Two Roads to Foreclosure: Preference Heterogeneity in Mortgage Default

Augustus Kmetz* Daria Matviienko†

Abstract

Using microdata from the Panel Study of Income Dynamics, we document that households with a history of high net worth but low liquid savings are more likely to default on their mortgages, even after controlling for current and lagged income, lagged liquid wealth, and lagged home equity. A household that held little liquid wealth at every earlier interview has a default probability about twice the average, while a history of low net worth has no such association. To explain these facts, we estimate a structural lifecycle model of housing and mortgage choice with aggregate and idiosyncratic income and house price risk, in which households may differ in their discount factors and intertemporal elasticities of substitution. A model with two preference types reproduces the relationship, while the best-fitting single-type model does not. The model implies that 60% of households are the more impatient type, and that they account for nearly 90% of foreclosures. With the estimated model, we evaluate a one-time assistance fund that pays the mortgages of owners who would otherwise default in 2008–2012. The fund reduces net foreclosures by 70% at a cost of $41,000 per foreclosure prevented. Preventing a foreclosure is 22% cheaper for patient households, who also keep 71 cents of every dollar received as net worth, compared with 29 cents for impatient households.

1 Introduction

Foreclosure is costly. Homeowners who foreclose lose both a place to live and one of their most important financial assets. At the same time, foreclosure limits current and future access to credit, and has spillovers on nearby homes (Diamond et al., 2020; Immergluck and Smith, 2006). The collapse of housing wealth in the bust sharply reduced household spending

*PhD student, Stanford Department of Economics. Email: akmetz@stanford.edu.

†PhD student, Stanford Graduate School of Business. Email: matvienk@stanford.edu. We are grateful to Christopher Tonetti, Sebastian Di Tella, Charles I. Jones for advising and support, as well as to Adrien Auclert, Adrien Bilal, Luigi Bocola, John Cochrane, Patrick Kehoe, Benny Kleinman, Pete Klenow, Peter Kress, Arvind Krishnamurthy, Monika Piazzesi, Morgane Richard, Yuliy Sannikov, Martin Schneider, and participants at the Stanford Macro Lunch for their helpful comments.

(Mian et al., 2013). A recent finding in the literature is that most mortgage defaults are not strategic. In bank account data, only about 6% of underwater defaults are caused by negative equity alone, and most follow a fall in income (Ganong and Noel, 2023; Low, 2026). Given the high pecuniary and non-pecuniary costs of foreclosure, one would expect that more households would hold extra liquid savings to smooth over fluctuations.

Mortgagors who start a default tend to be different from those who do not. They tend to be younger, earn less, have higher loan-to-value ratios, are more underwater, and tend to have low levels of liquid savings relative to income. Following Kaplan and Violante (2014), we call such households hand-to-mouth, or H2M in the tables. A hand-to-mouth household holds little or no liquid savings relative to income, so a lost paycheck cuts its spending at once. Among those with low buffers, some are poor, and some are wealthy. The poor hand-to-mouth households have low net worth, while the wealthy hand-to-mouth households have high net worth but low liquid savings. At the same time, the status is persistent. We find that a history of being wealthy hand-to-mouth is associated with a higher probability of default, even controlling for current and prior income, prior liquid wealth, and prior home equity. In contrast, a history of being poor hand-to-mouth has a small and imprecise association with default.

This paper argues that preference heterogeneity can explain this pattern, because the history reveals that some households are more impatient than other households and thus maintain lower levels of liquid savings. To separate persistent differences in preferences from differences in shocks, we estimate a life-cycle model of renting and owning, mortgage choice, liquid saving and unsecured borrowing, sale and default. Households face aggregate and idiosyncratic risk to income and house prices, and they live through the realized aggregate history of 1960–2023. They may differ in their discount factor and their intertemporal elasticity of substitution.

We estimate two versions of the model. One version has a single household type, and the other allows for up to three types of household a la Aguiar et al. (2024). The two versions reflect different interpretations of the information content of household history. In the single-type model, all defaults are driven by shocks alone. Household behavior only differs because they have experienced different shocks. In the multiple-type model, behavior may differ across households even conditioning on the same shocks. Our estimates imply that there are two types of households, and the two-type model reproduces our motivating facts, while the best-fitting single-type model cannot. We estimate that there are two types of households: a patient household and an impatient household. Patient households are 40% of the population, and impatient households are the remaining 60%. The two-type model reproduces the untargeted persistence of hand-to-mouth status, as well as the finding that

a history of having high net worth but low liquid assets is predictive of future defaults even controlling for income, wealth, and home equity.

We then use the model to analyze who forecloses. The impatient type is 60% of households but accounts for 88% of foreclosures. Impatient households own but hold no liquid buffer, so income shocks leave them unable to pay and they default, many with positive equity.

We conclude with an evaluation of a one-time Homeowner Assistance Fund (HAF) that pays the mortgage of owners that would otherwise default in 2008–2012. The fund reduces net foreclosures by 70% at a cost of $41,000 per foreclosure stopped. Stopping a foreclosure is 22% cheaper for a patient household. This policy is much more effective for preserving the net worth of patient households. Patient household net worth increases by 71 cents of every dollar received with the policy, while impatient households only keep 29 cents of every dollar.

We contribute to three strands of the literature.

Structural models of mortgage default. Campbell and Cocco (2015) solve a life-cycle model of a household with a mortgage under income, house price, and interest rate risk. In their model, default requires negative equity, which is typical in the literature. Kaplan et al. (2020) and Guren et al. (2020) put the household into an equilibrium housing market, in which the fall in house prices produces the wave of defaults, and Mitman (2016) uses this class of model to evaluate foreclosure and bankruptcy policy. Li et al. (2025) add educational heterogeneity to the model to understand the choice between bankruptcy and mortgage default, as well as the labor supply response. Their households share one discount factor, and default requires negative equity. Piazzesi and Schneider (2016) survey the field. In each of these models, households share one rate of time preference β, and default is generated through negative equity.

Why households default. More recent evidence suggests that negative equity is not the primary driver of defaults, but rather income or other shocks, such as divorce. Ganong and Noel (2023) find in bank account data that only about 6% of underwater defaults are caused by negative equity alone and that most follow a fall in income. Low (2026) finds in linked administrative and survey data that liquidity shocks trigger nearly all defaults and that many foreclosures happen with positive equity. These defaults are costly. Diamond et al. (2020) find that foreclosure causes housing instability, lower later homeownership and financial distress for the owner; Immergluck and Smith (2006) measure the loss to neighboring house values, and Mian et al. (2013) and Ganong and Noel (2019) show that lost housing wealth and lost income reduce spending. If foreclosure is costly, then households should hold a liquid buffer, but most defaulters do not. Two-thirds of defaulters are hand-to-mouth at the previous interview (Table 1). We show that the missing buffer is a persistent trait of the

household rather than the result of the latest shock, and write down a model to reproduce this pattern.

Preference heterogeneity. We also contribute to the literature on preference heterogeneity. Kaplan and Violante (2014) show that a large share of hand-to-mouth households hold illiquid wealth, and Aguiar et al. (2024) show that hand-to-mouth status is persistent in the PSID and that hand-to-mouth households do not have the higher spending growth a common-preference model predicts. They match both facts with heterogeneity in discount factors and intertemporal elasticities of substitution. Their finding motivates our approach. We adopt their hand-to-mouth classification structure and incorporate it into a rich structural model with housing, mortgages, and default. Impatient, hand-to-mouth households drive most mortgage defaults in our model.

Roadmap: Section 2 documents the empirical patterns we explain. Section 3 lays out the model. Section 4 describes the calibration and estimation. Section 5 discusses the model fit, untargeted moments, and results. Section 6 evaluates the assistance fund. Section 7 concludes.

2 Empirical results

We document new facts about the dynamics of mortgage default using data from the Panel Study of Income Dynamics (2025). Started in 1968, the PSID is a biennial longitudinal survey of households. It follows households and their descendants over time. It collects information on age, income, wealth, and other detailed data on households.

We use data from the PSID waves from 1999 to 2023 for households with heads aged 25 to 64. After limiting to spells of at least three consecutive interviews, we observe 10,706 households over 71,097 household-waves. In particular, we use data on household income, liquid wealth, net worth, home equity, mortgage status, as well as demographic information such as age, marital status, and education. Starting in 2009, the PSID began asking households if and when they had ever foreclosed on their mortgage, which we also use. We annualize the two-year PSID foreclosure hazard rate to be comparable with other surveys. On average, 0.53% of households with a mortgage at the previous interview foreclose per year. The peak annualized foreclosure hazard is 1.53% in 2011.

Our analysis focuses on the relationship between hand-to-mouth status and foreclosure. We classify households as hand-to-mouth following Kaplan and Violante (2014) and Aguiar et al. (2024). We distinguish between poor hand-to-mouth households, who have low net worth, and wealthy hand-to-mouth households, who have high net worth but low liquid savings. We define a household as poor hand-to-mouth following Zeldes (1989). If its net

worth is at or below one-sixth of annual earnings, it is poor hand-to-mouth. Many households have low liquid wealth but high net worth. We classify a household as wealthy hand-to-mouth if its net worth exceeds a sixth of annual earnings, but its liquid wealth is low. Liquid wealth is low if it is between zero and one week of earnings or if it is negative and within one week of earnings of an assumed credit limit of 0.185 times earnings. A household that is neither poor nor wealthy hand-to-mouth is classified as not hand-to-mouth.

Fact 1: Households that default have lower incomes, liquid assets, and home equity in the preceding period.

Table 1 compares mortgagors who start a foreclosure within two years with those who do not. This table compares the two groups before the foreclosure event, at the previous interview. Differences are bootstrapped and weighted to be representative of the population of mortgagors.

In general, defaulters have lower incomes and are more likely to face sharp earnings shocks than non-defaulters. They also have weaker balance sheets. They have lower liquid wealth and are over twice as likely to be hand-to-mouth. 66% of defaulters are hand-to-mouth at the previous interview, while only 30% of non-defaulters are. They also have higher loan-to-value ratios and are much more likely to be underwater on their mortgage and have high housing payments relative to income.

Defaulters tend to be younger, less often married, and are more likely to have become divorced since the previous interview. They report worse health and are about half as likely to be college graduates.

Fact 2: Hand-to-mouth status is highly persistent.

Using data from the PSID, we compute the probability of transitioning from each state to another. Table 2 shows the weighted transition probabilities for households in consecutive surveys. Hand-to-mouth status is persistent. Households that are poor or wealthy hand-to-mouth are much more likely to remain hand-to-mouth, while households that are not hand-to-mouth stay that way 81% of the time. Because the status is persistent, a household's hand-to-mouth frequency is informative about the household, not only its latest shock (Aguiar et al., 2024). We use the frequency of being in each type of hand-to-mouth as a summary statistic for a household's history.

The likelihood of these states varies over the life cycle. Figure 1 shows the probability of being in a given state for different age bins. We find that being poor hand-to-mouth is more common among the young. Its share falls from 68% at 25–29 to 19% at 60–64. At the same time, the wealthy hand-to-mouth share rises from 5% at 25–29 to about 14% in the 50s. The wealthy hand-to-mouth state is the least persistent. Only 40% stay while poor households

Variable	**No foreclosure**	**Foreclosure**	**Difference**
Demographics			
Age	45.4	42.1	−3.3***
			(0.7)
Married (at t), percent	72.7	55.3	−17.4***
			(3.7)
Divorced since previous wave, percent	1.3	6.4	5.0**
			(2.0)
Health worse than at previous wave, percent	10.7	21.5	10.8***
			(2.6)
College degree, percent	47.8	23.9	−23.9***
			(3.2)
Income			
Earnings (dollars)	$95,392	$57,177	−$38,215***
			($2,737)
Earnings change to t, % (median)	2.9	−9.7	−12.5***
			(2.4)
Earnings drop of 30% or more, percent	11.4	28.6	17.2***
			(3.0)
Balance sheet			
Liquid wealth / earnings (median)	0.05	−0.07	−0.11***
			(0.02)
Net worth / earnings (median)	1.83	0.64	−1.18***
			(0.10)
Hand-to-mouth, percent	29.9	65.6	35.7***
			(2.9)
Poor hand-to-mouth, percent	9.2	30.7	21.5***
			(2.9)
Wealthy hand-to-mouth, percent	20.7	34.9	14.2***
			(3.3)
Housing			
Loan-to-value (median)	0.61	0.89	0.28***
			(0.02)
Underwater (LTV > 1), percent	4.0	21.0	17.0***
			(2.6)
House value / earnings (median)	2.57	3.12	0.55***
			(0.18)
Housing payment / income (median)	0.18	0.29	0.11***
			(0.01)

Table 1. Mortgagors Who Foreclose versus Those Who Do Not, PSID

Notes: This table compares mortgagors who start a foreclosure within two years with those who do not. Variables are at the previous interview unless marked (at t). Change variables run from the previous interview to t. Differences are foreclosure minus no foreclosure, with household-cluster bootstrap standard errors in parentheses. Shares are in percent. Earnings are in 2009 dollars. PSID 1999–2023, weighted. *, **, ***: $p < 0.10, 0.05, 0.01$.

	Status $(t+2)$		
Status (t)	**H2M poor**	**H2M wealthy**	**Not H2M**
H2M poor	0.767	0.067	0.166
H2M wealthy	0.164	0.401	0.435
Not H2M	0.088	0.104	0.808

Table 2. Two-Year Transitions of Hand-to-Mouth Status, PSID

Notes: Biennial transition probabilities of hand-to-mouth status, PSID 1999–2023: 57,800 pairs of consecutive interviews two years apart within a household, weighted, moment sample. Hand-to-mouth on the model's net-worth concept (home equity plus liquid wealth), as in the targeted moments. Rows: status at t; columns: status at $t+2$.

stay poor 77% of the time.

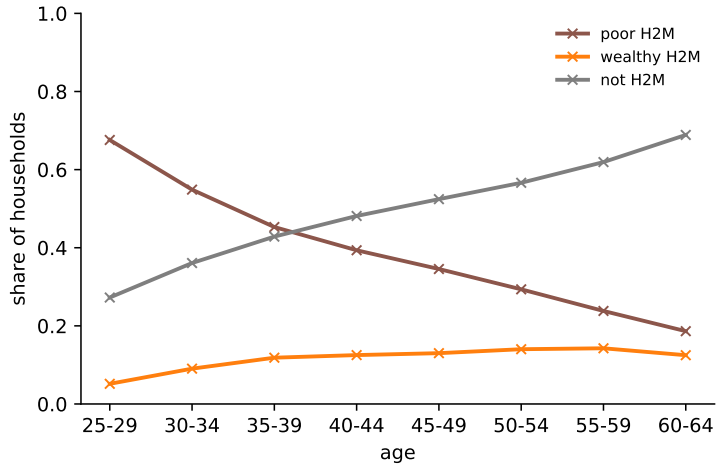


Figure 1. Hand-to-Mouth Status by Age, PSID

Notes: This figure shows the share of households that are poor hand-to-mouth, wealthy hand-to-mouth, and not hand-to-mouth in each five-year age bin. PSID 1999–2023, weighted.

