table 3. First, both the mortgage and RM rates vary systematically with economic conditions, reaching their lowest levels during crises (4.25% and 5.10%, respectively), when the risk-free rate is at its minimum. As the economy transitions from crisis to recession to expansion, both rates generally increase, reflecting higher risk-free rates and changing credit conditions.

Second, RM rates consistently exceed conventional mortgage rates across all states, with spreads ranging from 3.10% in crises to 4.76% in expansions with tight credit.[12] This premium compensates lenders for the unique risks associated with RMs: longer loan durations, compounding interest without periodic payments, and the non-recourse feature, which limits recovery to the home's value. The RM spread is largest during expansions with tight credit (4.76%), reflecting heightened concerns about house price volatility and the potential for negative equity positions.

[11] Yogo (2016) uses Epstein-Zin preferences to study portfolio choice in retirement with health risk and derives a risk-aversion coefficient of 5.

[12] RM rates have occasionally fallen below conventional mortgage rates during crisis episodes, reflecting temporary policy and liquidity conditions. The model instead targets long-run equilibrium spreads, under which RM rates exceed conventional mortgage rates in all states.

Third, the credit regime affects rates differently depending on the economic states. During recessions, the difference between tight and loose credit conditions is minimal for both mortgages (4.69% vs. 4.64%) and RMs (both 6.20%). This suggests that during economic downturns, other factors such as default risk and liquidity concerns dominate the effect of credit availability. In contrast, during expansions, rates are lower under loose credit than tight credit for mortgages (4.28% vs. 4.35%), though this difference is small.

Importantly, RM rates show less sensitivity to credit regimes than conventional mortgages. RM rates remain unchanged between recession with tight credit and recession with loose credit (both 6.20%), and similarly between expansion states (both 7.40%). This stability reflects the fact that RMs do not require stringent credit checks or income qualifications; eligibility depends primarily on age, home equity, and property value. RMs' non-recourse nature and FHA insurance further insulate RM rates from variations in credit conditions.

These equilibrium rates provide the foundation for analyzing household decisions in subsequent sections. The systematic variation in rates across economic states generates heterogeneity in household borrowing costs, influencing take-up decisions, refinancing behavior, and welfare outcomes documented in Section 5.

Table 3: Mortgage and RM Rates

This table presents the equilibrium model results for mortgage and RM rates in five economic states (crisis, recession with loose credit, expansion with loose credit, recession with tight credit, expansion with tight credit). The left column reports mortgage rates and their spreads relative to the 10-year Treasury yield. The right column shows the RM rates and spreads.

	Mortgage		FRRM	
	Rate	Spread	Rate	Spread
Crisis	4.25%	2.24%	5.10%	3.10%
Recession and tight	4.69%	2.19%	6.20%	3.69%
Expansion and tight	4.35%	1.70%	7.40%	4.76%
Recession and loose	4.64%	2.13%	6.20%	3.69%
Expansion and loose	4.28%	1.64%	7.40%	4.76%

Other Parameters Household refinancing processes are associated with fixed and variable costs. Specifically, following Guren et al. (2021), refinancing entails a fixed cost equal to 4% of average annual income, or roughly $2,000, along with a variable cost equivalent to 1% of the remaining mortgage balance. This variable cost aligns with the average refinancing costs reported by the Federal Reserve. For renters, a monthly rent payment is set at 0.2 to maintain a rent-to-income ratio of 20%.

Following a foreclosure, we assume the bank recovers 65.4% of the property's market value. Additionally, we consider the maximum LTV to be 90% under loose credit and 80% under tight credit. We assume the probability of a default flag being removed is 0.1.

3.2 Life-Cycle Profiles

To assess model fit, we simulate the saving, consumption, housing, and RM decisions of 100,000 households and compute the implied life-cycle profiles. We compare these profiles to corresponding averages constructed from the 2007–19 SCF. As shown in Figure 1, the model closely matches the life-cycle patterns observed in the data.

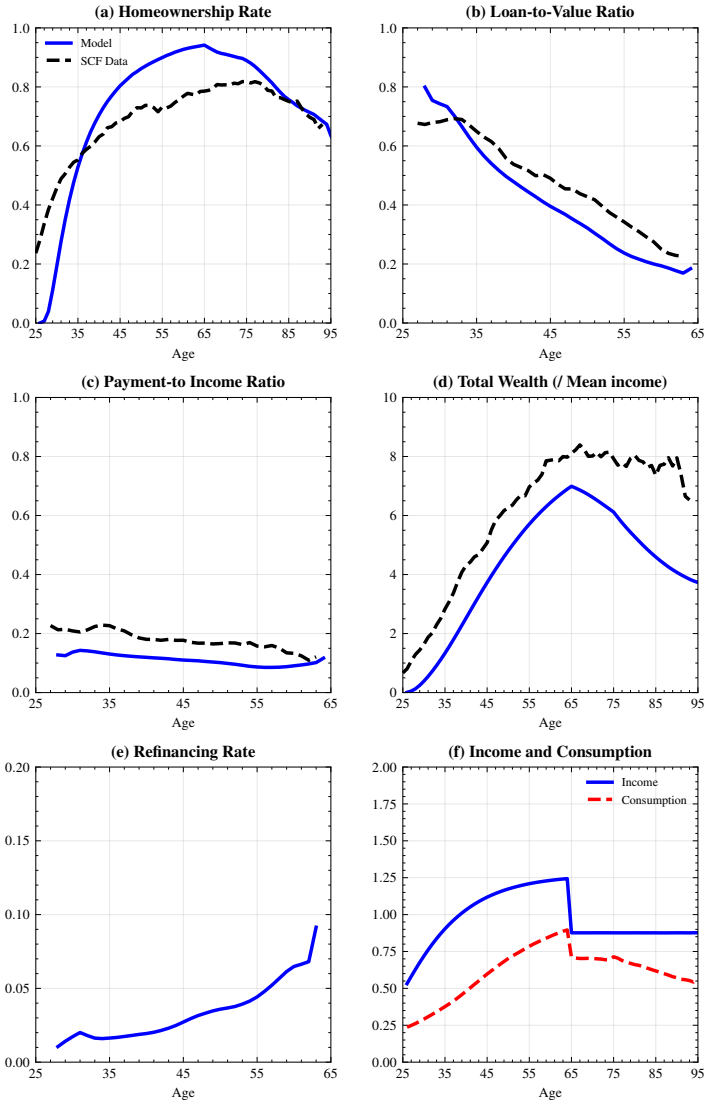


Figure 1: Life-Cycle Profiles

This figure plots key variables of model results (blue line) in comparison to empirical evidence (black dashed line) over the household life cycle. Panel A plots homeownership-rate results; Panel B plots the results of loan to value for homeowners; Panel C plots payment to income for homeowners; Panel D plots net wealth for households results; Panel E plots the homeowner refinancing rates over the life cycle; Panel F plots household consumption (blue line) and labor income (red line);

In Panel A of Figure 1, we present the homeownership-rate patterns over the life cycle. The model's simulations yield an average homeownership rate of 65%, which aligns with the data. However, the model tends to underestimate the rate for very young households and overestimate it for middle-aged households. This is possibly due to the existence of RMs in the model: Very young households are penalized financially, such that they cannot get on the property ladder, whereas throughout the rest of the life cycle, homeowners tend to hold on to houses due to the

benefit of RMs.

Panels B and C of Figure 1 show the LTV and PTI ratios by age. Our model overpredicts LTV for younger households (below 30) and underpredicts it for older households (above 39). With RMs in the model, the dynamics are asymmetric between younger and older homeowners: Younger homeowners do not have access to RMs because they have not fully repaid their mortgages; older homeowners have an incentive to repay mortgages early to access RM and hence lower the LTV. Although RMs are only available during retirement, their anticipated availability affects life-cycle borrowing decisions. Working-age households internalize future access to home equity, which reduces precautionary borrowing and dampens mortgage payments relative to income. This anticipation channel contributes to the lower modeled PTI ratios.

