Homeownership and the Cost of Living*

Gabriel Chodorow-Reich
Harvard University

Edward Glaeser
Harvard University

Xavier Jaravel
London School of Economics

Avi Lipton
Harvard University

December 2025

Abstract

How should price indices account for durable goods like housing, which are debt-financed, held for years, and resold? The Consumer Price Index uses "owners' equivalent rent," which imputes rent increases for homes that are owner occupied, but this measure can differ dramatically from the "one period user cost" of owner-occupied housing, which includes interest and maintenance payments and subtracts expected housing price appreciation. A preference for owning can explain this gap, but if the preference of the marginal homeowner changes over time, then "owners' equivalent rent" will not measure the population-wide changes in shelter cost. Using a customized survey, we measure the preference for owning, and find that households' willingness-to-pay for homeownership is both large and heterogeneous. We derive a price index in a dynamic model that measures changes to welfare with a money-metric value function and allocates the welfare change across years using the time path of the response of non-durable consumption to housing wealth. We calibrate a quantitative version to the survey evidence and other moments. A permanent 2 p.p. increase in the mortgage rate causes the shelter price index in our calibrated model to increase by 3%, due to both lower non-durable consumption and lost surplus of would-be homeowners. We argue that this captures the true welfare impact of higher interest rates better than owners' equivalent rent, which does not change by construction, or the one-period user cost, which increases by an order of magnitude more.

*We thank Bnaya Dreyfuss for his incredible assistance with running our survey and Justine Nayral for her outstanding help with the measurement of the user cost. The authors gratefully acknowledge financial support from the Chae Macroeconomic Policy Fund at Harvard University.

1 Introduction

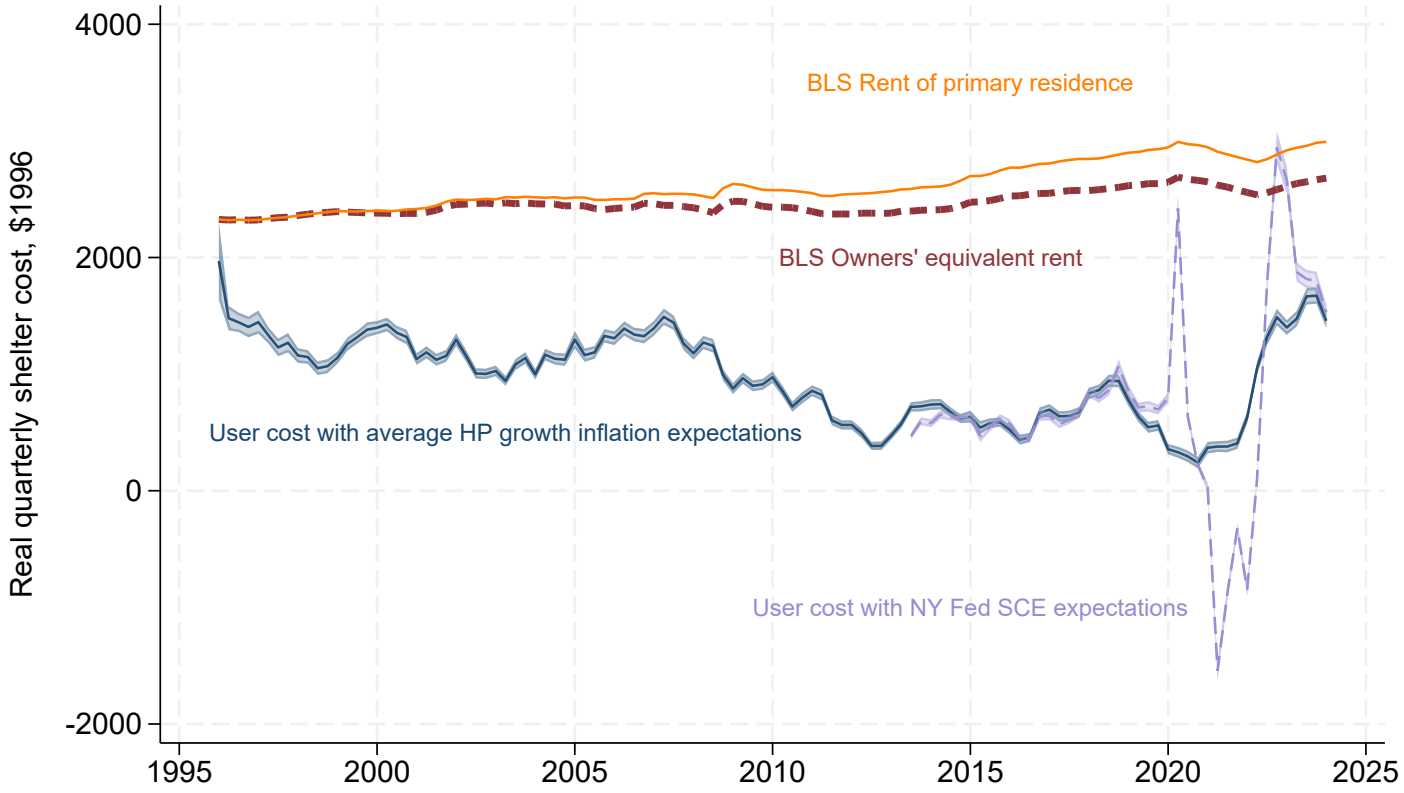
How should price indices treat durable goods, like housing, that are often debt-financed, owned for many years, and eventually resold? A standard approach follows the structure of a static expenditure function in which durable goods are only rented. Yet, correcting nominal incomes with a rent-based cost of living adjustment may misstate the true change in well-being for a population that contains large numbers of highly indebted owners. Adjusting pension or wage payments based on a rent-based inflation measure will introduce volatility to permanent income for a population that is largely living in owner-occupied housing.