Fact 3: A history of being wealthy hand-to-mouth predicts default, even controlling for observables, while a history of being poor hand-to-mouth has a small, imprecise coefficient.

In a standard representative agent model, a household's past should not matter once its current position is known. Using logistic regression, we find that a history of being wealthy hand-to-mouth is strongly associated with default, even controlling for current income, lagged liquid wealth, lagged home equity, and other covariates, as well as multiple lags of income.

To illustrate this, we run a logistic regression of the two-year default-or-foreclosure indicator on the household's hand-to-mouth history. The history is the share of its earlier interviews at which it was wealthy hand-to-mouth and the share at which it was poor hand-to-mouth. We control for current income, lagged liquid wealth, lagged home equity, and other covariates. We cluster standard errors by household.

We estimate the following logistic regression:

$$\ln \frac{p_{it}}{1-p_{it}} = \alpha + \beta_W \overline{W}_{i,<t} + \beta_P \overline{P}_{i,<t} + \mathbf{x}_{it}'\boldsymbol{\gamma} + \mathbf{z}_{it}'\boldsymbol{\theta}, \tag{1}$$
$$\mathbf{x}_{it} = \left(\ln E_{it},\ \Delta E_{it},\ \operatorname{asinh}(L_{i,t-1}/1000),\ Q_{i,t-1},\ a_{it},\ a_{it}^2\right)'.$$

where p_{it} is the probability of a default. $\overline{W}_{i,<t}$ is the share of prior interviews at which the household was wealthy hand-to-mouth and $\overline{P}_{i,<t}$ is the share of prior interviews where the household was poor hand-to-mouth. x_{it} contains the controls. z_{it} holds the additional controls of columns 2 and 3 of Table 3, year dummies and three lags of log earnings. E_{it} is household income at time t, $L_{i,t-1}$ is liquid wealth at the previous interview, and $Q_{i,t-1}$ is home equity divided by house value at the previous interview.[1] We include a polynomial quadratic in age a_{it}. We use PSID weights and cluster standard errors by household.

Table 3 shows the results of the logistic regression. We omit some of the controls from the table for brevity. We add year fixed effects in column 2, and three lags of log earnings in column 3.

In all specifications, the coefficient on the wealthy hand-to-mouth frequency is positive and statistically significant. Households with a history of being wealthy hand-to-mouth are much more likely to default, even controlling for current and lagged income, lagged liquid wealth, and lagged home equity. This suggests that their past behavior is informative of differences across households that are not captured by current income and balance sheet position.

The unweighted event rate is 1.46%, and the average derivative of the event probability with respect to the wealthy hand-to-mouth frequency is 1.33 percentage points per unit of frequency. A household that was wealthy hand-to-mouth at every earlier interview has a default probability about 1.33 percentage points higher than a household that never was, close to double the average rate.

A history of being poor hand-to-mouth has a small and imprecise association with default. This is likely because most households are poor hand-to-mouth early in life, and so the poor hand-to-mouth frequency is not informative about the household's type. In contrast, a history of being wealthy hand-to-mouth is informative about the household's type.

Consistent with our earlier observations, we find that households with lower current income, liquid wealth, and home equity are more likely to default.

[1] We clip the home equity share to $[-1, 1]$.

	(1) Baseline	(2) Year FE	(3) Income lags
Wealthy-H2M frequency (lag)	1.205***	1.218***	1.332***
	(0.434)	(0.435)	(0.448)
Poor-H2M frequency (lag)	0.139	0.383	0.203
	(0.474)	(0.491)	(0.483)
Log earnings	−0.885***	−0.807***	−1.259***
	(0.130)	(0.127)	(0.191)
Earnings change, % (2 years)	−0.003	−0.003	0.001
	(0.003)	(0.003)	(0.001)
IHS liquid wealth (lag)	−0.115***	−0.110***	−0.114***
	(0.038)	(0.039)	(0.038)
Home-equity share (lag, clipped)	−1.876***	−2.095***	−1.915***
	(0.261)	(0.280)	(0.266)
Age polynomial	✓	✓	✓
Year fixed effects		✓	
Earnings at the three previous waves			✓
Pseudo R^2	0.138	0.204	0.142
AME of wealthy-H2M frequency (pp)	1.33	1.31	1.47
N (household-waves)	12,731	12,731	12,706
Events (default or foreclosure)	186	186	186
Event rate, unweighted (%)	1.46	1.46	1.46

Table 3. Logit of Default or Foreclosure on Hand-to-Mouth History, PSID

Notes: This table reports the logit of equation (1). The dependent variable equals one if the household defaults or starts a foreclosure in the two years to interview t. The wealthy (poor) hand-to-mouth frequency is the share of the household's earlier interviews at which it was wealthy (poor) hand-to-mouth. Liquid wealth and home equity are at the previous interview. Column (2) adds year fixed effects. Column (3) adds log earnings at the three previous interviews. AME: average derivative of the event probability with respect to the wealthy hand-to-mouth frequency, in percentage points. PSID 2009–2023, weighted. Standard errors are clustered by household. *, **, ***: $p < 0.10$, 0.05, 0.01.

3 Model

We write down a life-cycle model of household decision-making under income and house price risk, similar to work by Campbell and Cocco (2015), Kaplan et al. (2020), and Guren et al. (2020). Households choose savings, housing, and mortgage contracts, and may default on their mortgage. They face both aggregate and idiosyncratic income and house price risk.

3.1 Preferences

Starting as adults, households live for T periods. We allow ex-ante heterogeneity in preferences. Households may have a type i that fixes their discount factor β_i and intertemporal

elasticity of substitution σ_i. All other preference parameters are common across households. Households have Epstein-Zin preferences with type-specific discount factor β_i and intertemporal elasticity of substitution σ_i. They have a value function over nondurable consumption c_t and housing services s_t:

$$V_{it} = \max_{c_t, h_t, b_{t+1}} \left[(1-\beta_i) \left(c_t^{\phi} s_t^{1-\phi} e^{-\delta_{def} \mathbb{1}[d_t=1] - \psi_m \mathbb{1}[\text{move}_t]} \right)^{1-1/\sigma_i} + \beta_i \left\{ E_t \left[V_{i,t+1}^{1-\gamma} \right] \right\}^{\frac{1-1/\sigma_i}{1-\gamma}} \right]^{\frac{1}{1-1/\sigma_i}} \tag{2}$$

where ψ_m is a utility penalty that reflects the "psychic cost" of moving, and $\mathbb{1}[\text{move}_t]$ is an indicator for whether an owning household moves in period t (Low, 2026, 2025). δ_{def} is a utility penalty that applies if a household decides to move *and* default, so that δ_{def} reflects the utility cost of default beyond moving. A household may be unhappy to move, but they will be even more unhappy to decide to move and default.

Households can rent or own. If households rent, they receive housing services h_t, and if they own, they receive a "warm glow" benefit $\alpha > 1$, so that $s_t = \alpha h_t$.

Finally, at period T, households die, and their final value is a bequest motive that takes the following form:

$$V_{iT} \;=\; (1-\beta_i)^{\frac{1}{1-1/\sigma_i}} \, \epsilon^{\frac{1}{\sigma_i - 1}} \left(W_{iT} + \bar{b} \right), \qquad W_{iT} = R(b_{iT})\, b_{iT} + (p_{iT}^h - M_{iT}) h_{iT}, \tag{3}$$

where W_{iT} is terminal net worth and b_{iT} is liquid wealth with gross return $R(b_{iT})$. $(p_{iT}^h - M_{iT})h_{iT}$ represents the proceeds from liquidating their house, where p_{iT}^h is the house price per unit of housing, and M_{iT} is the mortgage balance per unit of housing, and h_{iT} is the house size.

The bequest motive is linear in terminal net worth above the floor $\bar{b}$, with a luxury-bequest shifter $\bar{b}$ that makes bequests a luxury good after De Nardi (2004). When a household dies holding a mortgage, the estate is liable for the mortgage balance, and the household's heirs receive the house net of the mortgage balance.

3.2 Income Process

Households inelastically supply labor and face aggregate and idiosyncratic income risk. The log labor earnings process takes the following form:

$$\log Y_{it} = g_y t + a_t^y + \Gamma(age_{it}) + \xi_i + z_{it} + \tau_{it} + \eta_{it}, \tag{4}$$

$$z_{it} = \rho_z \, z_{i,t-1} + \omega_{it}, \qquad \omega_{it} \sim N\left(0, \sigma_\omega^2(age_{it})\right), \tag{5}$$

$$\eta_{it} \sim N(0, \sigma_\eta^2) \quad \text{i.i.d.}$$

where Y_{it} is gross earnings. a_t^y is the aggregate income deviation and $\Gamma(\cdot)$ is the deterministic age profile. ξ_i is a permanent type.

z_{it} is an AR(1) persistent shock with persistence parameter ρ_z. Innovations to the persistent shock ω_{it} are normally distributed with age-varying variance $\sigma_\omega^2(age_{it})$. Persistent income risk can vary over the life cycle. The transitory shock η_{it} is normally distributed with constant variance σ_η^2. τ_{it} is a two-state crisis component such that $E[\tau] = 0$. It takes a large negative value during a crisis and a small positive value otherwise, with an entry hazard and an exit hazard.

Households must pay income taxes. We model households as paying federal income tax, state income tax, and the employee payroll tax. The post-tax household income is given by the function $g(Y_{it})$. Some households also may receive transfers. Function $f(Y)$ adds average cash transfers to $g(Y)$. We include transfers such as unemployment insurance, TANF, SSI, other welfare, and workers' compensation, but exclude SNAP and Social Security. The tax function g and the transfer function f are both indexed to trend income.

To compute simple forms for $g(Y)$ and $f(Y)$, we simulate taxes and transfers using TAXSIM on PSID waves and interpolate between 19 bins of gross labor income to construct the tax and transfer scheme. Mortgage interest is deductible from taxes, so an owner's net income is $y^o(Y_{it}, I_{it}) = f(Y_{it}) + \Big[Y_{it} - q_{it} + g(q_{it}) - g(Y_{it}) \Big]$ with taxable income $q_{it} = \max\{Y_{it} - I_{it}, 0\}$. A renter's net income is simply $f(Y_{it})$.

3.3 Asset Markets

Households can save or borrow from a liquid account b. This account earns gross return $R(b)$. Positive balances earn the deposit return $1 + r_s$. Negative balances are charged the unsecured borrowing rate $1 + r_b$. Unsecured borrowing follows Aguiar et al. (2024) where borrowers can borrow up to a share of their income.

The borrowing limit $\underline{b}$ is a fraction χ of own annual income excluding the transitory shock.

$$b_{i,t+1} \geq -\underline{b}_t$$
$$\underline{b}_t = \min\Big\{ \chi \, y_{it}^p, \; N_t \Big\}$$

Borrowing is also subject to the natural borrowing limit that guarantees repayment on the worst income path $\underline{y}_{t+1}$. The natural limit is the most a household could repay out of its lowest possible future income:

$$N_t = \frac{N_{t+1} + \underline{y}_{t+1}}{1 + r_b}, \qquad N_{T-1} = \frac{\bar{b}}{1 + r_b}, \tag{6}$$

where $\underline{y}_{t+1}$ is net income at the lowest income state next year and $\bar{b}$ is the bequest shifter of (3).[2]

We specify that in the year of a mortgage default and in the year of a purchase, households are unable to borrow unsecured debt. Then,

$$b_{i,t+1} \geq \min\{b_{it}, 0\} \quad \text{in a default year or a purchase year.}$$

Households may repay debt or save. In these years, the household carries over its unsecured balance to the next period.

3.4 Housing Markets

Households can own or rent discrete house sizes. The distribution of available home sizes is segment-specific. That is, renters have access to a set of available home sizes $\mathcal{H}_r$, and owners to $\mathcal{H}_o$.

Home ownership is risky. Log house prices grow at a constant rate, but are subject to aggregate and idiosyncratic shocks that may affect the value of the property. For a homeowner, this takes the form:

$$\log P_{i,t} = \log P_0 + g^h \cdot t + a_t^h + \nu_{i,t}, \qquad \nu_{it} = \nu_{i,t-1} + u_{it}^h, \quad u_{it}^h \sim N(0, \sigma_w^2), \tag{7}$$

where $P_{i,t}$ is the price of house i at time t, g^h is the trend growth rate of house prices, a_t^h is the aggregate deviation from the trend, and $\nu_{i,t}$ is the idiosyncratic shock to house i's price. The idiosyncratic shock ν follows a random walk with normally distributed innovations u_{it}^h, and is observed by the homeowner. $\nu_{i,t}$ is set to zero when the house is bought.

Homeowners face costs associated with owning a home. They pay proportional property taxes τ^h and maintenance costs δ^h. When selling a home, they incur proportional transaction costs κ^s. When buying a home, they incur proportional transaction costs κ^m and a fixed cost κ_f. To reflect the costs of selling a home in distress, we introduce a fire-sale discount κ_p that applies to distressed sellers. A homeowner is considered distressed if the carrying costs of the home (mortgage payment, property tax, and maintenance) scaled by n_d exceed their after-tax income plus liquid wealth and unused credit.

Finally, upon selling the home, the homeowner receives a sale price that includes a

[2] In our estimated model, the natural limit never binds, so the credit limit is χy_{it}^p at every age.

transitory offer component v, such that the realized sale price is $\tilde{p}^h = p^h e^v$ with $E[e^v] = 1$. The decision to sell is made before observing the offer. The offer component reflects the uncertainty in the sale price due to market conditions and negotiations (Giacoletti, 2021). Foreclosure sales are not subject to this offer noise.

The price of rent is the user cost of housing. The user cost of housing is effectively the cost of purchasing a house in this period and selling at the end of one period, after paying maintenance, taxes, and mortgage expenses, reduced by the expected capital gains on the property. Therefore, the price of renting is:

$$p_t^r = \left[\ell\, r^m + (1-\ell)\, r_s + \tau^h + \delta^h - g^h\right] P_0 e^{g^h t + a_t^h}, \tag{8}$$

where the rent price p_t^r is determined by the mortgage rate r^m, the deposit return r_s, the property tax τ^h, the maintenance cost δ^h, and the trend price growth g^h. The term ℓ reflects the share of the house purchased through a mortgage, while $1-\ell$ represents the share financed through liquid savings. The aggregate house price deviation a_t^h captures the current aggregate price fluctuation in the housing market at the beginning of period t.

Mortgage contracts

After choosing a house size, a buyer chooses one of four financing options. Households can take an FHA-type loan with a low down payment and an upfront insurance premium financed into the balance, two loans with larger down payments, or pay in cash. All loans are constant-real fixed-payment annuities at the mortgage rate r^m. When households take out a loan with a down payment below 20%, they must pay mortgage insurance as a share of the balance while the scheduled balance is high relative to the original price. This insurance protects the lender in case of default and is a common feature of low-down-payment loans. Mortgage origination is also subject to a debt-to-income requirement that caps the first-year nominal payment (including insurance), property tax, and minimum card payment as a share of gross income. The cap reflects that in practice, regulators and lenders impose debt-to-income limits to ensure that borrowers can afford their mortgage payments. A new mortgage must be scheduled for repayment by age 85. So the FHA-type loan is open to buyers up to age 55, the 10% down loan up to 57 and the 20% down loan up to 60. Older buyers may always pay cash.