Figure 1, Panel E shows the fraction of owners refinancing. Refinancing is relatively low across all ages, then gradually elevates due to households' need for cash flow when approaching retirement. The availability of RMs provides an additional avenue for homeowners to access their home equity and alleviate liquidity constraints, reducing the need for traditional refinancing. By considering the impact of RMs on homeowners' financial strategies, our model provides insights into a more nuanced understanding of refinancing behavior, highlighting the role of alternative mechanisms in managing liquidity.

Figure 1, Panels D and F illustrate the life-cycle profiles of wealth, income, and consumption. Wealth accumulation is limited during the first 15 years of working life, reflecting liquidity constraints, but accelerates thereafter as households build assets that provide insurance against income risk and macroeconomic shocks. In retirement, wealth declines rapidly as households draw down accumulated assets to finance consumption. Consumption closely tracks income over the life cycle. During working years, rising permanent income supports increasing consumption. As retirement approaches, income growth flattens and consumption growth slows accordingly. In retirement, both income and consumption decline as households rely on accumulated wealth and retirement benefits. Overall, the model closely matches the observed life-cycle profiles.

4 RM Take-Up and Contract Choice

This section examines the determinants of RM take-up in the model.

4.1 Life-Cycle Patterns in RM Adoption

Comparing the empirical life-cycle pattern of RM take-up to the model's predictions, both the model and empirics display two key features: elevated take-up at initial eligibility, particularly in the later part of the sample period, followed by a hump-shaped pattern throughout retirement (see Figures 2 and 3).

The initial spike occurs because households face immediate liquidity needs upon retirement. For some households, the immediate availability of home equity through RMs provides essential liquidity that outweighs the benefits of waiting for higher PLFs. The subsequent rise in take-up rates—peaking in middle retirement—reflects households' optimal timing decision, balancing the benefits of waiting (higher PLFs, thus increasing borrowing capacity, and better resolution of health uncertainty, allowing them to observe whether they genuinely need liquidity) against

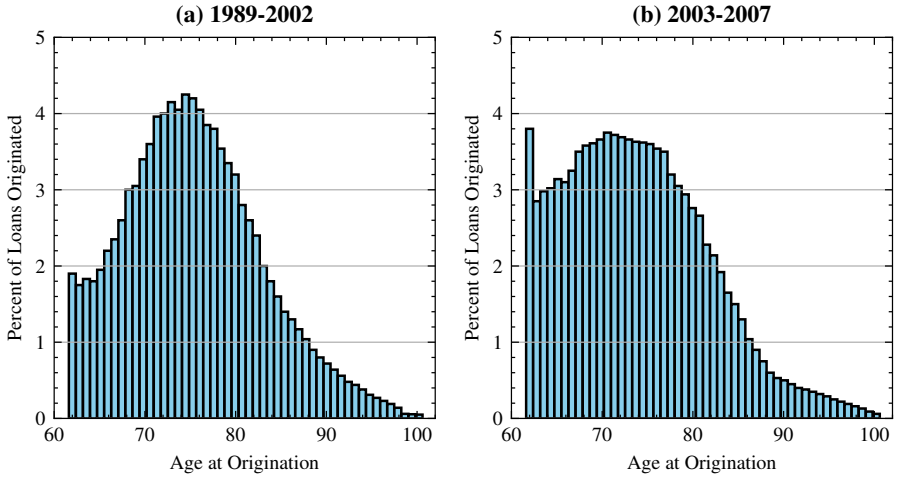


Figure 2: Empirical Age Distribution of Borrowers at Reverse Mortgage Origination

This figure shows the distribution of borrowers' age at the inception of HECM programs from Shan (2011). Panel (a) shows the patterns of 1989-2002, and Panel (b) shows the pattern of 2003–7.

the costs of delay. Delay imposes costs because (1) as remaining lifetimes shorten, the bequest motive becomes more binding, so additional debt accumulation reduces terminal wealth and makes RMs less attractive; and (2) the non-recourse feature of RMs offers insurance against house price declines (as borrowers never owe more their home's value), which is more valuable for younger retirees facing a long, uncertain retirement.

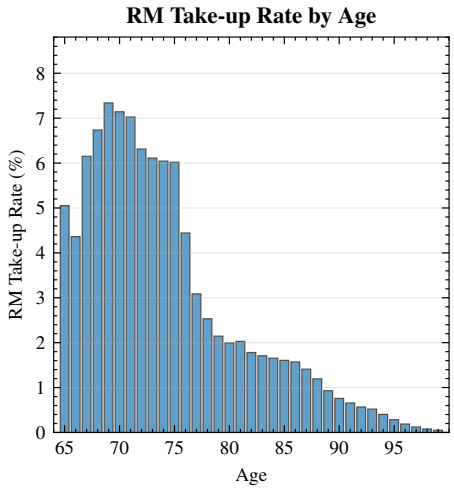


Figure 3: Life-Cycle Profile of Reverse Mortgage Take-up

This figure plots reverse mortgage (RM) take-up rates by age among eligible homeowners. The take-up rate is defined as the share of homeowners at each age who originate an RM.

4.2 Macroeconomic Conditions and Housing Prices

RM take-up varies across macroeconomic conditions. It is highest during recessions, lower during expansions with loose credit and during crises, and lowest during expansions with tight credit (Figure 4, Panel A). Although crises feature more severe adverse shocks, take-up does not peak then because borrowing capacity is procyclical with housing market conditions. Notice

that RMs help smooth consumption. Participation rises sharply in recessions because although credit conditions are tighter, precautionary demand for liquidity dominates the reduction in borrowing capacity. Participation falls during expansions with tight credit because tighter conventional mortgage constraints during working life induce greater precautionary savings, reducing their demand for equity extraction as retirees, and because tighter credit dampens house prices (Table 4), reducing principal limits. Expansions with loose credit occupy an intermediate position: Lower distress reduces precautionary borrowing, but stronger house prices and more favorable borrowing conditions sustain moderate participation.

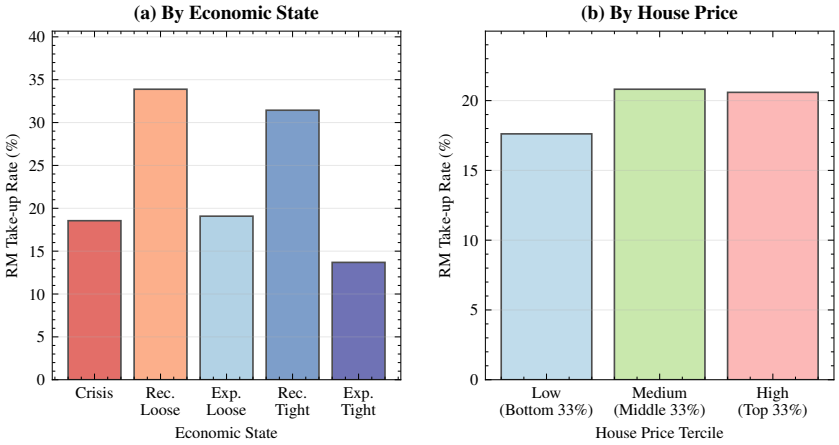


Figure 4: Reverse Mortgage Take-Up Across Macroeconomic States and House Price Terciles

This figure reports reverse mortgage (RM) take-up rates across macroeconomic conditions and local housing market segments. Panel A presents take-up by economic state, distinguishing crisis, recession with loose credit, expansion with loose credit, recession with tight credit, and expansion with tight credit. Panel B presents take-up by house price tercile, defined by the distribution of home values: low (bottom 33%), medium (middle 33%), and high (top 33%). Take-up rates are computed as the share of eligible homeowners originating an RM within each category.

Panel B turns to heterogeneity across local housing market conditions by reporting take-up by house price terciles. The pattern is mildly hump shaped. In the middle tercile, higher home values support larger credit lines and increase the attractiveness of RMs relative to their fixed costs. The slightly lower take-up moving to the highest tercile suggests a wealth effect: The typically greater overall wealth of households with more valuable homes reduces their reliance on home equity extraction. And households in the lowest tercile face limited collateral and high proportional origination costs.

4.3 Household Financial Resources

Figure 5 examines how household financial resources shape RM take-up decisions. Panel A shows a strong negative relationship between income and participation, which is consistent with the idea that RMs function primarily as a liquidity-provision device for income-constrained retirees. Lower-income households often face binding cash-flow constraints despite holding substantial housing wealth, and RMs convert illiquid housing assets into spendable resources that support consumption. By contrast, higher-income households rely more heavily on stable income streams, reducing the need to extract home equity.