This paper reconsiders how to incorporate shelter costs into a Consumer Price Index (CPI), taking into account the dynamic aspects of housing. Shelter is the largest expenditure item in the U.S. CPI. It comprises 32% percent of total costs, divided between a seemingly straightforward 7.5% of rental costs paid by renters and a far more complicated 25.1% of total spending associated with owners. Currently, the CPI measures shelter inflation for owners using the growth rate of actual rents reweighted to match the characteristics of owner-occupied properties, referred to as owners' equivalent rent (Poole, Ptacek and Verbrugge, 2005).[1] Owners' equivalent rent differs conceptually from the traditional one-period user cost, which combines maintenance costs, either interest costs or the opportunity cost of financial asset returns or both, and expected house price appreciation over the period (Steiner, 1961; Poterba, 1984). Consequently, the CPI does not capture any of the pain experienced by new home buyers when interest rates increase, even though most economists view such costs as an important component of the cost of housing.

The conceptual case for using owners' equivalent rent is that standard models predict that in equilibrium the expected costs of renting should equal the expected costs of owning. Yet, historical time series show that rents are far less volatile than user costs (Verbrugge, 2008). Figure 1 shows rental rates and one-period user costs for the U.S. over 1995-2025 (see Appendix A for details of the data construction). The solid orange line shows rent of primary residence and the dashed red line shows owners' equivalent rent. Both series trend up relatively smoothly. The blue shows the one-period user cost of housing with expected house price growth fixed at the average growth rate from

[1] From 1953 to 1983, the CPI used a hybrid combination of rents, prices and other payments; their formula was not tied to user costs.

Figure 1: Rent, Owners' Equivalent Rent, and User Cost



Notes: See Appendix A for details of the user cost series. We set the dollar value of the rent and owners' equivalent rent series to equal average rent in the CEX in 1996Q1 and deflate all measures using the non-shelter CPI.

1995-2025. The dashed purple line gives the user costs with expected house price growth based on the Federal Reserve Bank of New York Survey of Consumer Expectations. These measures exhibit much more high frequency volatility and have different low frequency trends than the rent series. Both user cost measures rise sharply in 2022 with the rise in mortgage interest rates. The user cost measures are also typically less than rent, because of expected or realized housing price appreciation and the absence of transaction costs. They can even turn negative.

We argue that this divergence reflects two key aspects missing from the standard model: owning and renting are not perfect substitutes, and substantial transaction costs mean that people rarely buy and re-sell houses so that the one period user cost does not equal the cost of owning for incumbent owners.[2] Both aspects affect the proper price of shelter.

Our first set of results relax the assumption that rent and owning are perfect substitutes.

[2]Two other possibilities are mis-measurement of expectations or time-varying risk premium. Neither can plausibly reconcile the time series behavior.

We characterize shelter inflation in Section 2 in a model with no transaction costs, and where households differ only in their non-pecuniary taste for owning, which we denote θ. These tastes may differ over the lifecycle and could reflect the desire for customization or specific house or neighborhood characteristics associated with home ownership. The marginal buyer equates rental costs with her user cost minus her non-pecuniary utility from owning. Changes in homeownership rates therefore imply that the identity of the marginal home buyer changes, rationalizing a time-varying wedge between user costs and rents.

We define shelter inflation as the required transfer to offset the change in money-metric utility when shelter costs change. In this simple framework, changes in rents correctly characterize shelter inflation when homeownership and hence the θ of the marginal buyer remains fixed. But shelter inflation is not in general independent of changes in mortgage rates, unlike in the CPI. Higher rates directly increase the cost of owning and also reduce the number of home buyers. Households that would have bought at lower rates have lost consumer surplus when they remain renters under the new rates. The loss in surplus depends on the change in homeownership and the distribution of tastes.