Once a loan is paid off, the household keeps the house and pays property tax and maintenance. There is no refinancing or prepayment. Mortgage interest is deductible from taxable income.

Default and exclusion

Households may default on their mortgage. Default is a discrete choice that occurs before the household chooses consumption and next-period liquid wealth. Following Low (2025), we model default as a delinquency year in which the household stops paying the mortgage and stays in the house, paying neither mortgage, rent, tax, nor maintenance. During the default year, the house is sold at a discount χ_f of its value. The household receives whatever is left after the mortgage balance and skipped payments, if anything remains. Mortgages are non-recourse, so the lender can only recover the house and cannot pursue the household's other assets. Card debt does survive default.

After defaulting, the household is temporarily excluded from the mortgage market for a random number of years. The household regains access to the mortgage market with probability π_{re} at the start of each year after default. While excluded from the housing market, the household can only rent. The expected time to readmission to the mortgage market is $1/\pi_{re}$ years from the default year. The excluded state has its own value function V^x (further described in Section A).

3.5 Timing

Timing follows the order below within a period (also illustrated in Figure 2). The discrete choice is made before consumption and saving, so that the household can condition on the choice when choosing consumption and saving.

Within a period:

1. Information is realized. The aggregate state S_t and the household's income shocks are drawn, so income Y_{it} and any credit limits are known. An excluded household learns whether it regains access to the housing market.

2. Owners choose to stay, default, or sell their homes. Renters with market access choose whether to rent or buy.

3. Owners who choose to sell draw their offer v and receive the proceeds of the sale.

4. Households make their housing decisions. Renters and buyers choose their new house size, and buyers choose mortgages subject to their constraints. Defaulting households receive any excess value from their home after the fire sale. Then, all households choose consumption and savings.

5. At the end of the period, the idiosyncratic price shock ν is drawn for each house and mortgages age for one year. The income process evolves.

Figure 3 shows the choice set of each ownership state.

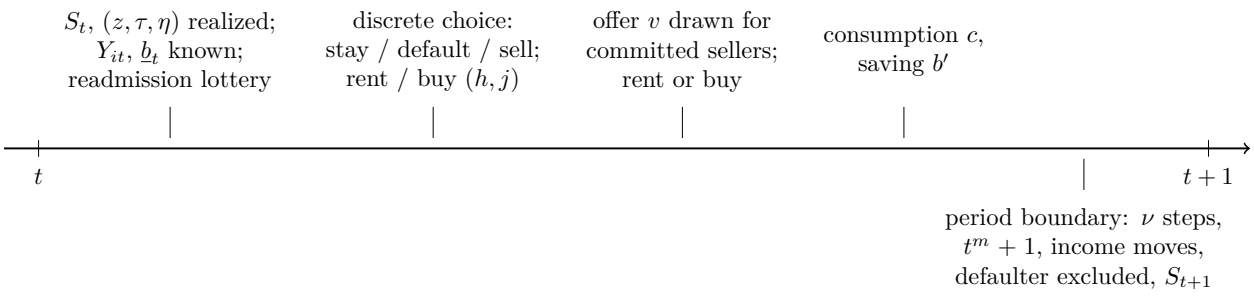


Figure 2. Timing Within a Period

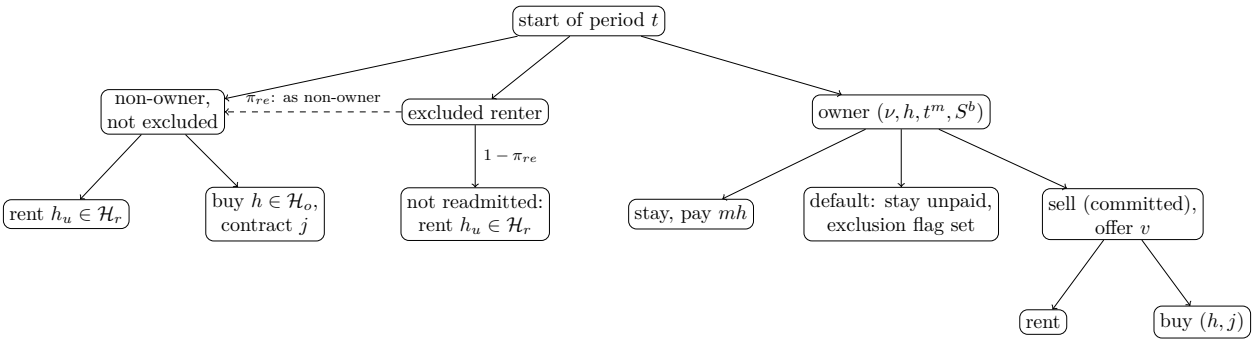


Figure 3. Choices by Ownership State

3.6 Aggregate risk, trend and normalization

Trend income grows at a constant rate g_y, and aggregate house prices grow at the same rate $g^h = g_y$. Trend income is then $G_t = e^{g_y t}$. The deviations from trend are captured by the aggregate state $S_t = (a_t^y, a_t^h, q_t)$, which follows a joint Markov process. a_t^y is the aggregate income state, a_t^h is the aggregate house price state, and q_t reflects momentum in house prices. In levels, the aggregate income process follows $\log Y_t^A = a_y + g_y t + a_t^y$ and the aggregate house price process satisfies $\log P_t^H = a_h + g_y t + a_t^h$.

Because the period composite in (2) is homogeneous of degree one, the problem is solved in units of the trend $G_t = e^{g_y t}$. Money amounts are measured in units of G_t. One model unit is \$81,230 in 2009 dollars. Dividing by G_t removes the common trend from income and house prices, because both grow at g_y. Appendix A writes the household's problem recursively in these units, which is what we solve on the computer.

4 Calibration and Estimation

We calibrate the model in three steps. First, in Section 4.1 we fix several standard parameters. Second, in Section 4.2 we externally estimate the income, house-price, and aggregate processes. Third, in Section 4.3 we estimate the remaining parameters using SMM on a synthetic panel based on the PSID. We discuss implementation in Section D.2. We calibrate and estimate the model for a model with three types of households in terms of preference heterogeneity, and a model with only a single type of household.

4.1 External calibration

We set several parameters based on the literature or standard moments. These are summarized in Table 4. First, we set the model to study households from 25-64, so that T = 40. We set the trend growth of real income per capita to 1.77% to match the NIPA growth series. A foreclosure remains on the credit report for 7 years, so we set the expected exclusion time to 7 years and the probability of readmission to $\pi_{re} = 1/7$.

For financial markets, we set the real interest rate r to 1.20%, which is the mean of the real ten-year Treasury yield over 1999-2023. The mortgage rate r^m is set to 3.07%, which is the real interest rate plus the average spread of the 30-year fixed rate over the ten-year yield. Deposits have a real negative return of $r_s = -1.4\%$, and credit cards cost $r_b = 7.93\%$. The credit line is set to 0.185 of own annual income, which is the SCF median self-reported limit.

The set of available sizes of rental housing $\mathcal{H}_r$ and owned housing $\mathcal{H}_o$ are set according to Kaplan et al. (2020). Maintenance δ^h is set to 2.5% and property taxes τ^h are set to 1%. We set the proportional costs of buying and selling κ^m and κ^s to 4% and 8%. Finally, we set the assumed leverage of landlords ℓ equal to 90%.

Mortgage contracts are fixed-rate mortgages. Households can choose a 3.5%, 10%, or 20% down payment, or can use cash. FHA loans incur a mortgage insurance premium upfront payment of 1.75% and a 0.7% per year mortgage insurance payment on the balance until the balance reaches 80% or below. The FHA-type loan is a 30-year fixed-rate loan, while we implement the 10 and 20% down loans as seasoned vintages of the same 30-year schedule (see Appendix D.2 for details). Therefore, the 10 and 20% loans are 28- and 25-year mortgages respectively.

We set the debt-to-income cap to 43%. We set the foreclosure discount $\chi_f = 0.355$ following Low (2025).

Parameter	Symbol	Value	Source
Life cycle			
Life span	T	40 years	Income-process age grid
Model ages		25–64	Income-process age grid
Trend income growth	g_y	1.77%	NIPA compensation per capita
Readmission probability	π_{re}	1/7	Credit-report retention convention
Financial markets			
Pricing rate	r	1.20%	Real ten-year Treasury mean
Mortgage rate	r^m	3.07%	Pricing rate plus FRM spread
Deposit return	r_s	-1.40%	After-tax M2 / FDIC composite
Card rate	r_b	7.93%	Assessed APR less charge-offs, real
Credit line	χ	18.5% of annual income	SCF median limit, Aguiar, Bils and Boar
Card minimum in DTI		14.76% APR + 12% principal	Nominal APR plus assumed principal share
Debt-to-income cap		43%	Assumed, close to the data
Inflation in DTI	π	2.15%	Mean PCE inflation
Housing			
Maintenance	δ^h	2.50%	Campbell and Cocco
Property tax	τ^h	1.00%	Kaplan, Mitman and Violante
Buying cost	κ^m	4.00%	Kaplan, Mitman and Violante
Selling cost	κ^s	8.00%	Kaplan, Mitman and Violante
Landlord leverage	ℓ	90%	Rental user-cost assumption
Rent-to-value ratio		4.35%	Implied rental user cost
Rental sizes	$\mathcal{H}_r$	3 sizes, 1.17–1.92	Kaplan, Mitman and Violante grid
Owner sizes	$\mathcal{H}_o$	6 sizes, 1.50–5.15	Kaplan, Mitman and Violante grid
Mortgages			
FHA-type down payment		3.5%	Solver FHA-type contract
Financed upfront premium		1.75%	Solver FHA-type contract
Annual insurance premium		0.7%	Share of outstanding balance
Base loan term	T^m	30 years	Solver mortgage schedule
Other down-payment targets		10%, 20%	Nearest vintages of the base schedule
Maximum repayment age		85	Remaining term must fit before this age
Default			
Foreclosure deadweight loss	χ_f	35.5%	Low, foreclosure loss calibration
Taxes and transfers			
Net-income knots	f, g	19 each	PSID renters and TAXSIM

Table 4. Externally Set Parameters

Notes: This table lists the parameters set outside the estimation. Rates are annual. Rent/value is $\ell r^m + (1-\ell)r_s - g_y + \tau^h + \delta^h$. The debt-to-income test counts the mortgage payment, property tax, insurance and the card minimum.

4.2 External processes

We calibrate several processes outside of the model. In Section 4.2.1, we calibrate the joint aggregate income and house price process using aggregate income and house price series. We then estimate the idiosyncratic labor process using PSID data in Section 4.2.2. We compute the idiosyncratic house price process and transaction noise in Section 4.2.3. We approximate the tax and transfer functions using data from the PSID combined with the `TAXSIM` program.

4.2.1 Aggregate income and house price process

We calibrate aggregate income and house price processes to take the following form:

$$\log Y_t^A = a_y + g_y t + a_t^y, \qquad \log P_t^H = a_h + g_y t + a_t^h, \tag{9}$$

where the aggregate income deviation a_t^y follows an AR(1) and the aggregate house price deviation a_t^h follows an AR(2) such that

$$a_t^y = \rho_y a_{t-1}^y + e_t^y, \tag{10}$$

$$a_t^h = \phi_1 a_{t-1}^h + \phi_2 a_{t-2}^h + e_t^h, \qquad \operatorname{corr}(e_t^y, e_t^h) = 0.25, \tag{11}$$

where Y_t^A is real compensation per capita and P_t^H is the real national house-price index. We use the NIPA real compensation per capita and the real Case-Shiller national house-price index from 1959–2023 to measure each process. We estimate each equation by least squares on the detrended series and take the innovation correlation from the residuals. The AR(2) gives house prices momentum and then reversion, with a cycle of 18.2 years. Using their joint processes, we discretize them into a 20-state Markov chain. Table 5 reports the estimates and details of the chains. Appendix B gives the details of the estimation.

4.2.2 Idiosyncratic labor process

We now discuss our estimation of the idiosyncratic labor-income process. We estimate the labor-income process using PSID household labor income from ages 25–64. First, we estimate the life-cycle function of income $\Gamma(\text{age}_t)$ as a quartic polynomial. Concretely, we regress log labor income on year dummies, a quartic in age, and demographic controls (education, race, sex, region, and parental background). The year dummies absorb the aggregate component, and the age terms give Γ. After removing the trend, the aggregate state, and the age profile, we are then left with the idiosyncratic component of income:

Quantity	Symbol	Value
Panel A. Annual estimates		
Income persistence	ρ_y	0.923
Income innovation SD	σ_{e^u}	0.021
Price first lag	ϕ_1	1.644
Price second lag	ϕ_2	-0.764
Price innovation SD	σ_{e^p}	0.027
Innovation correlation	$\text{corr}(e^u, e^p)$	0.249
Cycle length (years)		18.169
Annual observations	N	65
Panel B. Discretized chain		
Joint states		20
Income log-deviation nodes		$[-0.055, 0.055]$
Price log-deviation nodes		$[-0.251, -0.126, 0.026, 0.179, 0.373]$
Normalized price levels		$[0.778, 0.882, 1.026, 1.196, 1.453]$
Momentum log-change nodes		$[-0.034, 0.034]$

Table 5. Aggregate Income and House-Price Process

Notes: Panel A reports the estimates of equations (9)–(11) on annual data 1959–2023. Panel B reports the nodes of the Markov chain. Price nodes are log deviations from trend.

$$\log Y_{it} - g_y t - a_t^y - \Gamma(age_{it}) = \xi_i + z_{it} + \tau_{it} + \eta_{it}. \tag{12}$$

These residuals are the idiosyncratic component. We then estimate the parameters of (12) on the residuals by simulated minimum distance. We target the variances of earnings growth at several horizons, the kurtosis and left tail of earnings growth, and the life-cycle profile of the variance. We discretize the persistent income component with five Rouwenhorst (1995) nodes, and the crisis component with two states. Table 6 reports the estimates and the fit. Panel B shows that the estimated process fits the data well.

4.2.3 Idiosyncratic house price process

To estimate idiosyncratic house price shocks, we use CoreLogic deeds data on repeat sales from 1987–2023 to compute returns for spells of different lengths. To net out location-specific house prices and isolate the idiosyncratic shock, we subtract the change in the FHFA annual five-digit ZIP code house price index from Bogin et al. (2019), interpolated to months, over the same months. We drop pairs in ZIP codes without an index. Then, we use the idiosyncratic house price series on observed spells to calibrate the random walk. We discretize the random walk ν as a Markov random walk with seven nodes. The sale noise v uses three Gauss-Hermite nodes. Table 7 reports the estimates.