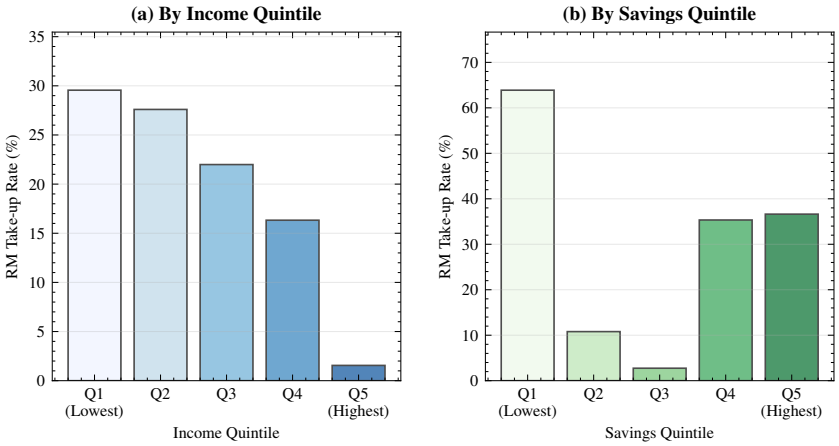


Figure 5: Reverse Mortgage Take-Up by Income and Savings Quintiles

This figure reports reverse mortgage (RM) take-up rates across quintiles of household financial resources. Panel A presents take-up by income quintile, from Q1 (lowest income) to Q5 (highest income). Panel B presents take-up by savings quintile, from Q1 (lowest) to Q5 (highest). These figures describe the distribution of new RM originations across quintile groups rather than the unconditional lifetime participation rate within each quintile; the aggregate lifetime RM take-up rate among eligible homeowners remains 4.5%.

Panel B reveals a U-shaped pattern across savings quintiles. Borrowing is heavily concentrated among liquidity-constrained households and households in the highest savings quintiles, while middle-savings households exhibit substantially lower rates. The pattern suggests heterogeneous motives for RM adoption. The high take-up rate among the lowest savings quintile reflects two facts: When liquid wealth is extremely low, income or medical shocks quickly push households toward the consumption floor; and the RM is the only instrument that relaxes the liquidity constraint while preserving housing services.Middle-savings households possess sufficient buffer wealth to avoid the floor but do not gain substantial strategic benefit from equity extraction. For high-savings households, RMs serve a strategic role in financial planning. Thus, liquidity constraints and wealth-management considerations jointly shape RM adoption.

4.4 Choice Between Fixed-Rate and Adjustable-Rate RMs

Figure 6 reports the share of RM borrowers choosing FRRMs rather than ARRMs across age groups. The pattern is hump shaped over the life cycle. Among borrowers aged 65–69, approximately 18% select FRRMs. The share rises to a peak of 24% for those aged 70–74, then declines steadily with age, reaching 17% among borrowers aged 90–94. This life-cycle variation in contract choice provides insight into how financial preferences evolve during retirement.

The relatively strong preference for FRRMs among younger retirees likely reflects several considerations. First, fixed-rate contracts lock in borrowing costs, which is attractive when households anticipate rising interest rates or value rate certainty. Second, individuals in early retirement face longer planning horizons and may prefer predictable repayment structures. Third, FRRMs typically involve lump-sum disbursements, which align with the needs of newly retired households seeking to repay outstanding mortgages, consolidate debt, or finance large expenditures.

The declining share of FRRMs at older ages suggests a shift toward flexibility. ARRMs generally provide line-of-credit features that allow borrowers to draw funds gradually rather than

receive a large upfront payment. This structure better matches irregular expenses, including medical costs or home maintenance. Moreover, as remaining life expectancy shortens, exposure to interest rate risk becomes less consequential. The line-of-credit feature also preserves unused borrowing capacity that can grow over time, offering insurance against late-life shocks.

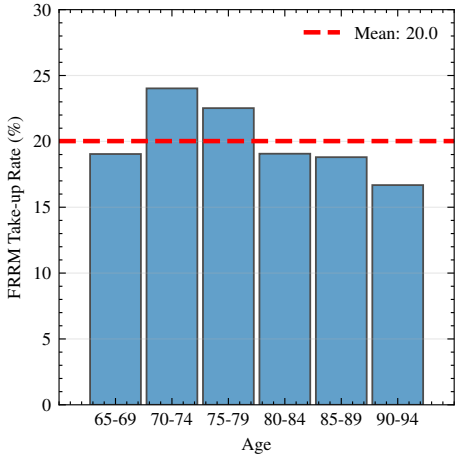


Figure 6: Life-Cycle Profile of Fixed-Rate Reverse Mortgage Take-Up
This figure plots the fraction of reverse mortgage borrowers who choose fixed-rate reverse mortgages (FRRMs) across age groups at origination. The dashed horizontal line indicates the average FRRM share across all age groups, equal to 20%.

The model generates an average allocation of 20% to lump-sum contracts, corresponding to FRRMs, and 80% to line-of-credit contracts. Empirically, HECM data from 2015 to 2024 show a substantially smaller lump-sum share of 3.5% and a line-of-credit share of 91.5%. The model's higher predicted use of lump-sum contracts partly reflects our abstraction from tenure and term payment options available in practice. In the data, some households that choose lump-sum contracts in the model select tenure or term payments instead, particularly those seeking stable income streams rather than large one-time disbursements.

5 Economic Effects of RMs

To assess the impact of RMs on households and markets, we compare two economies: a baseline economy with RMs and an alternative economy without them, holding all other structural parameters fixed. This counterfactual simulation enables us to assess how access to RMs shapes household welfare, consumption smoothing, house prices, and mortgage market dynamics.

5.1 Housing Market Effects

Table 4 compares housing market outcomes in the baseline and alternative economies. The introduction of RMs raises average house prices modestly, by 0.28% overall. The left panel reports house price differences across macroeconomic states. Prices are generally higher in the baseline economy than in the no-RM economy, although the effect is close to zero in a recession with loose credit. The largest increase occurs in a recession with tight credit, in which prices rise by 0.51%. When conventional credit is scarce, RMs become a more important source of liquidity, heightening housing demand and prices. By contrast, in loose-credit regimes the price gap is

small, as households can rely on alternative borrowing channels and the marginal value of RM access declines. During crises, prices increase by 0.46%. Although economic uncertainty suppresses demand, RM access reduces forced sales by liquidity-constrained homeowners, limiting downward pressure on prices.

Table 4: Housing Market Outcomes: Baseline Economy with Reverse Mortgages vs. No-RM Economy

This table compares housing market outcomes between the baseline economy with reverse mortgage (RM) availability and an alternative economy without RMs, holding all other structural parameters fixed. The left panel reports average house price index (HPI) levels across macroeconomic states, while the right panel reports house price volatility measured as the standard deviation (SD) of prices. "Change (%)" denotes the percentage difference between the baseline and no-RM economies. Economic states are crisis, recession (loose credit), expansion (loose credit), recession (tight credit), and expansion (tight credit).

Economic State	**Average HPI**			**Price Volatility (SD)**		
	Alternative (No RM)	Baseline (With RM)	Change (%)	Alternative (No RM)	Baseline (With RM)	Change (%)
Crisis	3.55	3.57	0.46	0.082	0.080	−2.09
Recession (loose)	4.31	4.31	0.00	0.078	0.075	−3.54
Expansion (loose)	4.41	4.42	0.09	0.098	0.095	−3.48
Recession (tight)	3.60	3.62	0.51	0.078	0.077	−1.78
Expansion (tight)	3.73	3.75	0.32	0.083	0.082	−1.39

RMs affect housing supply and demand simultaneously. On the supply side, RMs allow older homeowners to extract equity without selling, reducing turnover and tightening effective supply. On the demand side, the option value of future RM access raises the attractiveness of homeownership, increasing willingness to pay. Together, these forces generate a modest but persistent increase in equilibrium prices.