To assess the magnitude of this loss, we elicit preferences for homeownership in a customized survey. Our survey, which we describe in Section 4, provides respondents with a comparison of the cost of owning or renting over ten years and asks how much (if any) terminal wealth they would forgo to own rather than rent (where terminal wealth in the renting scenario fluctuates due to the returns on investment of their foregone downpayment). The distribution of elicited willingness-to-pay (WTP) to own has a positive mean and is right skewed. As our model suggests, owners have higher average WTP to own than renters. We also find a hump-shaped WTP over the life-cycle, with a peak for household heads age 45-54. A follow-up survey conducted one month later shows relatively stable individual preferences, helping to validate the survey design.

We next incorporate transaction costs and long-term contracts. In this case, no explicit per-period shelter price exists — think for example of the price paid by an incumbent owner with a long-term mortgage who observes changes to the mortgage rate or house prices. As in Bajari, Benkard and Krainer (2005), under these conditions the undisputed measure of intertemporal welfare is the value function consisting of the present value of the stream of nondurable consumption and

utility from housing. In Section 3, we first characterize this value function in money-metric terms. We then calculate the per-period transfer required to offset changes in nondurable consumption and housing utility due to changes in shelter costs. That transfer represents the price index contribution from housing.

Intuitively, an increase in the cost of owning has two effects. First, from the intertemporal budget constraint, the change to the present value of spending on shelter requires a matching change in the present value of nondurable consumption. We allocate this present value across periods using agents' intertemporal marginal propensities to consume (Auclert, Rognlie and Straub, 2024). With consumption smoothing, this component generates a one-time jump in the price index whenever shelter costs change. Second, housing utility falls if homeownership declines, as with the decline in consumer surplus in the simple model in Section 2. The price index path thus preserves the interpretation of the minimum per-period expenditure required to keep total utility fixed, as in the static case.

In principle, measurement of how changes in shelter cost affect nondurable consumption, homeownership, and the covariance of ownership with utility θ is sufficient to compute the price index. But these are complex empirical objects. We therefore build a quantitative general equilibrium life-cycle model in which we can assess welfare and price indexes. Section 5 augments Section 2 by including moving costs which generate long tenures, 30 year fixed payment mortgages (with an option to refinance), and heterogeneity in the propensity to move and in liquidity constraints that vary with age. The decision to own a home reflects four forces: (i) preference for owning θ; (ii) the likelihood of moving (transaction costs are higher for owners), which reflects the arrival rate of additional costs to remain in one's current house (for example, a job opportunity with a longer commute from the current location), (iii) ability to make a down payment, and (iv) the current and expected paths of costs associated with owning and renting.

We calibrate the model to our survey results and to other moments of the data, as described in Section 6. Our survey directly disciplines a life-cycle process for the preference for owning, θ, wherein θ typically increases with age but may "crash" with age-specific probability as individuals choose to downsize. We calibrate a process for liquidity constraints to match age-specific population shares with assets sufficient to make a minimum down payment. We set several other

parameters externally, including trend rent growth, transaction costs, discount and mortgage rates, and the supply curve for converting owner-occupied and rental housing. We estimate the remaining parameters jointly to minimize the distance between several steady state moments of the model and their data counterparts. The estimated parameters include age-specific likelihoods of receiving a "nudge" to move, the transition rate between being subject to a nudge and not, and the flow cost of owning. The moments include the WTP premium for owners from our survey, rent-to-rent, rent-to-own, own-to-rent, and own-to-own transition rates, and the overall homeownership rate.

We validate the calibration with two exercises. The first shows that the model matches the increasing, concave relationship between homeownership and age despite not targeting any moments related to age-specific homeownership or tenure transition rates. The second compares the effect of a first-time homebuyer tax credit (FTHC) in the model to the evidence in Berger, Turner and Zwick (2020) evaluating the 2009-10 FTHC in the U.S. Our calibrated model is consistent with the take-up of the FTHC in the data, although we note that the exact magnitude is sensitive to agents' expectations of future house prices.

We apply our results to measure the change in the cost-of-shelter when mortgage rates increase, as occurred in the U.S. in 2022. In Section 7 we analyze a permanent two percentage point increase in the mortgage rate with rents remaining fixed. As homeownership becomes more expensive, rent-to-own transitions decline. Due to "mortgage lock" (Liebersohn and Rothstein, 2025; Batzer et al., 2024; Fonseca and Liu, 2023), own-to-rent transitions also fall; households with low mortgage rates or who have paid off their mortgage and who in steady state would pefer to rent now remain owners in case their preferences switch again. On net, both house prices and homeownership drop in the first year of the rate increase and continue to decline thereafter.

Our shelter price jumps 3% (in units of trend shelter expenditure) when the mortgage rate increases, which would contribute about 1p.p. to total consumer inflation. Roughly 60% of this increase is due to higher lifetime shelter costs and 40% is due to the foregone utility of homeowners who have switched to renting. We further decompose the foregone utility into a component that reflects the decline in homeownership with perfect sorting by θ and a misallocation term that includes the role of mortgage rate lock in delaying sales by lower θ owners to higher θ buyers. Other possible price indexes deliver a different message about the change in consumer welfare

from the rate increase. By construction, a price index based on owners' occupied rent does not change since rents do not change. The one-period user cost increases by a much larger 50% of shelter expenditure, reflecting both the higher mortgage rate and the anticipated future house price decline due to the slow transition from owning to renting.