Quantity	Symbol / data	Value / process
Panel A. Estimated annual process		
Persistence	ρ_z	0.9161
Innovation SD, ages 25/35/45/55/60	$\sigma_\omega(a)$	$[0.147, 0.147, 0.147, 0.256, 0.256]$
Persistent-level SD, same ages	$\mathrm{sd}(z_a)$	$[0.147, 0.340, 0.363, 0.558, 0.606]$
Transitory log nodes	η	$[-0.302, 0.000, 0.302]$
Transitory weights		$[1/6, 2/3, 1/6]$
Permanent-type log nodes	ξ	$[-0.887, 0.000, 0.887]$
Permanent-type weights		$[1/6, 2/3, 1/6]$
Crisis / normal log level	τ	-1.7839 / 0.1155
Crisis entry / exit probability		0.0272 / 0.4198
Mean crisis duration	years	2.38
Panel B. Targeted moments		
Moment	Data	Estimated process
Variance of 2-year log income growth	0.4110	0.4112
Variance of 10-year growth	0.6886	0.6906
Variance of 20-year growth	0.8633	0.8053
Autocovariance of 2-year growth	-0.1290	-0.1345
Kurtosis of 2-year growth	6.9036	6.9491
Share with $\lvert\text{growth}\rvert > 1$ log point	0.0849	0.0851
1st percentile of 2-year growth	-2.1595	-2.1277
Recovery after a large drop	0.6426	0.6500
Large change after a large change	0.3437	0.3299
Variance of log income, pooled	0.6485	0.6541
Variance of log income, first wave	0.5939	0.5330
Variance of 2-year growth, ages 50+	0.4605	0.4697
Variance of log income, ages 50–54	0.6506	0.7334
Variance of log income, ages 55–60	0.9090	0.8538

Table 6. Idiosyncratic Income Process

Notes: Panel A reports the estimated process of Section 3.2 and its discretization. Panel B compares the targeted moments in the PSID with the estimated process. PSID head-plus-spouse labor income, ages 25–64, waves 1981–2023, N = 122,180 household-waves. Growth horizons k1/kmid/klong are 2/10/20 years.

Quantity	Estimate / count	Bootstrap SE / nodes
Random walk with sale noise		
Annual step SD σ_w	0.04741	(0.00075)
Sale-noise SD σ_v	0.12345	(0.00149)
Sample and discretization		
Repeat-sale pairs after trimming	36,984,427	
Repeat-sale pairs before trimming	37,739,237	
Sale years	1987–2023	
Idiosyncratic log-price nodes ν	7	Listed in note
Sale-offer quadrature nodes used by solver	3	

Table 7. Idiosyncratic House-Price Process

Notes: This table reports the random walk and sale-noise estimates from CoreLogic repeat sales net of the FHFA annual ZIP code index, fitted over holding periods of 2–15 years. Parentheses are county-cluster bootstrap standard errors. The log-price nodes of ν are $[-0.40, -0.20, -0.08, 0.00, 0.08, 0.20, 0.40]$.

4.2.4 Tax and Transfer

Finally, to approximate the tax function g and tax-plus-transfer function f, we simulate the tax schedule on PSID renters 1999-2019 with TAXSIM, and linearly interpolate the mean net income at 19 gross-income knots. Section 3.2 describes f and g in greater detail. Our interpolated functions are plotted in Figure 4.

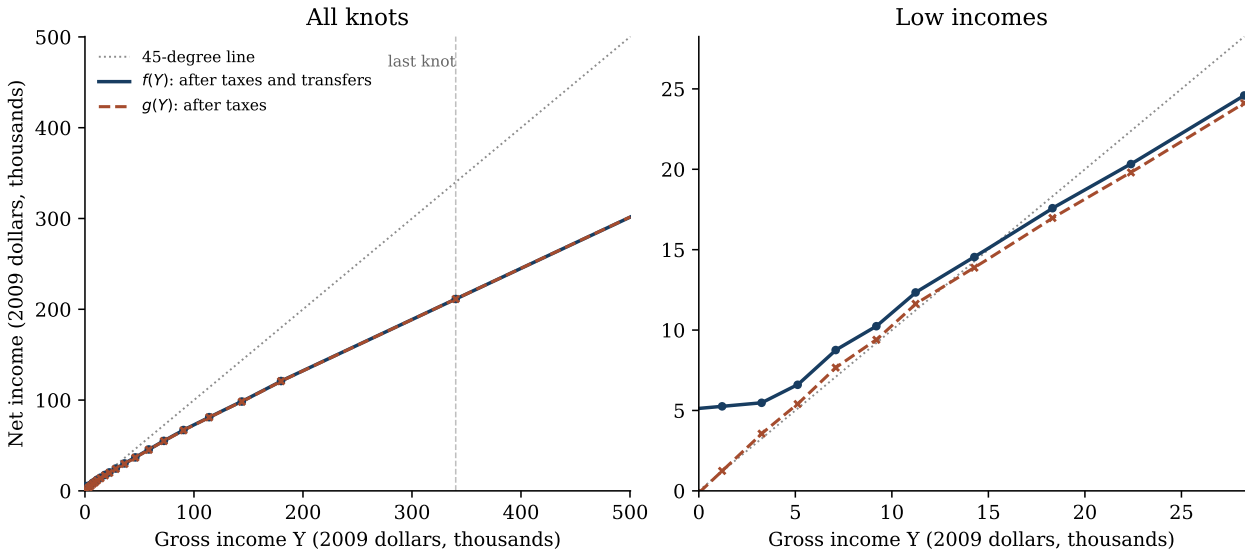


Figure 4. Net Income after Taxes and Transfers

Notes: This figure plots net income after taxes, $g(Y)$, and after taxes and cash transfers, $f(Y)$, against gross labor income. Dots are the knots. The right panel zooms in on low incomes. PSID renters 1999–2019, 2009 dollars.

4.3 Internal calibration

To estimate the remaining parameters, we use the simulated method of moments (SMM). In the spirit of Aguiar et al. (2024), we allow for up to three household types: a patient low-elasticity type, an impatient high-elasticity type, and an intermediate type. We estimate 17 parameters for the three-type specification and 13 parameters for the one-type model. We jointly target 37 moments. Table 8 lists the parameters we estimate and the moments that are informative about each parameter.

We minimize the objective function:

$$Q(\theta, s) = \sum_k w_k \min\left\{\left(\frac{m_k(\theta, s) - t_k}{\max\{|t_k|, \hat{\sigma}_k\}}\right)^2,\ 25\right\}, \tag{13}$$

where m_k is the simulated moment and t_k is the PSID moment. $\hat{\sigma}_k$ is the bootstrap standard deviation of the PSID moment (Appendix C). The cap prevents an unreachable moment from

potentially dictating the ranking.

We assign different weights to different moments, which are described along with the fit in Table 10. The ten headline moments (the poor and wealthy hand-to-mouth shares, the shares never and always in each state, the three foreclosure hazards and homeownership) get weight 10. The net worth of the poor hand-to-mouth gets 0.2 as it is almost always 0. The rest of the moments have unit weight.

For each candidate parameter vector, we take three steps. We solve the model, simulate a synthetic PSID panel, and then compute the moments with the panel.

Given the parameters, we compute the full life-cycle model by backward induction with the discrete-continuous endogenous grid method of Iskhakov et al. (2017).

We compute the simulated moments on a synthetic panel built to look like the PSID. For each type, we draw 10,000 households from the PSID panels using PSID weights. Each simulated household inherits its spell's birth year and interview years. It enters at 25, lives through the realized aggregate history of its cohort, and is simulated along 10 shock paths. We observe each household only at its PSID interview years and compute the moments following the PSID definitions. Appendix D.2 gives the details.

We then compute sample moments for a simulated set of households of each type. For the three-type specification, we then adjust shares of each type of household to match the targeted moments. To be clear, we compute the moments for every share vector on a grid with steps of 0.1, which is constructed by reweighting the three simulated panels for each type. We then keep the share vector that achieves the best fit.

Since the model is large, we use Sobol sets to search the parameter space. For the one-type model, we use 1,000 Sobol points, and for the three-type specification we use 462 points. We keep the point with the lowest objective. Appendix D describes the solution method, the grids, and the simulation details.

Table 9 shows the estimated parameters and shares for both the three-type specification and one-type model, as well as the estimates for the common parameters. We discuss the results of the estimation more in Section 5, but we estimate that a model with only two types fits the data best. At the best point, the middle type has zero share. We call the estimated model the two-type model from here on. The estimates then feature only two types: a patient type with $\beta = 0.978$ and $\sigma = 0.745$, who comprises 40% of households, and an impatient type with $\beta = 0.621$ and $\sigma = 2.820$, who makes up the remaining 60% of households.[3]

[3]Estimates with only two household types are common among our estimates. Among the 25 best points, the middle type is absent in 8 and the patient type in 4. The 15 best three-type points are in Appendix Table E.2.

Parameter	Informative Moments
Preferences	
• Discount factors (β_i)	• Median & mean NW/income, liquid & illiquid NW/income
• Intertemporal elasticity (σ_i)	• NW/income for homeowners
• Type shares (s_i)	• Share of poor & wealthy hand-to-mouth, share of always/never hand-to-mouth, NW/income and homeownership by hand-to-mouth group
• Risk aversion (γ)	
• Bequest ratio ϵ and luxury threshold $\bar{b}$	• Median net worth/income at 55–64; mean vs median net worth
Housing Market	
• House price level P_0	• Median house value/income among owners; average house size & income for owners vs. renters
• Warm glow from ownership (α)	• Aggregate homeownership rate, Median home equity/NW
• Housing consumption share ($1-\phi$)	• NIPA housing services share of consumption
Financial Frictions	
• Utility cost of default (δ_{def})	• Foreclosure hazard, pooled and by lagged hand-to-mouth status
• Fire-sale discount (κ_p)	• Negative equity shares for foreclosed & not foreclosed
• Fixed house transaction cost (κ_f)	• Houses sold annually
• Moving cost (ψ_m), distress horizon (n_d)	• Distressed share of sellers; high-LTV share of mortgaged buyers

Table 8. Internally Calibrated Parameters and Informative Moments

5 Results

5.1 Model fit

Table 10 reports the 37 targeted moments for the PSID and the two models. Overall, the model fits the 37 targeted moments well. The three-type specification has 17 parameters, but only 15 are active at the best point because the middle type has zero share. The headline moments are the hand-to-mouth shares, their persistence, the foreclosure hazards, and homeownership. The model hits most of them. The poor hand-to-mouth share is 40.2% in the model and 38.7% in the data, and the wealthy share is 8.7% and 11.8%. The pooled foreclosure hazard is 0.46% a year in the model and 0.53 in the data. The hazard of households hand-to-mouth at the previous interview is 1.16 and 1.13, and the hazard of the others is 0.22 and 0.22. Homeownership is 61.4% in the model and 63.4 in the data.

	Patient type	Type 2	Impatient type	One-type	Search box
Discount factor β_i	0.978	0.968	0.621	0.862	
	[0.93, 0.99]	[0.89, 0.97]	[0.60, 0.85]	[0.60, 0.99]	
Intertemporal elasticity σ_i	0.745	1.131	2.820	2.784	
	[0.40, 0.97]	[1.03, 2.00]	[2.00, 3.10]	[0.40, 3.10][a]	
Population share s_i (%)	40	0	60	100	
Risk aversion γ		2.906		2.499	[1.5, 4.0]
Consumption weight ϕ		0.716		0.836	[0.65, 0.88]
Ownership premium α		1.963		1.621	[1.01, 2.0]
Bequest ratio ϵ		6.153		15.705	[0.5, 40.0]
Luxury-bequest threshold $\bar{b}$		5.081		7.140	[0.0, 8.0]
Default penalty δ_{def}		0.534		0.345	[0.05, 0.80]
Moving cost ψ_m		0.390		0.071	[0.0, 0.5]
Fixed purchase cost κ_f		0.058		0.024	[0.005, 0.08]
Fire-sale discount κ_p		0.196		0.107	[0.10, 0.20]
Distress horizon n_d (years)		0.788		2.900	[0.5, 3.0]
Price per unit of housing P_0		1.442		1.544	[0.6, 1.8]

Table 9. Estimated Parameters

Notes: This table reports the best point of the Sobol screen for each model. Brackets give the search box. Type 2 receives zero share at the best point. [a]: excluding (0.97, 1.03).

The model's largest misses are on wealth. Mean net worth is 1.249 times net income in the model and 2.166 in the data, and median net worth at ages 55 to 64 is 0.803 and 1.710. The model misses on wealth because households enter with almost no wealth. The median wealth-to-income ratio is 0.004 in the first simulated year and 0.149 among observed PSID 25-year-olds.

The one-type model fits worse on nearly every headline moment. Its objective is 30.1 compared with 11.0 for the two-type model. It puts too many households in the poor hand-to-mouth state (58.4% compared with 38.7% in the data) and too few in the never-poor-hand-to-mouth group (12.7 compared with 35.2%). It also misses the homeownership moment, returning 44.8% compared with the PSID's 63.4. Its foreclosure hazard among hand-to-mouth households is half that in the data. In short, because shocks are the primary driver of behavior in the model, it is unable to reproduce the persistence of some patterns in the data and the decision to opt in to homeownership.

5.2 Overidentifying Restrictions

We present results on two over-identifying restrictions: replicating Fact 2 and Fact 3.