RM access also reduces price volatility by 2.46%. The right panel of 4 reports price volatility across economic states. Volatility is lower in the baseline economy in all states, with the largest percentage reductions occurring in expansions and recessions with loose credit. RMs dampen fluctuations through two channels. First, by providing liquidity to constrained homeowners, they reduce the likelihood of distress sales and fire-sale pricing during downturns. Second, RMs make long-term homeowners less susceptible to shocks and house price changes, reducing price fluctuations by lowering housing supply's responsiveness to price changes.

The stabilizing effect is stronger in loose-credit regimes, in which households can more readily access RM borrowing capacity. Under tight credit conditions, limited borrowing weakens RMs' insurance channel, reducing their ability to mitigate shocks and price volatility. This shows that keeping RM accessibility in downturns could improve housing market stability when it is most valued.

5.2 Household-Level Effects

We now turn to household-level outcomes. RMs' primary impact operates through household balance sheets and intertemporal decisions. By relaxing collateral constraints in retirement,

access alters refinancing behavior, consumption smoothing, and welfare over the life cycle. These micro-level adjustments clarify the mechanisms behind the aggregate results.

5.2.1 Mortgage Refinancing Behavior

Our model generates important insights into how RMs' presence affects conventional mortgage refinancing. Table 5 presents mortgage refinancing in the baseline vs. alternative economies across age groups. The refinancing rates in both economies are upward trending, reaching a peak for the highest age group, with the baseline-economy refinancing rates slightly lower than the alternative-economy ones. This is due to the increase in refinancing as households age in both economies: Households face higher refinancing costs at younger ages and hence refinance at a lower rate; as they approach retirement, the need for liquidity increases, which leads to a higher refinancing rate.

The gap in refinancing rates between the two economies initially shrinks from -0.06% (ages 25–29) to zero (ages 45–49), before widening and reaching -0.88% at ages 60–64. This pattern reflects how RM-induced increases in mortgage rates disproportionately affect rate-sensitive younger borrowers and do not affect middle-aged households, while they reduce refinancing the most among households approaching retirement.

A key finding is that RMs replace conventional mortgage refinancing, especially in retirement. Without RMs, retirees with declining incomes or rising expenses would need to refinance their conventional mortgages to access home equity or lower monthly payments. However, when RMs are available, many homeowners choose them over conventional mortgage refinancing. This substitution occurs because RMs offer retirees several advantages over refinancing: (1) no monthly-repayment obligations, which is especially valuable for households with limited and declining retirement income; (2) no income qualification requirements, making RMs accessible to households that might not qualify for conventional refinancing; and (3) the embedded put option on house prices, which protects borrowers from owing more than their home's value.

Our calibrated model shows that pre-retirement refinancing rates increase over the life cycle while remaining modest overall. In our model, retirees cannot refinance, and there are refinancing costs for pre-retirement borrowers. In contrast, eligible retired households have the option to obtain RMs for liquidity purposes. Hence, pre-retirement households expecting to be eligible for RMs may plan to access them for liquidity immediately after they become eligible. These prospective RM-eligible households are reluctant to refinance before they retire, lowering refinancing rates overall.

RMs' refinancing substitution effect affects mortgage lenders and the mortgage market. First, the introduction or expansion of RM programs may diminish older homeowners' appetite for conventional mortgage refinancing, affecting lenders' refinancing revenues. Second, the effect highlights that RMs and conventional mortgages form an interconnected housing finance system. RM-related policies such as lending criteria and insurance premiums affect traditional mortgage markets through refinancing behavior. Third, substituting refinancing with RMs may have welfare implications beyond the direct benefits due to RM accessibility. Transaction costs, closing costs, and credit checks are required to refinance conventional mortgages. If RMs help households achieve similar liquidity goals with lower transac-

tion costs or greater accessibility, the substitution represents an efficiency gain for the financial system. However, this substitution also means that households accumulate debt on their homes without the periodic reset that refinancing provides, potentially increasing long-term indebtedness and reducing bequests.

Table 5: Effect of Reverse Mortgages on Mortgage Refinancing Rates by Age

This table reports mortgage refinancing rates by five-year age groups in economies without RMs ("No RM") and with reverse mortgages ("With RM"). The sample includes homeowners aged 25–64. "Difference" denotes the level change (percentage points) in refinancing rates between the two economies, and "% Change" reports the percentage change relative to the No-RM economy. All statistics are computed in general equilibrium.

Age Group	No RM (%)	With RM (%)	Difference (%)	% Change (%)
25–29	1.30	1.24	−0.06	−4.58
30–34	1.65	1.60	−0.05	−3.09
35–39	1.82	1.79	−0.03	−1.49
40–44	2.33	2.31	−0.02	−1.06
45–49	3.32	3.32	−0.00	−0.09
50–54	3.96	3.92	−0.05	−1.16
55–59	5.95	5.66	−0.29	−4.88
60–64	10.01	9.13	−0.88	−8.81

5.2.2 Consumption Smoothing

Table 6 reports the cross-sectional standard deviation of consumption growth for workers and retirees in both economies. When RMs are available, homeowners, regardless of take-up, experience lower consumption growth volatility than in the no-RM economy. This pattern indicates that RM availability stabilizes consumption not only through direct access to home equity but by shifting equilibrium house prices, borrowing conditions, and refinancing behavior, which affect all households.

Panel A of Table 6 shows that access to RMs reduces consumption volatility by 0.79% in the aggregate. This decline is driven entirely by retirees, for whom volatility falls by 2.15%. For working-age households, the model implies no change (0.00%). The aggregate reduction therefore reflects the weighted contribution of improved consumption smoothing after age 65 rather than adjustments during working life. Consistent with the model structure, RMs affect consumption behavior only upon eligibility, and any pre-retirement option-value effects are quantitatively negligible in equilibrium.

Although the net effect for working-age households is zero, this masks small offsetting changes across owners, renters, takers, and non-takers. Thus, we examine heterogeneity by ownership and take-up status. Panel B decomposes the effects by homeownership status. The gains are concentrated among homeowners, particularly retired homeowners, whose volatility declines by up to 5.65%. Working-age homeowners experience a slight increase in volatility, reflecting earlier borrowing and housing adjustments. Renters exhibit only a small reduction (0.1%), consistent with their limited exposure to housing collateral. However, the modest decline suggests that changes in house prices and credit conditions indirectly affect their consumption

paths.

Panel C reports that retired RM takers experience large reductions in consumption volatility (23.32%), confirming the direct smoothing benefits of home equity extraction. Non-takers, especially working-age households, also experience small declines (0.03%), reflecting the economy-wide adjustments triggered by RM availability. Overall, RM access improves consumption smoothing, primarily for older homeowners, while generating smaller spillovers for other households.

Table 6: Consumption Growth Volatility: Economy with Reverse Mortgages vs. No-RM Economy)

This table reports the cross-sectional standard deviation of consumption growth in the economy with reverse mortgage (RM) availability (baseline) and in the economy without RMs (alternative), holding all other structural parameters fixed. "Change (%)" denotes the percentage difference between the baseline and no-RM economies. Panel A presents results by age group. Panel B decomposes outcomes by homeownership status (owners and renters) and age. Panel C further distinguishes households that obtain an RM at any point from those that do not. All statistics are computed after dropping the first 1,000 periods to ensure the economy has reached its stationary distribution.