Section 9 concludes by summarizing directions for future research.

A Very Short History of Shelter Indices and Other Related Literature. Price index statisticians have debated for a century how to treat housing. The BLS published its first national CPI in the Monthly Labor Review in 1921. Between 1921 and 1953, rents were a major component of the series, but homeownership costs such as mortgage payments and taxes were not. BLS justified this treatment in part because the original index focused on "moderate income" workers, who were poorer and less likely to own in a society in which the homeownership rate in 1940 was just 44%.

In 1953, the Monthly Labor Review announced the switch from the "Old Index," which only included households in which the primary earner made less than $2,000 per year $24,000 in 2025 dollars) to the "New Index," which included households with earnings up to $10,000 ($122,000 in 2025 dollars). The inclusion of wealthier households more likely to own their primary residence and an overall homeownership rate that reached 61% in 1960 made the exclusion of owners' costs untenable. The "New Index" used an average of different housing related prices in the category of "homeowners' expenditures", including the sales price of the home (6.08% of the total spending bundle), real estate taxes (1.08%), mortgage interest rates (1.64%) and property insurance rates (0.2%). Repairs and maintenance were a distinct category, including spending by renters as well, and an astonishing 0.78% of the entire CPI spending bottle was allocated to "replacing the hot water heater." As the New Index replaced the Old, shelter's budget share rose from 11% to 18%.

The Stigler Commission of 1961 provided a thorough review of America's price indices and criticized the expenditure formula in the "new Index", charting a path that would eventually lead to the change to owners' equivalent rent in 1983. The staff report on "Consumer Durables" favored a user cost approach that involved "depreciation," "interest," "incidental purchase costs," "taxes," "maintenance and repair" and "insurance", but also noted the theoretical equivalence to the rental rate (Steiner, 1961). Subsequent papers by economists affiliated with BLS and the

Office of Housing and Urban Development explored both the user cost and owners' equivalent rent, including key contributions by Dougherty and Order (1982) and Gillingham (1983), with Gillingham and Lane (1982) giving the official version for the BLS.[3] These papers recognized but did not resolve the time series differences between the user cost and rent. Given the additional implementation issues required to compute the user cost, such as house price expectations and discount rate assumptions, after 1983, BLS simply opted for owners' equivalent rent.

The debate among statistical agencies remains unresolved. The most recent *Consumer Price Index Manual* of the United Nations calls the treatment of owner-occupied housing "one of the most difficult issues faced by CPI compilers" (International Monetary Fund et al., 2020, p. 245) and outlines four approaches in use internationally: user costs, rental equivalence, a "payments" approach that includes all expenditure specific to owner-occupiers, and an "acquisitions" approach similar to the treatment of other durables that includes net purchases of dwellings and new construction. The *Manual* notes that many countries make *ad hoc* adjustments to these approaches, such as excluding the capital gain component of the user cost.[4] International Monetary Fund et al. (2025, chapter 10) discuss a fifth approach of using the maximum of owners' equivalent rent and the user cost. In our view, this debate remains unsettled because of the absence of a theoretical framework that reconciles the behavior of rents and user costs and, more deeply, that durable goods such as housing do not neatly fit into the economic approach to consumer price indexes. Indeed, International Monetary Fund et al. (2020, p.254) states that the rental equivalence approach "approximates the user cost approach" despite their very different time series behavior. Acknowledging that our full approach may pose implementation difficulties, we hope that the conceptual framework may stimulate new practical resolutions.[5]

[3] Gillingham and Lane (1982) also concisely describe the formula used to incorporate housing prices and interest rates prior to the change to owners' equivalent rent: "the weight for home purchase is the purchase price for homes bought in the survey year, less the sales price for homes sold, plus transactions costs for these purchases and sales," while "the weight for 'contracted mortgage interest cost' is the amount of interest that survey period borrowers promise to pay during the first half of the term of their mortgage loans," which "includes future payments". Determining the change in price meant that a "new selection of recently sold homes must be used each month" and "the average price of this month's set of homes must be compared-after adjustment for quality difference-to the average price for last month's set." For changes in mortgage rates, the Federal Home Loan Bank provided data on "all mortgages closed during the first 5 business days each month by a sample of savings and loans and other lenders," and then "the rate change is estimated using quality control cells similar to those used for house prices."

[4] Dougherty and Order (1982) specifically criticize this approach on the grounds that it makes the cost of owner-occupied housing erroneously non-neutral to overall trend inflation, which would increase nominal mortgage rates as well as expected house price growth equally.