Table 11 shows the empirical and model counterparts for Fact 2. We compare the observed transition matrix to that produced by the two-type and one-type model. Both models

				Model − PSID	
Moment	**PSID**	**Two-type**	**One-type**	**Two-type**	**One-type**
Hand-to-mouth status (weight 10)					
Poor hand-to-mouth, share (%)	38.7	40.2	58.4	1.5	19.7
Wealthy hand-to-mouth, share (%)	11.8	8.7	17.4	−3.1	5.6
Always poor H2M, share (%)	20.4	27.5	27.8	7.1	7.3
Never poor H2M, share (%)	35.2	40.9	12.7	5.7	−22.5
Always wealthy H2M, share (%)	0.9	0.4	0.7	−0.5	−0.2
Never wealthy H2M, share (%)	63.8	70.5	44.4	6.7	−19.3
Foreclosure and ownership (weight 10)					
Foreclosure hazard, pooled (%/yr)	0.53	0.46	0.46	−0.07	−0.07
Foreclosure hazard, H2M at previous wave (%/yr)	1.13	1.16	0.59	0.03	−0.54
Foreclosure hazard, non-H2M at previous wave (%/yr)	0.22	0.22	0.28	−0.01	0.05
Homeownership rate (%)	63.4	61.4	44.8	−2.0	−18.6
Ownership by age and status (weight 1)					
Homeownership, ages 25–34 (%)	40.1	41.1	29.4	1.0	−10.7
Homeownership, ages 55–64 (%)	78.5	66.0	49.2	−12.5	−29.3
Homeownership, poor H2M (%)	22.0	16.7	14.5	−5.3	−7.6
Homeownership, wealthy H2M (%)	100.0	100.0	100.0	0.0	0.0
Wealth (weight 1; Median net worth / net income, poor H2M: 0.2)					
Mean net worth / net income	2.166	1.249	0.286	−0.917	−1.880
Median net worth / net income	0.553	0.450	0.020	−0.103	−0.533
Median net worth / net income, owners	1.411	1.202	0.447	−0.209	−0.964
Median net worth / net income, ages 55–64	1.710	0.803	0.115	−0.907	−1.595
Median home equity / net worth, owners	0.908	0.882	1.108	−0.027	0.200
Mean liquid wealth / net income	0.645	0.290	−0.022	−0.355	−0.667
Median liquid wealth / net income	0.013	0.003	−0.012	−0.010	−0.025
Mean illiquid wealth / net income	2.762	0.959	0.307	−1.803	−2.455
Median illiquid wealth / net income	0.427	0.294	0.000	−0.132	−0.427
Median net worth / net income, poor H2M	−0.032	0.000	0.000	0.032	0.032
Median net worth / net income, wealthy H2M	1.220	0.791	0.559	−0.429	−0.662
Median net worth / net income, non-H2M	1.674	1.517	0.501	−0.157	−1.173
Housing market (weight 1)					
Median house value / net income, owners	2.574	2.559	1.749	−0.014	−0.824
Owned / rented house size	1.662	1.595	1.472	−0.068	−0.191
Owner / renter earnings	2.095	2.140	2.257	0.046	0.163
Annual fraction of houses sold (%)	3.6	4.8	7.7	1.2	4.1
Distressed share of sellers (%)	42.9	61.1	69.8	18.2	26.9
High-LTV share of mortgaged buyers (%)	42.4	66.9	56.6	24.5	14.2
Underwater share, defaulters (%)	33.7	47.7	27.4	14.0	−6.2
Underwater share, non-defaulters (%)	5.2	12.6	9.4	7.4	4.2
Housing expenditure share (NIPA) (%)	15.4	15.5	12.1	0.1	−3.3
Consumption (weight 1)					
Consumption growth on poor H2M	0.026	0.022	0.048	−0.003	0.022
Consumption growth on wealthy H2M	−0.007	−0.008	−0.011	0.000	−0.004

Table 10. Targeted Moments: PSID and Model

Notes: This table compares the targeted moments in the PSID with the two-type and one-type models at their best points. The last two columns are model minus PSID. Hazards are in percent per year. Shares and rates are in percent. Wealth ratios and the consumption-growth slopes are decimals. High-LTV buyers have a loan-to-value above 0.85 at purchase. The weight is the moment's weight in the objective. Net income is labour income net of payroll taxes plus cash transfers. PSID 1999–2023, weighted.

fit many of the moments well, but the two-type model matches the high share of individuals who remain not hand-to-mouth, while the one-type model cannot produce the persistence of the not hand-to-mouth households. The shares of households that are always and never in each hand-to-mouth state over their spell are targeted, but the two-year transition rates are not, so they are an overidentifying restriction. One way to think of the two models is that the one-type model is a model in which only shocks matter. Every household has the same preferences, so two households behave differently only because they have received different shocks. In the two-type model, households respond differently to the same shocks. In the one-type model, a household that is not hand-to-mouth today falls into the poor hand-to-mouth state within two years 25% of the time, and stays out of hand-to-mouth status only 44% of the time because shocks are the only differentiator of behavior. In the PSID, the numbers are 9 and 81% compared with 5 and 86% in the two-type model. With multiple types, patient households maintain sufficient reserves to stay not hand-to-mouth even with shocks. One weakness is that both models make the poor state too persistent. A poor hand-to-mouth household is still poor two years later 88% of the time with multiple types and 87% with one type, while it is 77% in the PSID.

	PSID			**Two-type model**			**One-type model**		
Status (t)	poor	wealthy	not	poor	wealthy	not	poor	wealthy	not
H2M poor	0.767	0.067	0.166	0.884	0.027	0.089	0.867	0.051	0.082
H2M wealthy	0.164	0.401	0.435	0.114	0.353	0.533	0.197	0.361	0.443
Not H2M	0.088	0.104	0.808	0.054	0.091	0.856	0.249	0.311	0.440

Table 11. Two-Year Transitions of Hand-to-Mouth Status: PSID and Model
Notes: This table shows the probability of each hand-to-mouth status two years later given status today, in the PSID and in the simulated panels of the two models. The never and always hand-to-mouth shares are targeted. The transitions are not.

We reproduce the motivating Fact 3 within the model. We carry out the same regression as in Table 3, estimated on each model's simulated panel from 2007. We use the appropriate weights and cluster standard errors by household. Table 12 shows the results. We find that the two-type model reproduces the main empirical patterns, while the one-type does not. The coefficient on the wealthy hand-to-mouth history is 1.38 ($p < 0.001$) with types, inside the PSID's 95% interval around 1.21 ($p = 0.01$). With one type, it is 0.11 ($p = 0.52$), and indistinguishable from zero. The coefficient on the poor history is -0.083 ($p = 0.35$) with types and 0.14 ($p = 0.77$) in the PSID, both small. With one typ,e it is -0.73 ($p < 0.001$). The two-type model reproduces the pattern where the wealthy hand-to-mouth history is associated with higher default rates, and the poor hand-to-mouth history is not meaningfully associated with higher default rates. On the other hand, the one-type model cannot produce

this pattern, and indeed, the poor hand-to-mouth frequency history is negatively correlated with default. In the one-type model, households have a lower discount factor β than the patient type and save less, and large shocks can induce long-term hand-to-mouth status. In the Appendix, Table E.1 adds different controls to the model regressions and achieves similar results.

The one-type model is the world in which only shocks and income drive foreclosures. In that model, every household has the same preferences, so a household's history can only tell us about the shocks it received. The multiple-type model allows different patterns of behavior for the same set of shocks, which is what allows for the history to affect household decisions even after controlling for the current state. A history of low-buffer behavior indicates a different type.

	PSID	**Two-type model**	**One-type model**
Wealthy-H2M frequency (lag)	1.205***	1.383***	0.111
	(0.434)	(0.106)	(0.173)
Poor-H2M frequency (lag)	0.139	−0.083	−0.731***
	(0.474)	(0.088)	(0.138)
Log earnings (model: log income)	−0.885***	−0.751***	−0.580***
	(0.130)	(0.043)	(0.083)
Earnings change, % (2 years)	−0.003	−0.012***	−0.007***
	(0.003)	(0.001)	(0.002)
IHS liquid wealth (lag)	−0.115***	−0.191***	0.024
	(0.038)	(0.011)	(0.019)
Home-equity share (lag, clipped)	−1.876***	−3.669***	−4.915***
	(0.261)	(0.082)	(0.196)
Pseudo R^2	0.138	0.175	0.087
AME of wealthy-H2M frequency (pp)	1.33	0.81	0.07
N (household-waves)	12,731	463,508	141,889
Events	186	2,294	903
Event rate, unweighted (%)	1.46	0.49	0.64

Table 12. Logit of Default on Hand-to-Mouth History: PSID and Model

Notes: This table estimates the specification of Table 3, column (1), on the PSID and on the simulated panels of the two models. In the model the event is a default decision. AME: average derivative of the event probability with respect to the wealthy hand-to-mouth frequency, in percentage points. Standard errors are clustered by household. Model standard errors are sampling errors of the simulated panels. *, **, ***: $p < 0.10, 0.05, 0.01$.

5.3 Who defaults?

Table 13 compares the two types in terms of parameters and summary statistics. The impatient type is 60% of households and accounts for 88% of foreclosures. Its annual foreclosure

hazard among mortgagors is 0.90% compared with 0.10 for the patient type, a ninefold difference. The two types differ in how they hold wealth. The patient type owns a home 88% of the time and is poor hand-to-mouth 6% of the time. The poor hand-to-mouth years are generally concentrated in youth. Of the patient type's poor hand-to-mouth years, 82% are before the age of 35. The patient type also typically maintains a buffer. A year after purchasing a house, the median liquid wealth of the patient type is 18.5% of the mortgage. In contrast, the impatient type owns 44% of the time, is poor hand-to-mouth 65% of the time, and has no net worth at the median. A year after buying, its median liquid wealth is zero, and 33% of its buyers have no liquid wealth at all, compared with 4% of patient buyers.

The missing buffer is why a history of being wealthy hand-to-mouth predicts default. A wealthy hand-to-mouth household has had the income to build net worth and holds it in a house, but builds no liquid buffer to smooth shocks. Wealthy hand-to-mouth owner-years are 30% of the impatient type's owner-years and 2% of the patient type's. Due to low reserves, the impatient type is much more exposed to income shocks, which cause them to default more quickly. Indeed, 40% of impatient defaulters have negative equity at default, so most default with positive equity. More-patient households care more about the future, care more about exclusion from the mortgage market, and so maintain higher liquid reserves to smooth over fluctuations.

Table 14 compares simulated mortgagors who default within two years with those who do not, using information from the previous interview. Defaulters look alike in the two models and in the PSID, with larger income losses in the model. They face income losses, are more leveraged, and hold less liquid wealth. The models quantitatively differ in who does not default. In the one-type model, 57% of mortgagors who do not default are hand-to-mouth, against 25% with types and 30% in the PSID.

Figures 5 through 8 show when the different household types default. The impatient type accounts for most of the 2009–2013 wave (Figure 5). Its foreclosure hazard is high at every age, 1.33% a year at 25–29 and 1.20% at 60–64 (Figure 6), so its defaults are spread over the life cycle. Indeed, the median impatient-household defaulter is 49 years old. In contrast, the patient type defaults almost only when young. Of patient-household defaults, 75% are before age 35, and its median defaulter is 30. Figure 8 splits the population by hand-to-mouth status and type at each age. After 40, almost every wealthy hand-to-mouth household is an impatient one.

	Patient type	Impatient type
Discount factor β	0.978	0.621
Intertemporal elasticity σ	0.745	2.820
Population share (%)	40	60
Default		
Annual foreclosure hazard among mortgagors (%)	0.10	0.90
Share of foreclosures among mortgagors (%)	11.6	88.4
Defaults with negative equity at default (%)	23.3	40.2
Liquid wealth at default (mean, income units)	0.050	−0.077
H2M frequency at default (mean)	0.499	0.659
Median age at default	30	49
Defaults before age 35 (%)	75.5	13.5
Housing		
Homeownership (%)	87.9	43.7
Underwater among mortgagors (%)	3.5	13.2
Annual sale rate of owners (%)	3.6	7.0
High-LTV share of mortgaged buyers (%)	65.4	68.0
Purchases per household over its window	0.49	0.45
LTV one year after purchase (mean)	0.87	0.93
Liquid wealth a year after purchase, % of mortgage (mean)	58.3	18.2
Liquid wealth a year after purchase, % of mortgage (median)	18.5	0.0
Buyers with no liquid wealth a year after purchase (%)	4.2	33.0
Wealth and hand-to-mouth status		
Poor H2M (%)	6.4	64.5
Poor H2M years before age 35 (%)	82.3	29.5
Wealthy H2M (%)	1.9	12.7
Median net worth / net income	1.924	0.000
Mean liquid wealth / net income	0.764	−0.026

Table 13. Behaviour and Outcomes by Preference Type

Notes: This table compares the two types at the best point of the three-type search over the simulated households' PSID observation windows, age-weighted. The foreclosure hazard uses the targeted definition. Negative equity at default is measured in the default year. Purchase rows read the state in the year after purchase. Liquid wealth can be negative.

6 Policy Counterfactual

6.1 Homeowner Assistance Fund experiment

We use the model to evaluate a temporary Homeowner Assistance Fund (HAF) during the years of the Great Recession. We run the experiment from 2008–2012. When a mortgaged owner's decision rule calls for default in one of those years, the fund pays that year's mortgage payment, property tax, and maintenance. The fund pays nothing to households that would

Variable	Two-type model		One-type model	
	Default	**No default**	**Default**	**No default**
Demographics				
Age	46.5	44.9	43.7	45.3
Income				
Earnings change to t, % (median)	−68.3	1.6	−78.1	1.4
Earnings drop of 30% or more, percent	68.0	17.6	67.9	18.2
Balance sheet				
Liquid wealth / net income (median)	−0.02	0.12	−0.03	−0.06
Net worth / net income (median)	0.11	1.08	0.09	0.43
Hand-to-mouth, percent	64.8	25.2	74.3	57.4
Poor hand-to-mouth, percent	54.9	11.2	59.7	18.7
Wealthy hand-to-mouth, percent	9.9	13.9	14.6	38.7
Housing				
Loan-to-value (median)	0.95	0.63	0.94	0.72
Underwater (LTV > 1), percent	43.0	7.6	30.8	5.8
House value / net income (median)	2.56	2.53	1.67	1.75

Table 14. Mortgagors Who Default versus Those Who Do Not, Model

Notes: This table compares simulated mortgagors who default within two years with those who do not, at the previous interview, in the two-type and one-type models. Shares are in percent. Ratios use the model's net income. Table 1 reports the same comparison in the PSID.

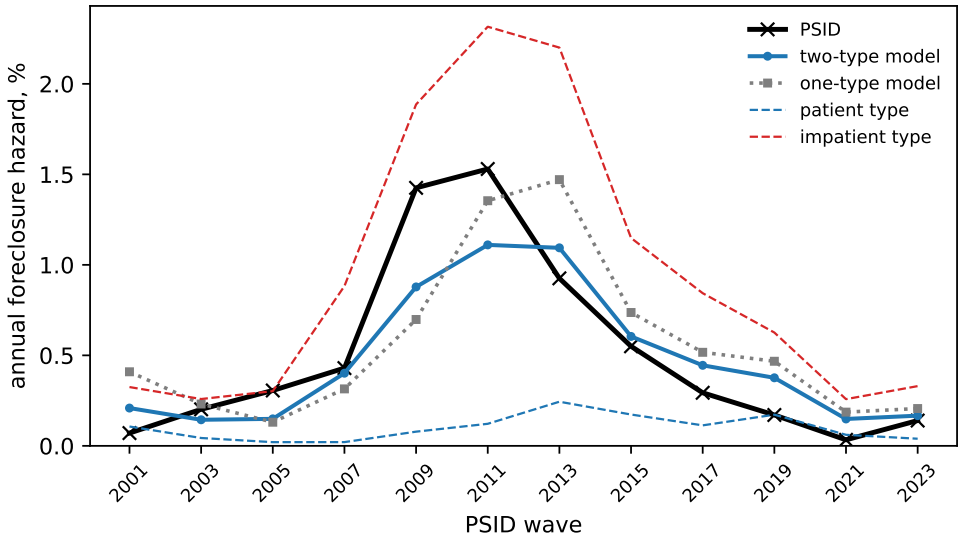


Figure 5. Foreclosure Hazard by Year: PSID and Model

Notes: This figure shows the annual foreclosure hazard among households mortgaged at the previous interview, by PSID wave, in the PSID, in the two-type model and its two types, and in the one-type model. The hazard by wave is not targeted.