Group	Consumption Growth Volatility		Change (%)
	Alternative (No RM)	Baseline (With RM)	
	Panel A: By Age Group		
All Ages	0.2605	0.2585	−0.79
Working Age (<65)	0.2364	0.2364	0.00
Retirement Age (≥65)	0.3194	0.3125	−2.15
	Panel B: By Homeownership Status		
All Ages			
Owners	0.2139	0.2108	−1.46
Renters	0.3405	0.3402	−0.10
Working Age (<65)			
Owners	0.2165	0.2166	0.05
Renters	0.2647	0.2646	−0.06
Retirement Age (≥65)			
Owners	0.1964	0.1853	−5.65
Renters	0.7156	0.7207	0.72
	Panel C: By RM Take-up Status		
All Ages			
Takers	0.2507	0.2311	−7.82
Non-takers	0.2618	0.2619	0.03
Working Age (<65)			
Takers	0.2348	0.2356	0.30
Non-takers	0.2366	0.2365	−0.03
Retirement Age (≥65)			
Takers	0.2784	0.2135	−23.32
Non-takers	0.3230	0.3235	0.15

5.2.3 Welfare Gains

To quantify welfare effects, we compute consumption-equivalent variation (CEV). Specifically, we measure the uniform percentage increase in consumption that households would require in the economy without RMs to attain the same expected lifetime utility as in the economy with RM access. Let V^0 and V^1 denote the value functions in the no-RM and RM economies, respectively. The CEV, $\Delta(S_{it}, \Sigma_t)$, is defined implicitly by equating lifetime utility under the two environments, holding prices and policies fixed within each economy:

$$\begin{aligned} V^1(S_{it}, \Sigma_t) =& E_t \Bigg\{ \sum_{n=t}^{t+T-a_{it}} \beta^{n-t} \prod_{m=t+1}^{n} p_m(a_{im}) \\ & \times \left[\frac{\left(C_n^0 (1+\Delta)\right)^{1-\gamma_i}}{1-\gamma_i} + D_n^o u_o - D_n^d u_d + (1-p_{n+1}) \psi^{bq} \frac{\left(Q_{in}^0 + \xi\right)^{1-\gamma_i}}{1-\gamma_i} \right] \Bigg\} \\ =& V^0(S_{it} \mid \Sigma_t) + \left[(1+\Delta)^{1-\gamma_i} - 1 \right] E_t \left\{ \sum_{n=t}^{t+T-a_{it}} \beta^{n-t} \prod_{m=t+1}^{n} p_m(a_{im}) \left[\frac{\left(C_n^0\right)^{1-\gamma_i}}{1-\gamma_i} \right] \right\} \end{aligned} \tag{38}$$

Here, $\Delta = \Delta(S_{it}, \Sigma_t)$ is the ex ante constant CEV; C_n^0, D_n^o, and D_n^d are the corresponding policies; and Q_{in}^0 is terminal wealth in the no-RM economy. Consequently,

$$\Delta(S_{it} \mid \Sigma_t) = \left(1 + \frac{V^1(S_{it} \mid \Sigma_t) - V^0(S_{it} \mid \Sigma_t)}{E_t \left\{ \sum_{n=t}^{t+T-a_{it}} \beta^{n-t} \prod_{m=t+1}^{n} p_m(a_{im}) \left[\frac{(C_n^0)^{1-\gamma_i}}{1-\gamma_i} \right] \right\}} \right)^{\frac{1}{1-\gamma_i}} - 1. \tag{39}$$

Positive values indicate welfare gains from RM availability.

Table 7 reports welfare gains by age and homeownership status. Homeowners experience sizable gains. Working-age homeowners benefit the most (4.82%), reflecting the option value of future RM access and improved consumption smoothing over the life cycle. Among retirees, gains remain positive but decline with age, from 3.12% for ages 65–75 to 2.59% for those above 75, consistent with shorter remaining horizons.

RMs' impacts on renters are heterogeneous. Young renters gain modestly (1.27%), mainly because some may transition into homeownership and value future RM access to RM. In contrast, retired renters experience welfare losses (–2.46% to –2.86%). They face higher equilibrium house prices induced by RM-driven demand but do not benefit directly from home equity extraction. These distributional patterns highlight a trade-off: RM availability benefits current and prospective homeowners but can disadvantage households that remain renters in retirement.

Aggregating across groups, the societal welfare gain is substantial at 3.22%. Homeowners gain 4.23% on average, while renters gain 0.99%.

The model overpredicts the use of lump-sum contracts relative to the data, as shown in Section 4.4. Because lump-sum disbursements provide less flexible liquidity than tenure or term options, this discrepancy could in principle affect welfare magnitudes. Expanding the contract space would enlarge the household choice set and therefore increase welfare. While broader

market adjustments may affect magnitudes, the gains reported above are driven primarily by the relaxation of borrowing constraints and improved access to housing collateral in retirement rather than by the precise timing of payouts. Accordingly, allowing more flexible disbursement structures would likely raise welfare modestly but is unlikely to materially alter the aggregate consumption-equivalent gains.

Table 7: Welfare Effects of Reverse Mortgage Availability

This table reports welfare effects measured by consumption-equivalent variation from introducing reverse mortgages in the baseline economy relative to the alternative economy without reverse mortgages. Entries represent the uniform percentage increase in consumption that households would require in the alternative economy to attain the same expected lifetime utility as in the baseline economy. Results are reported by homeownership status and age group: pre-retirement (<65), early retirement (65–75), and late retirement (>75). The rightmost column reports averages by tenure status, and the bottom row reports averages by age group.

	Age Groups			Overall
	< 65	$[65, 75]$	> 75	
Homeowners	4.82%	3.12%	2.59%	4.23%
Renters	1.27%	−2.46%	−2.86%	0.99%
Overall	3.48%	2.74%	1.88%	3.22%

5.2.4 Heterogeneity in Consumption Smoothing and Welfare Effects

The average effects of RMs on consumption smoothing and welfare conceal substantial heterogeneity across macroeconomic conditions and income groups. To uncover these distributional patterns, we examine how the impact of RM availability varies over the business cycle and across the income distribution. Figure 7 presents the corresponding results for consumption volatility and welfare gains.

Panels A and B report consumption-smoothing effects, measured as the percentage reduction in consumption growth volatility relative to the alternative economy. The stabilizing role of RMs is state dependent. As shown in Panel A, the largest reduction occurs during expansions with loose credit, followed by recessions with loose credit. The effect is smaller in crisis periods and in expansions with tight credit, in which the decline is closer to 40%–45%. Two forces determine this ordering. First, higher aggregate risk increases the demand for liquidity, raising the insurance value of RM. Second, credit conditions determine how effectively households can access home equity. Loose credit strengthens RMs' effect on consumption smoothing by lowering borrowing costs and relaxing constraints. As a result, the stabilizing impact of RMs is strongest when households both value liquidity and can readily obtain it.

The consumption-smoothing effects are also heterogeneous across the income distribution. Households in the lowest income quintile (Q1) experience the largest decline in volatility (58.1%), while the middle quintile (Q3) sees the smallest reduction (about 37%). The effect rises again for higher-income households (Q4 and Q5, around 40%–40.5%), producing a U-shaped pattern. Lower-income homeowners are more likely to face binding liquidity constraints, so the ability to convert illiquid equity into cash substantially improves consumption smoothing. Middle-income households exhibit intermediate effects, indicating that RMs provide meaningful, though diminishing, insurance as income and access to alternative credit sources increase.