[5] Interestingly, the U.S. debate has remained relatively quiet since the change to owners' equivalent rent. Notably,

The academic literature has recognized the tension between an intertemporal world and static price indexes but reached different conclusions. Alchian and Klein (1973) argued that a price index used to measure inflation must include asset prices. Reis (2005) offers a modern treatment of what he calls "dynamic inflation" but retains the assumption for durable goods of zero transaction costs so that the one-period user cost applies. While we sympathize with the theoretical purity of including all asset prices in a dynamic world in which intratemporal and intertemporal prices receive equal treatment, we confine our measurement to shelter, where these considerations are unavoidable and which already receives special treatment in the CPI. Our approach of distributing the change in the value function across periods is in some ways the reverse of Baqaee, Burstein and Koike-Mori (2024), who derive a method to translate per-period price changes into changes in the value function. They allow for more flexibility in the consumption-savings problem but also restrict consideration of durables to the one-period user cost. Bolhuis et al. (2024) and Astin and Leyland (2023) argue that interest rates affect the cost of living, but differ in whether the CPI should incorporate them directly.

Academics and practitioners have also debated how to measure shelter costs for renters, since most rental contracts are long-term. Under current practice, the CPI measures average rent growth for all renters (with a lag structure for sampling reasons). Ambrose, Coulson and Yoshida (2023) advocates for using rent growth of new tenants only. Our methodology can accommodate either extreme, depending on when agents change their nondurable consumption in response to a change in new tenant rent.

The link between the price index and the change in the intertemporal budget constraint builds on earlier results related to consumption out of housing wealth (Sinai and Souleles, 2005; Campbell and Cocco, 2007; Guren et al., 2020) or more general asset price fluctuations (Fagereng et al., 2024). Our measure accords with these papers in incorporating house price changes only insofar as agents will transact in the future and therefore adjust their consumption today. Furthermore, like

the Boskin Commission saw far less to criticize about the housing cost methodology and even recommended that "the price of durables, such as cars, should be converted to a price of annual services, along the same lines as the current treatment of the price of owner-occupied housing" (Boskin, 1996). The Boskin Commission highlighted two major issues with housing in the CPI: "not to revise the treatment of housing costs for 1984 and earlier years," which meant that "the level of the CPI-W is 4.7 percent above the CPI-U X1, a measure of the cost of living based on the same primary data sources and similar methodology, but with a consistent treatment of housing costs," and the CPI's "measure of shelter rent is upward biased by neglecting the increase in the quality of apartments per square foot."

Fagereng et al. (2024), our welfare measure includes the present value of changes in nondurable consumption expenditure; our analysis builds on theirs by including heterogeneity in the non-pecuniary component of shelter utility, by converting the value function change into a per-period price index, and by using a simulated model to undergo measurement in real-time rather than using a long history of transactions *ex post*. Relative to Berger et al. (2017) and Greaney, Parkhomenko and Van Nieuwerburgh (2025), our quantitative model simplifies aspects of the consumption-saving problem such as life cycle dynamics or uninsurable idiosyncratic income risk in order to focus more sharply on housing dynamics in general equilibrium.

Like us, several articles have incorporated a preference for owning over renting into a tenure choice framework (Piazzesi and Schneider, 2016; Kaplan, Mitman and Violante, 2020). The closest treatment is in Greenwald and Guren (forthcoming), who also use heterogeneity in this parameter to generate a downward-sloping demand curve for owner-occupied housing. We contribute to this modeling framework by using strategic survey questions (in the terminology of Ameriks et al. (2020)) to provide explicit discipline on the level of and heterogeneity in this preference. The non-pecuniary preference for owning due to e.g. customization or location preference likely qualitatively distinguishes housing from other durable goods such as cars. This feature along with the much lower depreciation rate of housing explains our focus on this particular type of durable.

Last, given its weight in the CPI, the debate over measurement of shelter costs inevitably touches on the practice of monetary policy. Indeed, one motivation for the 1983 change to owner equivalent rent may have been to remove the direct feedback from higher interest rates into inflation. While our measure restores this link, we think the appropriate response involves changing the response of monetary policy rather than distorting measurement of the cost-of-living. Along these lines, Bianchi, McKay and Mehrotra (2025) argue that monetary policy should ignore housing inflation because housing is inelastically supplied. More simply, changes in mortgage rates bear similarity to classic cost-push shocks that policy may look through.

2 Static Model with Preference Heterogeneity

This section presents an equilibrium model of house prices and homeownership where households have heterogeneous preferences for owning and renting. Our goal here is to examine the link

between rents and the user cost of housing, and to develop formulas for measuring inflation when rent, interest rates, or other shelter-related variable change. To promote clarity, we omit elements such as moving costs, fixed rate mortgages, or liquidity constraints that we introduce in Section 5.