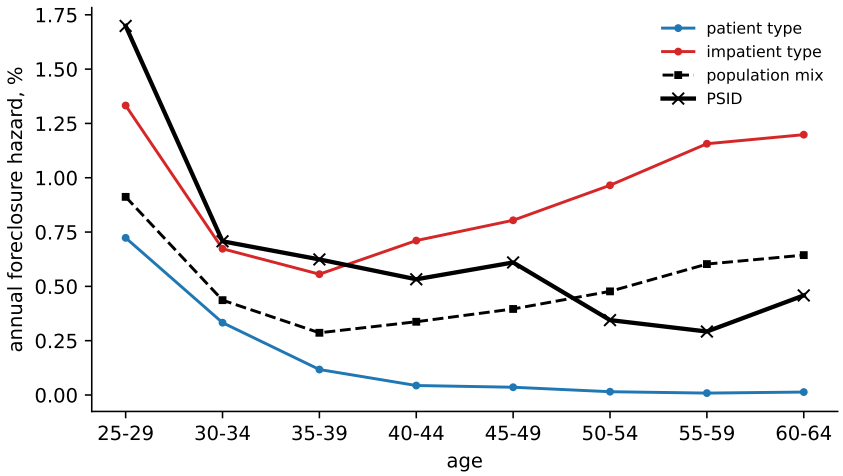


Figure 6. Foreclosure Hazard by Age and Type

Notes: This figure shows the annual foreclosure hazard among mortgagors by age for the patient and impatient types, and in the PSID. Weighted.

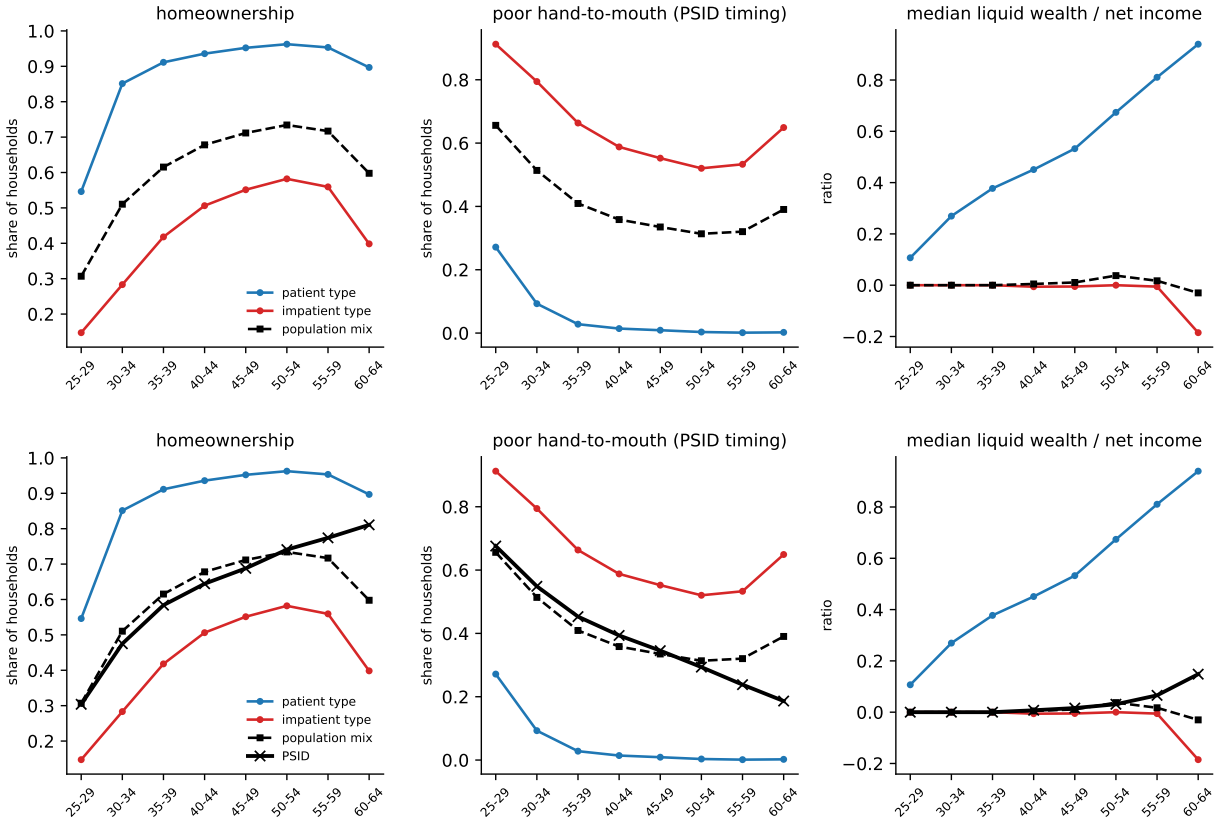


Figure 7. Homeownership, Hand-to-Mouth Status and Liquid Wealth by Age and Type

Notes: This figure shows homeownership, the poor hand-to-mouth share, and median liquid wealth to net income by age for each type. The bottom row adds the PSID series. Weighted.

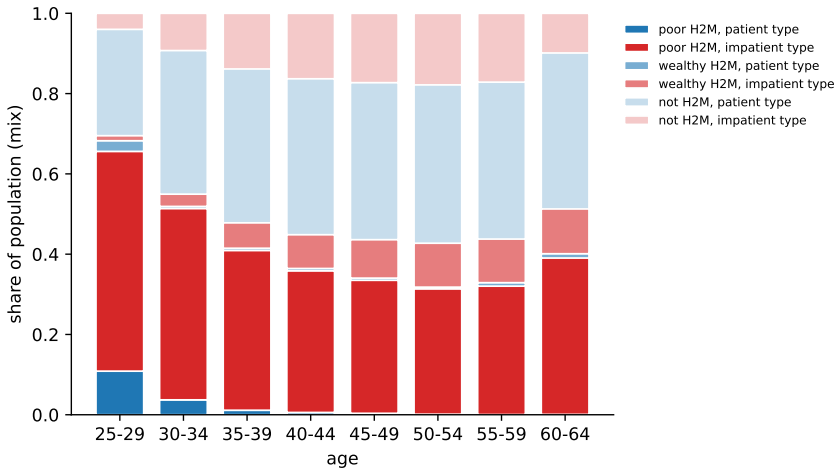


Figure 8. Population Shares by Hand-to-Mouth Status and Type

Notes: This figure shows the share of households in each hand-to-mouth status and type, by age. The six shares sum to one in each age bin. Weighted.

not otherwise default. After being selected, the household can stay in its house, keep the resources it had, and consume what it had planned to consume on the default branch, but does not default in that period. We treat the fund as an unanticipated rescue policy.

Starting in 2013, households follow their ordinary policies and can default again. We do not re-solve the household's problem, so households do not change their saving or housing choices in anticipation of help. The fund and the baseline run on the same simulated households and shocks. We count transfers only and do not consider the deadweight loss of foreclosure, utility, or house-price effects in our analysis.

The fund acts year by year. A household is helped in every year of the window in which its rule calls for default, so a household can be helped more than once. 34% of patient recipients and 37% of impatient recipients are helped in two or more years (Table 16). The similarity in shares is consistent with many defaults during this period being caused by the large income shocks of the Great Recession years.

Table 15 reports the results. The cost block of Table 15 divides total transfers by three counts: assisted household-years, foreclosures stopped in 2008–2012, and the net reduction in foreclosures over 1999–2023, which subtracts the later defaults of assisted households who default after the HAF ends. The fund stops every foreclosure from 2008 to 2012, at a cost of around $26,500 per assisted household-year and $41,100 per foreclosure stopped in the bust. However, some assisted households default later, and on net the cost is about $58,600 per foreclosure prevented, since some households default after the fund ends. The fund prevents 27% of all foreclosures from 1999–2023.

The transfer cost and efficiency differ by type. Per foreclosure stopped, the fund spends

$32,900 on a patient household and $42,200 on an impatient household. Impatient households who receive the benefit are older and live in larger homes, worth $260,000 on average compared to patient households' $223,000 average. Preventing a foreclosure is 22% cheaper for patient types. Net of later foreclosures, it narrows to 15%, because a larger share of the foreclosures stopped for patient recipients reappears once the fund ends, 36% for patient recipients and 29% for impatient recipients. To understand this counter-intuitive result, we look at Table 16, which shows information about the recipients of the fund by type. First, patient households who need to use the fund are much younger. Their median age is 31, and 77% of their assisted years are under 35.

Second, patient defaulters earn less, in part because they are younger. Three years before first assistance, the median patient recipient earned $66,000, while it is $123,000 for the median impatient recipient (Table 17). Recipients of both types lose most of their earnings. The year after first assistance, the median patient recipient earns 26% of what it earned three years earlier, and the median impatient recipient 37%. Almost all later defaults happen in 2013, the first year without the fund. Among recipients observed in 2013 who default again within six years of first assistance, 93% of the patient and 80% of the impatient re-defaults happen in 2013. Almost all are by recipients whose earnings have not fully recovered from the shocks. Among recipients who still earn less than 40% of their earlier earnings in 2013, 87% of patient and 69% of impatient recipients default again. Among recipients whose earnings are back to 70% or more, 4 and 5% default. The patient recipients who default again are young, low-earning households whose earnings have not recovered.

Homeownership is a stated goal of US government housing policy, and the HAF preserves homeownership relative to a world without it. The ownership numbers compare the same household with and without the fund at its last interview, in 2013 or later. Without the fund, 54% of patient recipients own a home again by then. With the fund, 79% own, a gain of 25 points. The gain is much larger for impatient recipients, who rarely buy again after a foreclosure. Without the fund 24% own at their last interview, and with it 63%, a gain of 39 points.

One rationale for keeping people in their homes is that homes are an important financial asset. Does the HAF preserve net worth? We compute changes in net worth for recipients in a world with and without the HAF. For patient households, the median recipient gains $4,300 of net worth, while the median impatient recipient gains nothing (the median change is $0). Impatient households often received larger payoffs, but patient households converted the benefits into longer-term wealth at a higher rate. We measure net worth for the household in its last interview year with and without the transfer and compute the change in net worth divided by the transfer. Patient households increased their net worth by 71 cents per dollar

of transfer received and impatient household net worth only increased by 29 cents per dollar of transfer.

	Patient type	Impatient type	Population mix
Population share (%)	40	60	100
2008–2012 bust			
Foreclosures, baseline	47.5	230.1	157.1
Foreclosures, with fund	0.0	0.0	0.0
Prevented (%)	100.0	100.0	100.0
Six years after (2013–2018)			
Foreclosures, baseline	67.3	164.7	125.7
Foreclosures, with fund	84.2	230.8	172.2
Stopped in the bust, not replaced (%)	64.4	71.3	70.4
Whole panel 1999–2023			
Foreclosures, baseline	180.1	560.3	408.2
Foreclosures, with fund	149.3	397.4	298.2
Prevented (%)	17.1	29.1	27.0
Cost			
Assisted household-years	70.7	358.6	243.4
Transfer per assisted year	\$22,088	\$27,095	\$26,513
Transfer per foreclosure stopped	\$32,876	\$42,226	\$41,095
Transfer per foreclosure prevented, net	\$50,701	\$59,646	\$58,645

Table 15. The Assistance Fund: Foreclosures and Cost

Notes: This table reports the one-time assistance fund, active in 2008–2012, against the baseline on the same simulated households and shocks. Counts are per 10,000 households of the type over their PSID observation windows. The population mix weights the types by their estimated shares. Dollars are 2009 dollars.

7 Conclusion

Foreclosure is predictable from a household's past. In the PSID, wealthy households that have a history of having a low level of liquid assets have a higher default probability, even conditioning on current and lagged income, lagged wealth, and lagged home equity. At the same time, hand-to-mouth status is highly persistent. This persistence suggests that households differ in behavior, not only in the shocks they receive. We write down and estimate a life-cycle model with preference heterogeneity to replicate these facts. A life-cycle model with a single type cannot replicate these patterns, but a two-type model can generate both patterns. In a model in which shocks alone drive default, a household's history of being wealthy but with low liquid savings should reveal nothing differential about foreclosure

	Patient type	Impatient type
At assistance (assisted at least once in 2008–2012)		
Assisted households	480	2,322
Years of assistance per household	1.47	1.54
Assisted two or more years (%)	34	37
Median age	31	51
Under 35 (%)	77	10
Median liquid wealth / income	0.28	−0.19
Median net worth / income	0.08	−1.08
Median loan-to-value	1.03	1.08
Mean house value	$222,565	$259,580
Payment per assisted year	$22,088	$27,095
At the end of the observation window (windows ending 2013 or later)		
Households	441	2,022
Fund payments received (mean)	$32,637	$42,529
Change in net worth, mean	$23,073	$12,316
Change in net worth, median	$4,252	$0
Net worth kept per dollar received (cents)	71	29
Homeownership at the end, baseline (%)	54	24
Homeownership at the end, with fund (%)	79	63
Change in homeownership (percentage points)	25	39

Table 16. Who the Fund Helps

Notes: This table describes the households assisted at least once in 2008–2012, by type, and compares their outcomes at the end of the observation window with the baseline for the same household. The first block is over assisted household-years, each at its assisted year. The second block compares each household at its last interview with and without the fund. Wealth is relative to gross income. Dollars are 2009 dollars.

	Patient type	Impatient type
Recipients	480	2,322
Median earnings three years before first assistance ($ thousand)	66	123
Median earnings the year after, percent of that	26	37
Recipients observed in 2013	342	1,867
Earnings in 2013 below 40 percent of earlier earnings (%)	35	37
Default again within six years (%)	34	31
of which in 2013 (%)	93	80
Default again, earnings still below 40 percent (%)	87	69
Default again, earnings back to 70 percent or more (%)	4	5

Table 17. Recipients Around First Assistance

Notes: This table shows the earnings path of the households in Table 16 around the first year in which the fund paid for them, by type, and how many default again. Earnings are gross labor income in 2009 dollars. Earlier earnings are earnings three years before the first assisted year, the last year before the median recipient's earnings begin to fall. A re-default is a default in the six years after the first assisted year in a year without a transfer. The last five rows use recipients whose observation window reaches 2013.

probabilities, but in the two-type model, such low-buffer behavior provides information that the household is the impatient type.

This heterogeneity has implications for policy. In the event of a crisis, the government may wish to direct transfers to preserve homeownership or net worth through a Homeowner Assistance Fund. If the government's goal is to increase homeownership relative to a world without intervention, it should target impatient households, whose homeownership rate is much more responsive to the transfer. However, if the government's goal is to preserve net worth, targeting patient households is much more effective.

References

Aguiar, M. A., Bils, M., and Boar, C. (2024). Who Are the Hand-to-Mouth? *Review of Economic Studies*.

Bogin, A., Doerner, W., and Larson, W. (2019). Local house price dynamics: New indices and stylized facts. *Real Estate Economics*, 47(2):365–398.

Campbell, J. Y. and Cocco, J. F. (2015). A model of mortgage default. *The Journal of Finance*, 70(4):1495–1554.

De Nardi, M. (2004). Wealth inequality and intergenerational links. *The Review of Economic Studies*, 71(3):743–768.

Diamond, R., Guren, A., and Tan, R. (2020). The Effect of Foreclosures on Homeowners, Tenants, and Landlords. NBER Working Papers 27358, National Bureau of Economic Research, Inc.