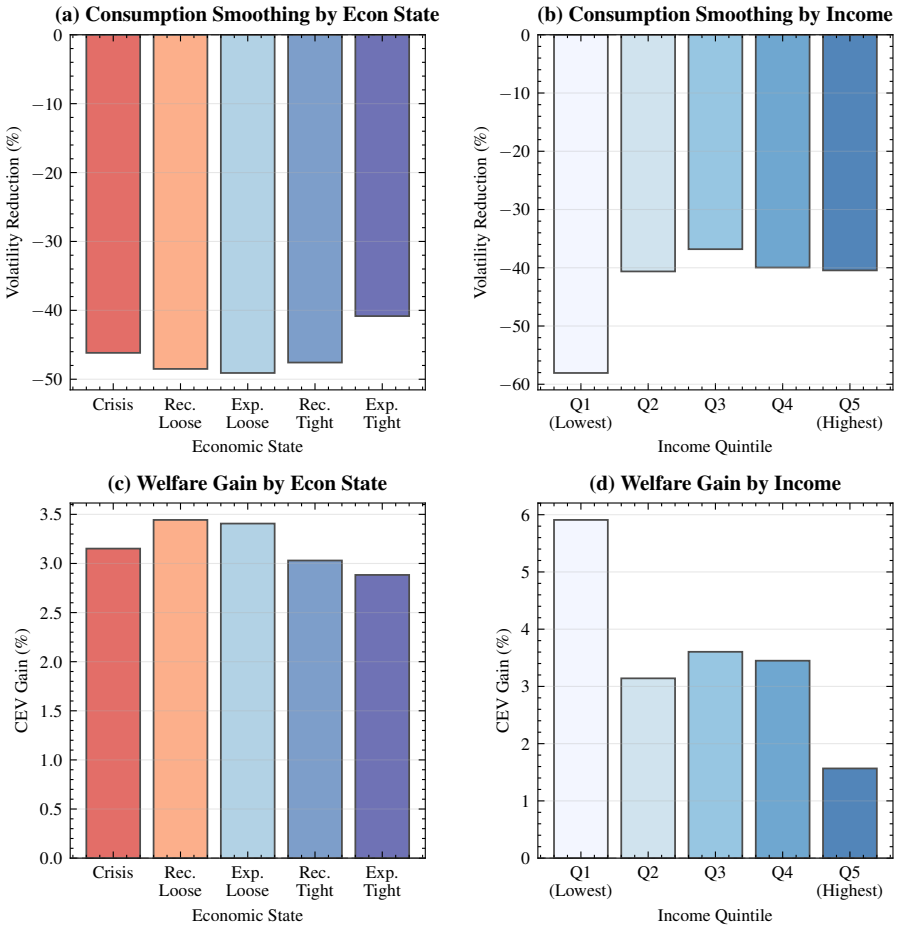


Figure 7: Heterogeneous Effects of Reverse Mortgages

This figure presents the heterogeneous effects of RM availability across economic states and income levels. Panel (a) shows consumption-smoothing benefits (measured as percentage reduction in consumption growth volatility) by economic state: crisis, recession with loose credit, expansion with loose credit, recession with tight credit, and expansion with tight credit. Panel (b) displays consumption-smoothing benefits by income quintiles from Q1 (lowest) to Q5 (highest). Panel (c) presents welfare gains measured by consumption-equivalent variation across economic states. Panel (d) shows welfare gains by income quintiles. All effects are computed relative to an economy without RMs. Negative values for consumption smoothing indicate reduced volatility (improved smoothing). Positive values for welfare gains indicate households would require that percentage increase in consumption in the no-RM economy to be indifferent between the two economies.

Panels C and D report welfare effects measured by CEV. Welfare gains are largest in recessions with loose credit (3.4%) and smallest in expansions with tight credit (2.9%). Averaging across macroeconomic states, gains are higher under loose-credit regimes overall. By relaxing equity requirements and lowering borrowing costs, loose credit increases effective access to home equity, allowing more households to use RMs and magnifying their welfare impact. Welfare effects are also highly heterogeneous across income groups. Households in the lowest income quintile gain 5.9%, compared with 1.6% for those in the highest quintile. Because lower-income households face tighter liquidity constraints and higher marginal utility of consumption, access to housing equity delivers disproportionately larger welfare improvements.

Overall, the effects of RM availability vary systematically with macroeconomic conditions and income. Benefits are larger in loose-credit regimes, when households access home equity more easily and liquidity is most valuable. Gains are also concentrated among lower-income

households, who face tighter borrowing constraints and higher marginal utility of consumption. These patterns underscore the state-contingent and progressive insurance role of RMs.

5.2.5 Decomposing the Effects of RMs: Liquidity and Price Feedback

RM availability affects household outcomes through two equilibrium channels: a direct-liquidity channel, as availability relaxes borrowing constraints by allowing homeowners to extract housing equity, thereby improving consumption smoothing and welfare; and a price-feedback channel, as RM-induced increases in housing demand raise equilibrium house prices, affecting both incumbent homeowners and prospective buyers. To isolate these mechanisms, we compare the baseline economy to a counterfactual in which RMs are accessible but house prices are held fixed at their no-RM level, thereby shutting down the general equilibrium price-feedback effect. Table 8 reports the results of this decomposition.

The welfare effects reflect opposing forces. The direct-liquidity channel generates a 7.92% welfare gain by enabling households, especially retirees, to smooth consumption and reduce exposure to income and house price risk. However, the rise in house prices reduces welfare by 4.70% because of reduced affordability, higher leverage costs, and tighter entry conditions for prospective buyers. This price-feedback effect offsets roughly 60% of the direct gains, leaving a net welfare improvement of 3.22%. The magnitude of the offset highlights that part of the benefit to current homeowners is capitalized into higher housing values, redistributing resources rather than creating pure surplus.

In contrast, the two channels reinforce each other in terms of consumption smoothing. Direct RM access lowers consumption growth volatility by 6.65%. The price-feedback channel contributes an additional 1.17% reduction, yielding a total decline of 7.82%. In general equilibrium, RM access raises and stabilizes house prices, which strengthens household balance sheets and provides a more reliable collateral base. The resulting increase in borrowing capacity enhances the effectiveness of home equity extraction, amplifying the stabilizing role of RMs. The additional reduction in consumption volatility therefore reflects improved collateral values and lower house price volatility, not heightened price risk.

Table 8: Decomposition of Reverse Mortgage Effects

This table decomposes the effects of reverse mortgages (RMs) into direct and general equilibrium price-feedback channels. Total Effect compares the baseline economy without RMs to the economy with 19% RM awareness. Direct Effect is computed from a counterfactual in which households can access RMs but house prices and mortgage rates remain fixed at no-RM levels. Price-Feedback Effect captures how RM-induced changes in equilibrium prices affect outcomes, calculated as the difference between Total and Direct Effects. Panel A reports average welfare gains measured by consumption certainty-equivalent variation across all households. Panel B reports the percentage change in consumption growth volatility for RM takers only.

	Total Effect	Direct Effect	Price-Feedback Effect
Panel A: Welfare (Cons. Equiv. Variation, %)			
All Ages	3.22	7.92	−4.70
Panel B: Consumption Smoothing (RM Takers, % Change in Vol.)			
RM Takers	−7.82	−6.65	−1.17

This decomposition highlights that the aggregate impact of RMs depends critically on equilibrium housing market responses. Part of the direct welfare gain for existing owners (from relaxed liquidity constraints) is offset by reduced affordability for prospective buyers (from raised prices), so the net welfare effect reflects a balance between improved risk sharing for current homeowners and redistribution across cohorts and tenure groups rather than an increase in aggregate surplus.

6 Robustness and Extensions

6.1 Financial Literacy

We now examine financial literacy, captured as the share of households aware of RMs. Motivated by survey evidence that limited knowledge constrains demand (Redfoot et al. (2007)), we vary the RM awareness rate from 19% (baseline) to full awareness. Table 9 presents the results relative to an economy without RMs.

We find that as awareness rises, RM take-up increases steadily, reaching 12.45% at 60% awareness and 19.67% under full awareness. Even under full awareness, take-up remains well below 100%, indicating that limited participation reflects not only informational frictions but optimal household preference heterogeneity, the bequest motive, income risk, and housing positions. For many households, RMs are simply not welfare improving.

Higher awareness substantially strengthens the insurance role of RMs. Panel A shows that consumption volatility declines monotonically with awareness among retired households. At full awareness, retirees experience an 11.14% reduction in volatility, compared with 2.15% in the baseline economy with 19% awareness. Homeowners benefit the most, with volatility reductions reaching 8.02%, reflecting both higher take-up and improved risk sharing. By contrast, the volatility of renters' consumption decreases modestly, reflecting the reduction in equilibrium house price volatility, which stabilizes rental costs despite higher average housing prices.

Panel B indicates that aggregate welfare rises with awareness, peaking at 3.97% in consumption-equivalent terms. The gains are asymmetrically distributed. Working and retired homeowners experience steadily increasing welfare improvements, reaching 6.16% and 4.77% under full awareness. In contrast, retired renters incur welfare losses that deepen as awareness rises, reaching -6.82% at full awareness. These results show that awareness causes welfare to diverge among homeowners and renters.