2.1 Setup

The economy consists of a continuum of agents indexed by their preference for owning θ, with $\theta \sim F_\theta(\theta)$. Each agent consumes one unit of housing and freely chooses whether to rent or own each period. We let $\mathcal{H}_t(\theta)$ denote an indicator function equal to 1 if an agent of type θ owns and 0 otherwise and $h_t = \int \mathcal{H}_t(\theta)\, dF_\theta(\theta)$ the homeownership rate.

Prices. We denote market rent by R_t. Since all housing units are identical, R_t also corresponds to owners' equivalent rent. Owners make a down payment $(1-\ell_t)\, P_t^H$, where ℓ_t is the loan-to-value ratio and P_t^H the price of a house, and then make interest payments given mortgage rate i_t of $i_t \ell_t P_t^H$ and a payment f_t to cover property taxes, insurance, maintenance, and depreciation. Owners then resell their house at the beginning of the next period, recouping $P_{t+1}^H - \ell_t P_t^H$. If agents discount the sale proceeds using a discount factor $\beta_{t,t+1}$, then the cost of owning can be written as the user cost $\rho_t P_t^H$, with:

$$\rho_t \equiv (1-\ell_t)(1-\beta_{t,t+1}) + \ell_t i_t + \frac{f_t}{P_t^H} - \beta_{t,t+1}\mathbb{E}_t\left[\frac{P_{t+1}^H - P_t^H}{P_t^H}\right]. \tag{1}$$

The user cost consists of a weighted average of the discount and mortgage rates, plus the flow carrying cost, less the expected discounted house price appreciation, all scaled by the house price. The bundling of home-buying with mortgage financing makes mortgage costs an inextricable component of the cost of homeownership.

Preferences. We normalize the consumption-equivalent utility benefit from renting to 0. Thus, flow net utility of renters is $U_t(\theta|\mathcal{H}_t(\theta)=0) = -R_t$. Agents differ in their non-pecuniary consumption-equivalent utility from owning. An agent of type θ receives consumption-equivalent utility $\theta\bar{R}_t$, where the scalar $\bar{R}_t$ denotes rent along the balanced growth path. Thus, an agent with $\theta = 0$ receives no additional utility from owning relative to renting. Positive values of θ may reflect owners' ability to customize their houses, a desire for neighborhoods dominated by

owner-occupied housing, or privacy from landlord intrusion, among other factors. The net utility for an owner over the period in money-metric terms is therefore $U_t\left(\theta|\mathcal{H}_t\left(\theta\right)=1\right)=\theta\bar{R}_t-\rho_t P_t^H$. With probability δ_θ each period an agent draws a new theta from the distribution $F_\theta(\theta)$, which we assume is everywhere differentiable.

Supply. The details of the supply side do not matter to our main result in Proposition 2, since the price index requires only equilibrium prices. However, they allow us to characterize the balanced growth path and to consider equilibrium outcomes that involve changes in the supply curve, as we do in Lemma 2.

We treat market rents as exogenous and specify a supply curve between rental and owner-occupied units. The price of a rental unit depends on the gross inverse net "capitalization rate" c_t:

$$c_t=\frac{P_t^R}{R_t}. \tag{2}$$

"Private equity firms" can convert a rental to an owner-occupied unit at a cost $g(h)$ proportional to the value of a rental building, with $g'(h)>0$. The function $g(h)$ may reflect the cost of literal conversion from owner-occupied to rentals, or, with depreciation, the cost of changing the mix of new residential investment across these categories.

2.2 Equilibrium

There are three equilibrium conditions. The first defines a cutoff value θ_t^* at which an agent is indifferent between renting and owning:

$$-R_t=\theta_t^*\bar{R}_t-\rho_t P_t^H \Longrightarrow \rho_t P_t^H=R_t+\theta_t^*\bar{R}_t. \tag{3}$$

According to equation (3), the user cost equals market rent shifted by $\theta_t^*\bar{R}_t$. With a degenerate distribution of θ and an interior value of the homeownership rate, this equation would require that market rent perfectly tracks the user cost.

With heterogeneity in θ, market rent can move differently from the user cost as the cutoff value θ^* varies. Thus, preference heterogeneity can resolve the dichotomy between the time series of rents and user costs. Section 5 will introduce additional sources of heterogeneity (in expected

duration and liquidity) that will make the indifference condition multidimensional; at this point, the taste for homeownership (θ) provides the only source of heterogeneity.