Druedahl, J. (2021). A guide on solving non-convex consumption-saving models. *Computational Economics*, 58(3):747–775.

Ganong, P. and Noel, P. (2019). Consumer spending during unemployment: Positive and normative implications. *American Economic Review*, 109:2383–2424.

Ganong, P. and Noel, P. (2023). Why do borrowers default on mortgages? *The Quarterly Journal of Economics*, 138(2):1001–1065.

Giacoletti, M. (2021). Idiosyncratic risk in housing markets. *The Review of Financial Studies*, 34(8):3695–3741.

Guren, A., Krishnamurthy, A., and McQuade, T. (2020). Mortgage design in an equilibrium model of the housing market. *The Journal of Finance*, 76(1):113–168.

Immergluck, D. and Smith, G. (2006). The external costs of foreclosure: The impact of single-family mortgage foreclosures on property values. *Housing Policy Debate*, 17(1):57–79.

Iskhakov, F., Jørgensen, T. H., Rust, J., and Schjerning, B. (2017). The endogenous grid method for discrete-continuous dynamic choice models with (or without) taste shocks. *Quantitative Economics*, 8(2):317–365.

Kaplan, G., Mitman, K., and Violante, G. (2020). Housing boom and bust/ model meets evidence. *Journal of Political Economy*, 129.

Kaplan, G. and Violante, G. L. (2014). A model of the consumption response to fiscal stimulus payments. *Econometrica*, 82(4):1199–1239.

Li, W., Meghir, C., and Oswald, F. (2025). Consumer bankruptcy, mortgage default, and labor supply. *International Economic Review*, 66(3):1019–1042.

Low, D. (2025). An empirically-disciplined theory of mortgage default. Working paper, Consumer Financial Protection Bureau, revised August 8, 2025. CFPB Office of Research Working Paper 2021-01; revised and resubmitted to the Review of Financial Studies.

Low, D. (2026). What triggers mortgage default? new evidence from linked administrative and survey data. *The Review of Economics and Statistics*, 108(1):282–290.

Mian, A., Rao, K., and Sufi, A. (2013). Household balance sheets, consumption, and the economic slump*. *The Quarterly Journal of Economics*, 128(4):1687–1726.

Mitman, K. (2016). Macroeconomic effects of bankruptcy and foreclosure policies. *American Economic Review*, 106:2219–2255.

Panel Study of Income Dynamics (2025). Panel study of income dynamics, public use dataset. Produced and distributed by the Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI.

Piazzesi, M. and Schneider, M. (2016). Housing and macroeconomics. In Taylor, J. B. and Uhlig, H., editors, *Handbook of Macroeconomics*, volume 2, pages 1547–1640. Elsevier, Amsterdam. Available online 4 October 2016, Version of Record 14 November 2016.

Rouwenhorst, K. G. (1995). Asset pricing implication of real business cycle models. *Frontiers of Business Cycle Research, Thomas Cooley editor, Princeton University Press*, 79.

Shiller, R. J. (2015). *Irrational Exuberance: Revised and Expanded Third Edition*. Princeton University Press, rev - revised, 3, revised and expanded third edition edition.

Zeldes, S. P. (1989). Consumption and liquidity constraints: An empirical investigation. *Journal of Political Economy*, 97(2):305–346.

A Recursive formulation

House prices are in units of trend income. The normalized price of one unit of housing in house i costs $p_{it}^h = P_0\, e^{a_t^h + \nu_{it}}$, where P_0 is the price-level parameter, a_t^h is the aggregate house-price deviation, and ν_{it} is the house's idiosyncratic appreciation component. ν_{it} is set to 0 at purchase.

State	Values	Renter	Excluded renter	Owner
Age t	25–64	•	•	•
Preference type i	patient, impatient	•	•	•
Permanent income type ξ_i	3 values	•	•	•
Liquid balance b	120 nodes, 73 negative	•	•	•
Aggregate state S	20 nodes	•	•	•
Persistent and crisis income (z, τ)	10 nodes, 5 by 2	•	•	•
Transitory income η	3 nodes	•	•	•
House size h	6 owned sizes			•
House price component ν	7 nodes			•
Loan age t^m	0 to 30			•
Price level at origination S^b	5 levels			•

Table A.1. State Variables by Household Status

Notes: This table shows the state variables each household carries. A renter excluded from the mortgage market after a default has the same state as a renter and solves a different problem. The mortgage balance M and the payment m per unit of housing follow from the loan age and the price level at origination.

Table A.1 lists the state variables of each household status. A renter has seven states and owners have eleven. The income state $\mathbf{s} = (S, z, \tau, \eta)$ collects the aggregate state and the persistent, crisis, and transitory components of income. The permanent income type ξ_i and the preference type i are fixed for the household and enter every problem below. All quantities are in units of trend income, so the discount factor is $\hat{\beta}_i = \beta_i e^{g_y(1-1/\sigma_i)}$ and each gross return is multiplied by e^{-g_y}. Table E.3 lists the symbols and their meanings.

Households face different Bellman equations depending on their status. Each problem maximizes the Epstein-Zin aggregator of current utility u and next year's value $\mathcal{V}'$,

$$\mathcal{A}_i\big[u, \mathcal{V}'\big] \equiv \left[(1-\beta_i)\, u^{1-1/\sigma_i} + \hat{\beta}_i \Big\{\mathbb{E}_t\, \mathcal{V}'^{\,1-\gamma}\Big\}^{\frac{1-1/\sigma_i}{1-\gamma}}\right]^{\frac{1}{1-1/\sigma_i}}, \tag{A.1}$$

where the expectation is over next year's income state and, for an owner, the house's price shock.

A.1 Renter with access to the mortgage market

A household that starts the period renting with access to the mortgage market chooses between renting and buying:

$$V_i^n(t,b,\mathbf{s}) = \max\Big\{V_i^r(t,b,\mathbf{s}),\ V_i^o(t,b,\mathbf{s})\Big\}. \tag{A.2}$$

A.1.1 Renting

Conditioning on renting, the household chooses a rental size h_u and next year's liquid balance b' subject to its budget and borrowing constraint:

$$\begin{aligned} V_i^r(t,b,\mathbf{s}) &= \max_{h_u\in\mathcal{H}_r,\, b'} \ \mathcal{A}_i\Big[c^{\phi}h_u^{1-\phi},\ V_i^n(t+1,b',\mathbf{s}')\Big] \\ \text{s.t.}\quad c + b' + p_t^r h_u &= R(b)\,b + f(Y), \qquad b' \geq -\underline{b}_t. \end{aligned} \tag{A.3}$$

A.1.2 Buying

Conditioning on choosing to buy, the household chooses a house size h, a mortgage contract j and savings b'. A new house costs $p_t = P_0 e^{a_t^h}$ per unit. Contract j has loan-to-value λ_j and remaining term n_j, and enters the amortization schedule at loan age t_j^m. The payment m_j includes mortgage insurance. The homeowner is subject to the budget constraint in terms of house payments as well as the borrowing constraint. It is also subject to the debt-to-income constraint on the nominal first-year payment m_j^{nom}, property tax, and the card minimum κ_c, as well as the rule that the loan is repaid by age $\overline{\text{age}}$:

$$\begin{aligned} V_i^o(t,b,\mathbf{s}) = \max_{h\in\mathcal{H}_o,\, j\in\mathcal{J}_t,\, b'} \ & \mathcal{A}_i\Big[c^{\phi}(\alpha h)^{1-\phi}, \\ & V_i^h(t+1,b',\mathbf{s}',\nu',h,\min\{t_j^m+1,T^m\},a_t^h)\Big] \\ \text{s.t.}\quad & c + b' + \Big[(1+\kappa^m+\tau^h+\delta^h)\,p_t + m_j\Big]h + \kappa_f = R(b)\,b + \lambda_j p_t h + y^o(Y,\, r^m\lambda_j p_t h), \\ & b' \geq \max\{-\underline{b}_t,\ \min\{b,0\}\}, \\ & \frac{m_j^{nom}h + \tau^h p_t h + \kappa_c \max\{-R(b)b,0\}}{Y} \leq \overline{DTI}, \qquad \mathcal{J}_t = \{j : \text{age}_t + n_j \leq \overline{\text{age}}\}. \end{aligned} \tag{A.4}$$

A.2 Renter excluded from the mortgage market

A household excluded after a default can only rent. It regains access with probability π_{re} at the start of each year:

$$V_i^x(t,b,\mathbf{s}) = \max_{h_u \in \mathcal{H}_r,\, b'} \mathcal{A}_i\Big[c^\phi h_u^{1-\phi},\ \mathcal{V}^x(t+1,b',\mathbf{s}')\Big], \tag{A.5}$$
$$(\mathcal{V}^x)^{1-\gamma} \equiv \pi_{re}\,(V_i^n)^{1-\gamma} + (1-\pi_{re})\,(V_i^x)^{1-\gamma},$$
$$\text{s.t.}\quad c + b' + p_t^r h_u = R(b)\,b + f(Y), \qquad b' \geq -\underline{b}_t.$$

A.3 Owner

A household that starts the period owning a home chooses between paying, defaulting and selling, with $M \equiv M(t,t^m,S^b)$, $m \equiv m(t,t^m,S^b)$ and $p^h \equiv P_0 e^{a_t^h+\nu}$:

$$V_i^h(t,b,\mathbf{s},\nu,h,t^m,S^b) = \max\Big\{V_i^p,\ V_i^d,\ V_i^s\Big\}, \tag{A.6}$$

A.3.1 Paying

If it decides to keep the home, the owner pays the mortgage payment, property tax, and maintenance and chooses b':

$$V_i^p = \max_{b'}\ \mathcal{A}_i\Big[c^\phi(\alpha h)^{1-\phi},$$
$$V_i^h(t+1,b',\mathbf{s}',\nu',h,\min\{t^m+1,T^m\},S^b)\Big] \tag{A.7}$$
$$\text{s.t.}\quad c + b' + \Big[m + (\tau^h+\delta^h)p^h\Big]h = R(b)\,b + y^o(Y,\,r^m M h), \qquad b' \geq -\underline{b}_t.$$

A.3.2 Defaulting

If the owner chooses to default, it stays in the house for the year without paying and bears the penalty δ_{def}. The house is sold at the discount χ_f, the surplus Π^d goes to the household, and next year it becomes an excluded renter:

$$V_i^d = \max_{b'}\ \mathcal{A}_i\Big[c^\phi(\alpha h)^{1-\phi}e^{-\delta_{def}-\psi_m},\ \mathcal{V}^x(t+1,b',\mathbf{s}')\Big] \tag{A.8}$$
$$\text{s.t.}\quad c + b' = R(b)\,b + f(Y) + \Pi^d, \qquad b' \geq \max\{-\underline{b}_t,\ \min\{b,0\}\},$$
$$\Pi^d = \max\Big\{(1-\chi_f)\,p^h h - (1+r^m)\Big(M + (\tau^h+\delta^h)p^h\Big)h,\ 0\Big\}.$$

A.3.3 Selling

If the owner decides to sell, it commits before the offer noise v is drawn. The proceeds, net of the sale cost and of the fire-sale discount κ_p when the household is distressed (D), are

$$\Pi(v) = p^h e^v h\Big(1 - \kappa^s - \kappa_p \mathbb{1}[D]\Big) - Mh, \tag{A.9}$$
$$D \;\Leftrightarrow\; n_d\Big[m + (\tau^h + \delta^h)p^h\Big]h \;>\; y^o(Y,\, r^m Mh) + R(b)\, b + \underline{b}_t.$$

where the second line defines the condition for a distressed sale. The household then continues as a renter with market access, with the proceeds from the sale added to its resources and the moving cost $e^{-\psi_m}$ on its period composite utility. Its value of selling averages over the offers:

$$V_i^s = \Big\{\sum_v w_v\, \tilde{V}_i^n(t, b, \mathbf{s}; \Pi(v))^{1-\gamma}\Big\}^{\frac{1}{1-\gamma}}. \tag{A.10}$$

where $\tilde{V}_i^n(t, b, \mathbf{s}; \Pi(v))$ is problem (A.2) with proceeds and moving costs, and selling and buying face the same debt-to-income test as a purchase.

A.4 Terminal period

At T, the household values terminal net worth as in (3).

B Aggregate and house-price processes

B.1 Aggregate risk

To compute the aggregate income and house price processes, we use annual data from 1959–2023. We use NIPA compensation of employees per capita for the aggregate income process. For national house prices, we use the long series of Shiller (2015) spliced onto the S&P/Case–Shiller index in 1987. We deflate both income and house prices with the PCE price index. We remove the income trend $g_y = 0.0177$ from both series, so house prices relative to income have no trend in the model. However, the deviations of income and house prices do not move one-for-one, and so the price-to-income ratio can move over time. We model the joint process as a Markov chain with 20 states. It has two income nodes, five price levels, and two momentum nodes that stand in for the second lag of the AR(2). Table 5 lists the nodes. In the simulation, each year of 1960–2023 is assigned to its nearest node, and households live through the realized sequence of aggregate states.

B.2 House values and idiosyncratic house-price risk

The value of an individual house i is the aggregate index scaled by a persistent idiosyncratic component,

$$P_{it} = P_t^H \, e^{\nu_{it}}, \qquad \nu_{it} = \nu_{i,t-1} + u_{it}^h, \qquad u_{it}^h \sim \mathcal{N}(0, \sigma_w^2), \tag{B.1}$$

The component ν_{it} is a state variable of the household problem: it is what determines whether a particular house is above or below water at a given aggregate state, and how long it is likely to remain so.

Sale prices also have a transitory offer component realized only upon selling the house:

$$\tilde{P}_{it} = P_{it} \, e^{v_{it}}, \qquad v_{it} \sim \mathcal{N}\left(-\tfrac{1}{2}\sigma_v^2, \; \sigma_v^2\right), \tag{B.2}$$

such that $\mathbb{E}[e^v] = 1$. Foreclosure sales are at the fixed discount χ_f and have no offer noise.

B.3 Estimation of the idiosyncratic house-price process

The data are property-level repeat sales in the Cotality (formerly CoreLogic) owner-transfer records, 1987–2023, 127 million deeds on 68.5 million properties. We keep arm's-length residential resales. Using the record-type flags, we drop estimated or undisclosed prices, multi-parcel and split-parcel deeds, partial interests, interfamily transfers, properties rebuilt between sales, and the second sale of new construction. 37.7 million pairs remain after the exclusions and 37.0 million after a 1/99 trim within holding-period bins.

For each consecutive pair of sales of house i held k years, the idiosyncratic change is the log price change net of the FHFA annual five-digit ZIP index, interpolated to months, over the same months. Under a random walk with sale noise at both ends, the variance of changes takes the following form:

$$\mathrm{Var}[\Delta\nu(k)] = 2\sigma_v^2 + \sigma_w^2 \, k, \tag{B.3}$$

where σ_w is the standard deviation of the annual step u^h in (B.1) and σ_v is the standard deviation of the sale noise v in (B.2). We estimate this relationship by weighted least squares over horizons $k = 2, \ldots, 15$ and estimate that $\sigma_w = 0.047$ (county-cluster bootstrap standard error 0.0008) and $\sigma_v = 0.123$ (0.0015). Giacoletti (2021) reports a sale-noise standard deviation of 0.10–0.13.