Panel C reports, first, that RM awareness causes average house prices to rise across all regimes. Second, RM access mitigates price fluctuations the most under credit-driven amplification or borrowing constraints, as they magnify fluctuations in the absence of access. By relaxing borrowing constraints, increased awareness improves access to housing equity and reduces the likelihood of forced sales, thereby dampening price fluctuations when credit conditions are tight. The stabilizing effect is weaker in recessions with loose credit and in severe crises, when aggregate shocks dominate household-level balance sheet adjustments and limit the extent to which RM access can influence housing market dynamics. In contrast, during expansions with tight credit conditions, the volatility-reduction effect first peaks at intermediate awareness levels (around 80%), then declines slightly under full awareness. Under higher awareness, improved

Table 9: Effects of Reverse Mortgage Awareness on Consumption Volatility, Welfare, Housing Markets, and Refinancing

This table reports model outcomes under alternative reverse mortgage (RM) awareness rates, ranging from 19% (baseline) to 100% (full awareness). All percentage changes are measured relative to an otherwise identical economy without RMs. Panel A reports percentage changes in the standard deviation of consumption (negative values indicate reduced volatility). Panel B reports welfare changes in consumption-equivalent terms. Panel C reports percentage changes in average house prices and house price volatility (standard deviation) across macroeconomic states. Panel D reports percentage changes in mortgage refinancing among working-age households (ages 25–64).

	RM Awareness Rate				
	19% (Baseline)	40%	60%	80%	100%
Take-Up Rate (%)	4.50	8.23	12.45	16.18	19.67
A. Consumption Volatility Reduction (%, rel. to No-RM Economy)					
By Age Group					
All Ages	−0.79	−1.58	−2.37	−3.17	−4.06
Working (<65)	0.00	0.04	0.09	0.06	0.13
Retired (≥65)	−2.15	−4.39	−6.66	−8.90	−11.14
By Homeownership					
Owners	−1.46	−3.09	−4.64	−6.32	−8.02
Renters	−0.10	−0.08	−0.11	−0.01	−0.06
By RM Take-up					
Takers	−7.82	−7.80	−7.76	−7.75	−7.86
Non-takers	0.03	0.19	0.32	0.47	0.61
B. Welfare Gains (%, rel. to No-RM Economy)					
By Age Group					
All Ages	3.22	3.52	3.90	3.97	3.97
Working owners	4.82	5.23	5.89	6.07	6.16
Retired owners	2.90	3.39	3.92	4.35	4.77
Working renters	1.27	1.23	1.24	0.89	0.49
Retired renters	−2.70	−3.99	−4.61	−5.89	−6.82
C. Housing Market Effect (%, rel. to No-RM Economy)					
Average Price					
Crisis	0.46	0.69	0.95	1.23	1.26
Recession (loose)	0.00	0.48	1.04	1.34	1.29
Expansion (loose)	0.09	0.28	0.44	0.50	0.35
Recession (tight)	0.51	0.68	0.97	1.87	2.17
Expansion (tight)	0.32	0.78	1.14	1.74	2.61
Price Volatility (SD)					
Crisis	−2.09	−5.70	−8.11	−9.97	−13.48
Recession (loose)	−3.54	−5.87	−7.23	−10.50	−14.20
Expansion (loose)	−3.48	−8.22	−11.65	−15.64	−20.06
Recession (tight)	−1.78	−4.53	−6.98	−11.61	−14.98
Expansion (tight)	−1.39	−1.99	−3.40	−3.81	−1.78
D. Mortgage Refinancing (%, rel. to No-RM Economy)					
Working Age (25–64)					
Ages 25–34	−3.75	−14.80	−13.24	−17.02	−21.70
Ages 35–44	−1.25	−1.60	−1.97	−2.37	−4.94
Ages 45–54	−0.67	−1.42	−2.01	−2.76	−3.94
Ages 55–64	−7.35	−15.90	−24.65	−33.90	−43.76

access to housing equity strengthens borrowing capacity and stimulates housing demand, which partially offsets the stabilization arising from the relaxation of borrowing constraints. Consequently, the marginal stabilizing effect of awareness diminishes once housing-demand responses begin to dominate balance sheet adjustment effects.

Panel D documents life-cycle adjustments in mortgage refinancing associated with increases in RM awareness. Higher awareness reduces mortgage refinancing among working-age households—particularly among borrowers aged 55–64, by up to 43.76% under full awareness. This pattern reflects the role of anticipated future access to housing equity in reducing precautionary borrowing needs earlier in the life cycle. When households expect to be able to access housing wealth with RM products in retirement, the incentive to smooth consumption through pre-retirement refinancing declines, reducing reliance on intertemporal mortgage adjustment. This mechanism highlights the role of RM availability as a retirement-contingent liquidity backstop that substitutes for earlier-life mortgage refinancing and shifts intertemporal credit demand from pre-retirement borrowing toward later-life housing-equity extraction.

The results in Table 9 indicate that RM awareness serves primarily to stabilize balance sheets over the life cycle. Anticipated access to housing equity in retirement reduces precautionary borrowing and refinancing earlier in life while lowering consumption volatility and moderating housing market fluctuations when credit constraints are binding. These findings support the interpretation of RM availability as a retirement-contingent liquidity backstop that improves household risk-sharing capacity and alters the timing of housing-equity use in equilibrium.

6.2 RMs as a Substitute for Social Security

Can private financial innovation partially substitute for the insurance provided by public old-age income programs? To quantify the insurance value of RMs, we conduct a welfare-equivalence exercise summarized in Table 10. In the baseline economy, the retirement income drop at age 65 is fixed at 35 log points. In a counterfactual no-RM economy with identical average retiree welfare, the income drop must fall to 34.47 log points. In other words, introducing RMs at baseline awareness provides insurance equivalent to a 0.53% permanent increase in retirement income, or 1.51% relative to the baseline.

This comparison should be interpreted strictly as an insurance-equivalence exercise within the model. Because the framework does not include a distinct social security system, government budget constraint, or tax-financing block, the implied benefit adjustments do not represent fiscal savings. Rather, they measure the magnitude of publicly provided income that would be required to replicate the welfare gains generated by private access to RMs.

We now examine how this insurance-equivalent value varies with financial literacy, captured by the RM awareness rate. The welfare-equivalent retirement income adjustment initially grows with awareness and peaks at 60% awareness. At that level, replicating retiree welfare in a no-RM economy requires reducing the retirement income drop to 33.80 log points, corresponding to a 3.44% permanent-income increase. Beyond 60% awareness, however, the insurance-equivalent value of RMs diminishes. At 80% and 100% awareness, the implied income increases fall to 0.77% and 0.19%. The nonmonotonic pattern reflects diminishing marginal insurance gains as participation expands, together with general equilibrium adjustments in housing and credit

markets that offset part of the incremental welfare improvement.

Overall, the results indicate that RMs provide substantial private insurance by enabling retirees to smooth consumption through home equity extraction. The magnitude of this insurance value depends on participation and awareness but is moderated by equilibrium price effects that limit marginal welfare gains at high take-up rates.

Table 10: Social Security Equivalent of Reverse Mortgage Insurance

This table quantifies the fiscal substitution value of reverse mortgages (RMs) through a welfare-equivalence exercise. Each column represents a general equilibrium with the specified RM awareness rate among eligible homeowners (age 65 and above).

	RM Awareness Rate				
	19% (Baseline)	40%	60%	80%	100%
Retirement Income Drop at Age 65 (log points)					
Welfare-equivalent No-RM	34.47	34.32	33.80	34.23	34.81
RM economy	35.00	35.00	35.00	35.00	35.00
Changes in Retirement Income					
Absolute (%)	-0.53	-0.68	-1.20	-0.77	-0.19
Relative (%)	-1.51	-1.94	-3.44	-2.20	-0.54

7 Conclusion

We develop a quantitative general equilibrium life-cycle model to evaluate the household, market, and welfare effects of RMs. By jointly endogenizing housing prices, conventional mortgage rates, and household credit decisions, we provide a unified framework to assess how RMs reshape retirement behavior, mortgage markets, and housing dynamics.

Our model matches the life-cycle profiles observed in the data, such as LTV, homeownership rate, household wealth level (especially for the PTI ratio), the fraction of owners refinancing, and the RM take-up rate. RM interest rates consistently remain higher than mortgage rates, and the difference between RM and mortgage rates tends to be larger under tight credit.

We show that RMs improve risk sharing in retirement. Access to home equity without required repayment reduces consumption growth volatility for retirees, with the largest gains accruing to liquidity-constrained households. Participation is concentrated among lower-income and lower-savings retirees and varies across macroeconomic states. RMs therefore serve primarily as a targeted liquidity instrument rather than a universal retirement product.