The second equilibrium condition requires landlords to be indifferent between operating a building as a rental and converting it to an owner-occupied unit:

$$c_t R_t = P_t^R = P_t^H - g\left(h_t\right) c_t R_t \Longrightarrow P_t^H = \left(1 + g\left(h_t\right)\right) c_t R_t. \tag{4}$$

Combining equations (3) and (4) relates θ^* to the homeownership rate:

$$\theta_t^* = \left(R_t / \bar{R}_t\right)\left(\left(1 + g\left(h_t\right)\right) c_t \rho_t - 1\right). \tag{5}$$

Market clearing gives the third equilibrium condition:

$$h_t = 1 - F_\theta\left(\theta_t^*\right). \tag{6}$$

Equations (5) and (6) determine θ^* and h as functions of the conversion cost function $g(h)$, the capitalization rate c, the user cost component ρ, and the preference distribution F_θ. Let $X_t\left(\theta\right)$ denote shelter expenditure, with $X_t\left(\theta | \theta < \theta_t^*\right) = R_t$, $X_t\left(\theta | \theta \geq \theta_t^*\right) = R_t + \theta_t^* \bar{R}_t$. We have the following result (see Appendix B.1):

Proposition 1 *There exists a balanced growth path with $\bar{R}_{t+1}/\bar{R}_t = 1 + \mu$, $\ell_t = \ell$, $i_t = i$, f_t/P_t^H fixed, $c_t = c$, $\rho_t = \rho$, and $R_t = \bar{R}_t$. Along this balanced growth path, the cutoff θ^*, the homeownership rate h, and detrended shelter expenditure $X_t\left(\theta\right)/\bar{R}_t$ for each type θ are all constant.*

2.3 Shelter Inflation

With $\theta \neq 0$, renting and owner-occupied housing become distinct varieties in the overall category of shelter. Following the economic approach to price indexes (see e.g. International Monetary Fund et al., 2025, chapter 5) or "Kon us index", we define the change in the composite price of shelter as the pecuniary transfer required to keep utility fixed as costs change.[6] Using equation (3),

[6]The economic approach to index number theory typically expresses inflation using the difference in the expenditure required to achieve utility $U_t(\theta)$ at the old and new prices. This approach is equivalent to ours if there exists an outside good C_t with price normalized to 1, since the difference $U_t(\theta) - U_{t+1}(\theta)$ then equals the change in expenditure required to keep total utility inclusive of the outside good fixed. Section 3 explicitly introduces an outside good. We also defer discussion of changes to other factors that affect allocations, such as shifts in the distribution of preferences for owning.

equilibrium utility is:

$$U_t(\theta) = \begin{cases} -R_t, & \theta < \theta_t^* \Rightarrow \mathcal{H}_t(\theta) = 0, \\ (\theta - \theta_t^*)\bar{R}_t - R_t, & \theta \geq \theta_t^* \Rightarrow \mathcal{H}_t(\theta) = 1. \end{cases} \tag{7}$$

We first define the price change for a single type with $\theta_{t+1} = \theta_t$ as the transfer required to keep utility fixed when shelter costs change:

$$P_{t+1}(\theta) - P_t(\theta) = U_t(\theta) - U_{t+1}(\theta). \tag{8}$$

Using equations (3) and (7):

$$P_{t+1}(\theta) - P_t(\theta) = \begin{cases} R_{t+1} - R_t, & \mathcal{H}_t(\theta) = \mathcal{H}_{t+1}(\theta) = 0, \\ R_{t+1} - R_t + \left(\theta_{t+1}^* \bar{R}_{t+1} - \theta_t^* \bar{R}_t\right) - \theta\left(\bar{R}_{t+1} - \bar{R}_t\right), & \mathcal{H}_t(\theta) = \mathcal{H}_{t+1}(\theta) = 1, \\ R_{t+1} - R_t + (\theta - \theta_t^*)\bar{R}_t, & \mathcal{H}_t(\theta) = 1, \mathcal{H}_{t+1}(\theta) = 0, \\ R_{t+1} - R_t - \left(\theta - \theta_{t+1}^*\right)\bar{R}_{t+1}, & \mathcal{H}_t(\theta) = 0, \mathcal{H}_{t+1}(\theta) = 1. \end{cases} \tag{9}$$

The first line gives the required transfer for types who rent in both periods, the second line the transfer for types who own in both periods, the third line is the transfer for types who own in t and rent in $t+1$, and the fourth line provides the transfer for types who rent in t and own in $t+1$.

The aggregate price change is the total transfer:

$$P_{t+1} - P_t = \int_\theta P_{t+1}(\theta) - P_t(\theta)\, dF_\theta(\theta). \tag{10}$$

The reshuffling of θs as agents take new draws from $F_\theta(.)$ creates winners and losers but does not change the required aggregate transfer: equation (10). We can now state the main results of this section concerning shelter inflation:

Proposition 2 *If there is a change so that $\theta_{t+1}^* \geq \theta_t^*$, then the aggregate transfer to keep utility fixed is:*

$$P_{t+1} - P_t = \overbrace{(R_{t+1} - R_t)}^{\textit{Rent change}} + \overbrace{\left(h_{t+1}\theta_{t+1}^* \bar{R}_{t+1} - h_t \theta_t^* \bar{R}_t\right)}^{\textit{Additional owner costs}} + \overbrace{\left(\mathbb{E}_\theta\left[\mathcal{H}_{t+1}(\theta)\,\theta \bar{R}_{t+1}\right] - \mathbb{E}_\theta\left[\mathcal{H}_t(\theta)\,\theta \bar{R}_t\right]\right)}^{\textit{Non-pecuniary utility change}},$$

where: $\mathcal{H}_t(\theta) = \mathbb{I}\{\theta \geq \theta_t^*\}$.