The random walk is discretized on the seven nodes listed in Table 7. A purchase starts at the middle node, and each interior node moves to itself or to a neighbor with probabilities that match the annual step in (B.1), with mean zero and variance σ_w^2. The two end nodes

move only inward. Because the index is at the ZIP level, ν reflects the property's idiosyncratic deviation from its neighborhood.

C Data

C.1 Source and panel construction

We use the Panel Study of Income Dynamics (PSID), biennial waves 1999 to 2023. The family-level files of each wave are merged with the cross-year individual file, and variable codes are harmonized across waves, to build a household panel. Since 1997, the PSID interviews every two years, so we keep the odd-numbered survey years from 1999 on. Income questions refer to the calendar year before the interview, while wealth, housing and mortgage questions refer to the interview date. We keep this timing explicit throughout, both in the moments and in their model counterparts.

C.2 Sample selection

We keep households whose head is aged 25 to 65 at the interview. We drop household-waves with real taxable and transfer income below \$2,000 or real total expenditure below \$2,000 (2009 dollars). Nominal values are deflated with the PCE price index, income with the index of the year it refers to. To compute lagged variables and the frequency of hand-to-mouth status, the unit of observation is a household spell: a run of at least three consecutive biennial interviews. A household that leaves and re-enters the survey contributes one spell per qualifying run, and lags never cross a gap in participation. This leaves 72,784 household-waves in 11,240 spells of 10,725 households.

The moment sample additionally requires positive earnings, a head aged 25 to 64, and a home value consistent with reported home equity. It contains 71,097 household-waves in 11,221 spells of 10,706 households. Wealth and income are not directly trimmed, but the mean wealth-to-income targets are winsorized at $[-50, 200]$. All statistics use the PSID family longitudinal weight of the wave.

We keep all PSID samples – the original SRC and Census (SEO) samples and the immigrant samples added in 1997/1999 and 2017 – and weight every statistic with the PSID core/immigrant family longitudinal weight of the wave, which is constructed to make the weighted sample representative of the US population of the survey year. Observations with zero weight (for example, the 2017 immigrant families in their first wave) do not enter any statistic.

C.3 Variables

Earnings are head and spouse labor income plus government transfers and social security income, less employee payroll taxes at 7.65% of labor income, in 2009 dollars. Net worth is the sum of all assets net of all debts. Liquid wealth is checking and savings balances, stocks, and bonds net of non-mortgage debt. Checking, savings, and bonds are scaled by 1.055 for cash held outside accounts. Stocks exclude IRAs. Non-mortgage debt includes credit card, student, medical, legal, and family loans, following Aguiar et al. (2024). Because the model has only liquid assets and housing, the wealth moments that enter the estimation are recomputed on the PSID with the model's concept of net worth ("model-concept" moments), so that both sides measure the same object.

A household is a homeowner if it owns its home, and has a mortgage if it reports one at the interview. The PSID records the year in which a foreclosure started on the first or a second mortgage, for foreclosures since the previous interview; whether the home was eventually lost is asked without a date. A household-wave is flagged as foreclosed if a foreclosure started in the interview year or the year before. Foreclosures starting before 2009 come from the retrospective questions of the 2009 and later distress module, so they are reported only by households still in the survey in 2009, while the pre-2009 at-risk rows include all households. The foreclosure hazard is computed on households that had a mortgage at the previous interview, exactly two years earlier, and divided by two to express it at an annual rate. This at-risk set contains 28,339 household-waves and 382 foreclosure starts.

C.4 Hand-to-mouth status

Following the two-asset definition, a household is poor hand-to-mouth if its net worth is at or below two months of earnings. It is wealthy hand-to-mouth if it is not poor hand-to-mouth and its liquid wealth is either between zero and one week of earnings, or negative and within one week of earnings of the credit limit, set to 0.185 times annual earnings. Because wealth is measured at the interview and earnings refer to the previous calendar year, the PSID classification compares assets at t with income of $t-1$. The model's classification uses the same timing. Lagged hand-to-mouth status and its frequency over a household's previous waves are computed within spells.

C.5 Moments and their uncertainty

The vector of target moments is produced by a single script from the cleaned panel. Its sampling variance is estimated by a household-cluster bootstrap: households are resampled

with replacement, and the whole target vector is recomputed 300 times. The bootstrap standard deviations enter the weighting of the estimation criterion.

C.6 Model counterpart of the sample

Simulated households are drawn to reproduce the composition of the PSID sample: for every PSID spell we record the head's birth year, the first and last wave of the spell, and its weight. We then draw simulated households with replacement from these spells. We observe households in the model only in PSID interview years within its panel window. For example, we would not observe a model household in 2022, only 2021 or 2023. Model moments use the PSID definitions and the PSID timing of hand-to-mouth status. The simulated population contains the 10,905 spells with a positive weight in their first wave. The simulation draws 10,000 households per type from these spells, with replacement.

D Computational Appendix

D.1 Solution and simulation

We solve the model by backward induction with the discrete-continuous endogenous grid method (Iskhakov et al., 2017; Druedahl, 2021). For every discrete branch (rent by size, buy by size and contract, stay, sell and rent, sell and buy, default) the saving choice comes from the endogenous-grid step with an upper envelope over the branch's non-concave regions, and the discrete choice is the pointwise maximum over branches. We checked the solver against an exact search over the asset grid and results match. Expectations over income, house-price and aggregate shocks are precomputed once per age. Mortgage balances and payments are closed-form annuity tables by age, loan age and origination price level.

The simulation runs in continuous wealth, with the saving policy interpolated between grid nodes. The annual panel is collapsed to a PSID-shaped wave panel in which each simulated household is observed at the same PSID waves as the PSID household it was drawn from. All moments, hand-to-mouth classifications, hazards, and regressions are computed from that wave panel with the PSID definitions. The wave panel is saved for every Sobol point, so moments built from saved variables can be recomputed without a re-solve.

D.2 Implementation

Mortgage schedule: We implement mortgage schedules using a single schedule, based on an FHA 30-year fixed-rate loan. To adjust for higher down payments, the 10 and 20% down

loans are the FHA 30-year schedule entered at loan ages 2 and 5, where its loan-to-value is 0.908 and 0.800, with 28 and 25 years left on the mortgage. The mortgage state is then the loan age and the price level at origination. Mortgage insurance is paid while the scheduled balance exceeds 80% of the original price.

Prices and history: Households do not draw the aggregate state over the sample period. Each year of 1960–2023 is assigned to its nearest chain node and every household lives through that sequence. The chain's standard deviation of the price deviation is 0.135 and 0.127 in the data.

Entry: A household enters the panel at age 25 in the year in which the PSID household it is based on turned 25, as a renter with access to the mortgage market. We draw its income states from the chain's initial distribution, and use the entry-year aggregate state for their first aggregate state.

Measurement: Wealth ratios in the model use the model's net worth, which is home equity plus liquid wealth. Model earnings exclude Social Security, veterans' benefits, or other pensions, since the model runs to 64 and the focus is on working households. Consumption growth uses total expenditure in the data and nondurable consumption in the model. The two consumption-growth moments regress the change in log consumption on the hand-to-mouth indicators. In the PSID, consumption is total household expenditure and includes housing. In the model, it is nondurable consumption c, because housing services are a separate good. The default year in the model is the year in which the household chooses to default. In the PSID, it is the year in which the household reports that the foreclosure started.

D.3 Numerical safeguards

We apply two rules in the code to avoid numerical issues. These rarely bind, so the equations in Section A leave them out.

First, we implement a floor on consumption. As a numerical safeguard, when a household that rents or defaults cannot afford \$1,600 of consumption, plus the cheapest rent when it rents, the code tops up its resources to that level. This is separate from the transfer programs in f. It binds in 0.50% of household-years.

Second, we allow for flexibility in the credit line χy^p, which falls when income falls. Entering a crisis cuts it by 85%. A household that borrowed up to its old line would then have to repay the difference at once. If it cannot, the code lets it keep the debt above the new line and repay later. This happens in 0.11% of household-years, and is consistent with reality.

E Additional Model Results

	Two-type model			One-type model		
Added controls	Wealthy	Poor	N	Wealthy	Poor	N
None	1.38 (0.11)	-0.08 (0.09)	463,508	0.11 (0.17)	-0.73 (0.14)	141,889
Current H2M status	1.29 (0.11)	0.02 (0.09)	463,508	-0.04 (0.18)	-0.53 (0.14)	141,889
Income type, past earnings	1.33 (0.11)	0.05 (0.09)	463,508	0.09 (0.18)	-0.43 (0.14)	141,889
Three earnings lags	1.67 (0.15)	-0.25 (0.11)	377,577	-0.29 (0.26)	-1.21 (0.19)	118,571
All of the above	1.35 (0.15)	-0.01 (0.12)	377,577	-0.37 (0.25)	-0.74 (0.19)	118,571

Table E.1. History Coefficients with Additional Controls, Model

Notes: This table shows the coefficients on the wealthy and poor hand-to-mouth history from the regression of Table 12, estimated on the simulated panels with the controls in the first column added. Standard errors clustered by household are in parentheses. The first row repeats Table 12. Current H2M status is the household's poor and wealthy hand-to-mouth indicators at the interview. Income type and past earnings are the permanent income type and the mean of past log earnings. The earnings lags are log earnings at the three previous interviews, which shorten the sample. Mortgagors at the previous interview, 2007 on, weighted.

Idx	**Objective**	$s_1/s_2/s_3$	β_1	β_2	β_3	σ_1	σ_2	σ_3	δ_{def}	P_0
98	11.0	0.4/0.0/0.6	0.978	0.968	0.621	0.75	1.13	2.82	0.53	1.44
531	14.1	0.6/0.0/0.4	0.939	0.926	0.634	0.65	1.56	3.10	0.25	0.86
81	14.2	0.0/0.6/0.4	0.963	0.960	0.651	0.54	1.98	2.95	0.42	1.17
173	14.5	0.0/0.6/0.4	0.981	0.966	0.760	0.42	1.68	2.34	0.19	1.32
245	15.0	0.4/0.1/0.5	0.983	0.937	0.803	0.62	1.64	2.62	0.27	1.62
505	15.0	0.4/0.0/0.6	0.969	0.912	0.842	0.43	1.41	2.93	0.72	1.80
533	15.8	0.4/0.0/0.6	0.986	0.925	0.815	0.60	1.17	2.14	0.70	1.50
518	16.2	0.2/0.3/0.5	0.969	0.958	0.808	0.74	1.34	2.62	0.74	1.36
175	16.5	0.4/0.2/0.4	0.958	0.927	0.640	0.64	1.89	2.62	0.75	1.06
253	17.1	0.5/0.1/0.4	0.976	0.913	0.610	0.45	1.76	3.00	0.31	0.83
72	17.3	0.3/0.3/0.4	0.947	0.947	0.715	0.92	1.66	3.05	0.50	1.16
650	17.4	0.1/0.3/0.6	0.983	0.951	0.792	0.87	1.99	2.31	0.15	0.88
158	17.7	0.2/0.1/0.7	0.967	0.966	0.728	0.79	1.31	2.22	0.77	0.99
546	17.7	0.4/0.0/0.6	0.977	0.954	0.734	0.80	1.16	2.40	0.32	0.64
93	17.9	0.4/0.2/0.4	0.977	0.938	0.729	0.41	1.51	2.67	0.20	1.66

Table E.2. The 15 Best Three-Type Points of the Sobol Screen

Notes: This table lists the 15 best of the 462 solved three-type points, each at its best share vector. The one-type screen solved 1,000 points.

Symbol	Meaning	Value / status
Preferences and bequest		
β_i, σ_i	discount factor, intertemporal elasticity, by type	estimated, up to 3 types
$\hat{\beta}_i$	growth-adjusted discount factor $\beta_i e^{g_y(1-1/\sigma_i)}$	derived
γ	risk aversion	estimated, common
ϕ	consumption share in the period composite	estimated
α	ownership premium on housing services	estimated
δ_{def}	default-year penalty, composite $\times\, e^{-\delta_{def}}$	estimated
ψ_m	moving cost on sales and default	estimated
ϵ, $\bar{b}$	bequest ratio, luxury threshold	estimated
Income		
ξ_i	permanent income type	$\{-0.887, 0, 0.887\}$
z_{it}, τ_{it}	persistent AR(1), crisis component	joint chain, estimated outside
η_{it}	transitory shock	$\{-0.302, 0, 0.302\}$
$\Gamma(age)$	age profile	estimated outside
$a_t^y \equiv u_t$	aggregate income deviation	state, 2 nodes
g_y	trend growth of income (and of house prices)	0.0177
f, g	net income after taxes and transfers, after taxes only	PSID tables, 19 knots
$y^o(Y, I)$	owner net income with interest I deducted from taxes	derived
y^p	income base of the credit line (excludes η)	derived
Liquid account		
b	liquid position, negative is unsecured debt	about 120 nodes (73 negative)
r_s, r_b, r	deposit, card, pricing rates	-0.014, 0.0793, 0.012
$R(b)$	kinked gross return, normalized	derived
χ	credit line as a fraction of y^p	0.185
N_t, $\underline{b}_t$	natural limit, effective credit line	derived
Housing		
P_0	price per unit of housing, trend-income units	estimated
a_t^h	aggregate price deviation	state, 5 levels
ν_{it}, σ_w	idiosyncratic price node, its step	7 nodes, 0.047
v, σ_v	sale offer shock, its sd	3 nodes, 0.123
$\mathcal{H}_r$, $\mathcal{H}_o$	rental and owned sizes	KMV grids
$\bar{u}$, p_t^r	user cost, rent per unit	0.0435
ℓ	landlord leverage in the user cost	0.9
τ^h, δ^h	property tax, maintenance	0.01, 0.025
κ^m, κ^s	proportional purchase and sale costs	0.04, 0.08
κ_f, κ_p	fixed purchase cost, fire-sale discount	estimated
D, n_d	distress indicator, horizon in years of carrying cost	estimated
χ_f	foreclosure deadweight loss	0.355
Mortgage		
r^m	real mortgage rate	0.0307
T^m	term of the schedule	30
λ_j, t_j^m	loan-to-value and entry loan age of contract j	$\{0.982, 0.908, 0.800, 0\}$, loan ages $\{0, 2, 5\}$
MI	mortgage insurance, share of balance	0.007 while the schedule balance > 0.8 of original price
t^m, S^b	loan age, price level at origination	states
M, m	balance and payment per unit, schedule	derived
$\overline{DTI}$, π	debt-to-income cap, underwriting inflation	0.43, 0.0215
κ_c	card minimum, APR plus principal share of balance	0.1476 + 0.12
$\overline{\text{age}}$	latest repayment age	85
π_{re}	readmission probability after default	1/7

Table E.3. Notation