RMs also reshape equilibrium housing and mortgage markets. By allowing older homeowners to extract equity without selling, they reduce effective housing supply, raise equilibrium house prices modestly, and dampen house price volatility. RMs also substitute for conventional refinancing near retirement, altering intertemporal borrowing patterns. These general equilibrium effects are quantitatively important and cannot be captured in partial equilibrium.

Importantly, welfare effects reflect the interaction between direct-liquidity and price-feedback channels. While RMs generate substantial gains through improved consumption smoothing, part of the benefit is capitalized into higher house prices. As a result, homeowners experience

sizable welfare gains, whereas some retired renters incur losses due to reduced affordability. Overall, welfare increases. The magnitude of these effects depends critically on financial literacy, which expands participation and strengthens the insurance effects. However, as adoption rises, equilibrium price adjustments attenuate marginal welfare gains.

Finally, our welfare-equivalence exercise shows that access to RMs provides insurance comparable to a permanent increase in retirement income. This underscores the quantitative importance of housing wealth as a self-insurance device in old age.

As housing remains the dominant asset on household balance sheets, understanding these general equilibrium interactions is central to evaluating financial innovation in aging economies.

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Appendix A Numerical Solution

The model has no closed-form solution. We solve it by combining backward induction over the household problem with an outer equilibrium loop that updates the conventional mortgage rates r^m and the house-price forecasting-rule parameters (b_h, k_{ih}).

A.1 Household Problem

State space. The idiosyncratic state of household i at the start of period t is the 14-dimensional vector

$$S_{it} = (a_{it},\, Y_{it}^{id},\, W_{it},\, D_{it}^{o},\, D_{it}^{mov},\, D_{it}^{med},\, M_{it}^{m},\, r_{it}^{m},\, D_{it}^{d},\, D_{it}^{rm},\, M_{it}^{rm},\, D_{it}^{fix},\, r_{it}^{rm},\, \alpha_{it}^{rm})'. \tag{40}$$

We discretize each continuous dimension (savings W_{it}, mortgage balance M_{it}^{m}, and RM balance M_{it}^{rm}) onto a grid and evaluate the value function at each grid node. At the terminal period T, the value function equals the bequest utility. For each $t < T$, we maximize utility over the discrete housing decision $D_{it}^{H} \in \{-2, -1, 0, 1, 2, 3, 4\}$ and the continuous choices $(W_{it+1}, M_{it+1}^{m}, M_{it+1}^{rm}, \alpha_{it+1}^{rm})$, subject to the budget constraint (18)–(20) and the credit constraints (7)–(13). The procedure iterates backward from T to $t = 1$.

Labor income. Log labor income is $y_{it} = v_t + \epsilon_{it}$ (eq. (2)). Following Guren et al. (2021), the idiosyncratic shock ϵ_{it} is discretized onto a seven-point grid and the aggregate component v_t takes one of five values, one per macroeconomic state:

$$\boldsymbol{\epsilon} = \begin{bmatrix} -1.2663 \\ -0.9286 \\ -0.5909 \\ -0.2533 \\ 0.0844 \\ 0.4221 \\ 0.7598 \end{bmatrix}, \qquad \mathbf{v} = \begin{bmatrix} 0.0976 \\ 0.1426 \\ 0.1776 \\ 0.1426 \\ 0.1776 \end{bmatrix} \begin{matrix} \text{Crisis} \\ \text{Recess-l} \\ \text{Expans-l} \\ \text{Recess-t} \\ \text{Expans-t} \end{matrix}. \tag{41}$$

The idiosyncratic transition matrix $P_y(\theta_t)$ takes two values: one shared by the crisis and recession states (Ξ_{rec}^{id}), and one for the expansion states (Ξ_{exp}^{id}), reflecting higher earnings risk in downturns. Rows and columns are indexed by $\boldsymbol{\epsilon}$ from lowest (row 1, $\epsilon = -1.2663$) to highest (row 7, $\epsilon = 0.7598$):

$$\Xi_{\text{rec}}^{id} = \begin{bmatrix} 0.8183 & 0.1593 & 0.0103 & 0.0003 & 0.0001 & 0.0001 & 0.0116 \\ 0.1820 & 0.5046 & 0.2847 & 0.0279 & 0.0007 & 0.0001 & 0 \\ 0.0563 & 0.0783 & 0.6038 & 0.2611 & 0.0005 & 0 & 0 \\ 0.0123 & 0.0209 & 0.1493 & 0.6123 & 0.2011 & 0.0041 & 0 \\ 0.0021 & 0.0091 & 0.0227 & 0.1939 & 0.6093 & 0.1595 & 0.0034 \\ 0.0001 & 0.0019 & 0.0099 & 0.0268 & 0.2391 & 0.5904 & 0.1318 \\ 0.0033 & 0.0049 & 0.0067 & 0.0083 & 0.0140 & 0.1648 & 0.7980 \end{bmatrix}, \tag{42}$$

$$\Xi_{\text{exp}}^{id} = \begin{bmatrix} 0.7059 & 0.2663 & 0.0235 & 0.0005 & 0 & 0 & 0.0038 \\ 0.0911 & 0.5794 & 0.3204 & 0.0091 & 0 & 0 & 0 \\ 0.0021 & 0.1138 & 0.6156 & 0.26116 & 0.0069 & 0 & 0 \\ 0 & 0.0030 & 0.1478 & 0.6327 & 0.2116 & 0.0049 & 0 \\ 0 & 0 & 0.0042 & 0.1887 & 0.6361 & 0.1674 & 0.0036 \\ 0 & 0 & 0 & 0.0032 & 0.2462 & 0.6104 & 0.1402 \\ 0.0070 & 0 & 0 & 0.0001 & 0.0073 & 0.1456 & 0.8400 \end{bmatrix}. \tag{43}$$

Macroeconomic states. Following Guren et al. (2021), the economy takes one of five states: crisis, recession with loose credit (Recess-l), recession with tight credit (Recess-t), expansion with loose credit (Expans-l), and expansion with tight credit (Expans-t). The transition matrix is:

$$\mathbb{P}^e = \begin{array}{c} \\ \text{Crisis} \\ \text{Recess (l)} \\ \text{Expans (l)} \\ \text{Recess (t)} \\ \text{Expans (t)} \end{array} \begin{array}{c} \begin{array}{ccccc} \text{Crisis} & \text{Recess (l)} & \text{Expans (l)} & \text{Recess (t)} & \text{Expans (t)} \end{array} \\ \left\| \begin{array}{ccccc} 0.6364 & 0.0000 & 0.0000 & 0.0000 & 0.3636 \\ 0.0000 & 0.1011 & 0.8989 & 0.0000 & 0.0000 \\ 0.0133 & 0.1832 & 0.8035 & 0.0000 & 0.0000 \\ 0.0000 & 0.0000 & 0.0000 & 0.1011 & 0.8989 \\ 0.0133 & 0.0000 & 0.0200 & 0.1832 & 0.7835 \end{array} \right\| \end{array} \tag{44}$$

Credit conditions (loose vs. tight) are independent of whether the economy is in recession or expansion, so transitions between credit regimes occur only within the recession or within the expansion block.

A.2 Equilibrium Computation

Let $\Xi = (b_h, k_{ih}, r^m)^T$ collect the endogenous equilibrium parameters: the house-price forecasting-rule coefficients (b_h, k_{ih}) defined in (34), and the vector of conventional mortgage rates r^m (one per economic state). We iterate as follows until convergence:

i) Initialize Ξ as Ξ_0.

ii) Solve the household optimization problem backward under Ξ_{n-1} to obtain policy functions.

iii) Simulate an economy of 100,000 households over 19,000 periods, clearing the housing market each period via (36).[13]

iv) Update Ξ_n: Estimate r^m from the lender break-even condition (35), and reestimate (b_h, k_{ih}) by regressing $\ln P_{t+1}^h$ on $\ln P_t^h$ separately for each (θ_t, θ_{t+1}) pair using the simulated time series, as in (34).

v) Terminate when $\|\Xi_n - \Xi_{n-1}\|_\infty < \varepsilon$.

RM rates (r^{rm}) are not iterated upon; they are calibrated from HECM data as described in Section 3 and held fixed throughout the equilibrium loop.

[13] When a household dies, a new 25-year-old household with no assets enters the economy.