The first term in Proposition 2 contains the change in market rent. The second term contains the change in the additional costs of owning, due to changes in θ^* or a user cost-rent ratio above one. The third term contains the change in non-pecuniary utility for agents who previously owned and now rent.

One can also arrive at Proposition 2 by simply defining the date t price as the income amount equivalent to shelter utility U_t: $P_t = -U_t = -\int U_t(\theta)\, dF_\theta(\theta)$. With this definition and Proposition 1, we have the following result:

Lemma 1 *Gross inflation on the balanced growth path is:*

$$\frac{P_{t+1}}{P_t} = 1 + \mu.$$

Thus, owners' equivalent rent correctly captures shelter inflation on the balanced growth path.

Lemma 2 elucidates the implications in three other special cases.

Lemma 2 *(i) Suppose $\theta = \bar{\theta}$ for all agents. Then:*

$$P_{t+1} - P_t = R_{t+1} - R_t.$$

(ii) Suppose $R_{t+1} \geq R_t$, $g(.), \rho, \bar{R}$ do not change, and c adjusts such that $h_{t+1} = h_t$.[7] *Then:*

$$P_{t+1} - P_t = R_{t+1} - R_t.$$

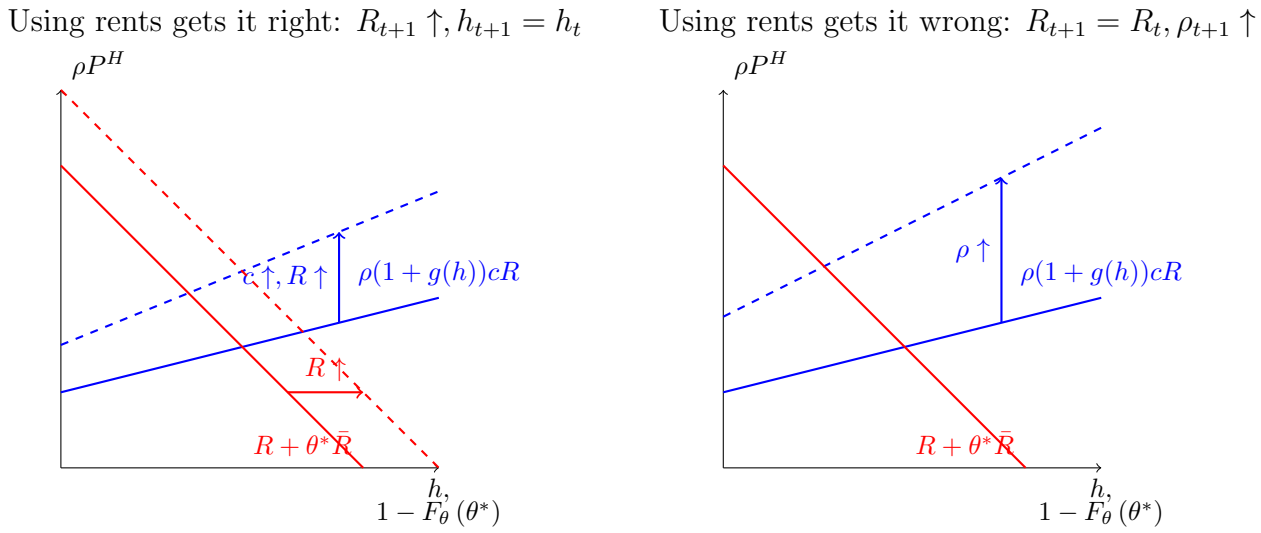
(iii) Suppose $i_{t+1} > i_t$ unexpectedly and (in expectation) permanently and $g(.), c, R, \bar{R}$ do not change. Then:

$$P_{t+1} - P_t = \overbrace{h_{t+1}\left(\theta^*_{t+1} - \theta^*_t\right)\bar{R}}^{\textit{Owner costs}} + \overbrace{\left(h_t - h_{t+1}\right)\mathbb{E}_\theta\left[\theta - \theta^*_t | \theta^*_t \leq \theta < \theta^*_{t+1}\right]\bar{R}}^{\textit{Extensive margin consumer surplus}}.$$

Part (i) removes preference heterogeneity by fixing $\theta = \bar{\theta}$ for all agents. In this case, utility is $-R_t$ whether an agent owns or rents (see equation (7)) and using owners' equivalent rent again gets the change in the shelter price right (the second and third terms in Proposition 2 cancel). However, equation (3) shows that this case cannot reconcile the time series differences between rent and the user cost.

[7] That is, given initial θ^*_t, h_t, $c_{t+1} = \frac{1+\theta^*_t \bar{R}_{t+1}/R_{t+1}}{(1+g(h_t))\rho_t}$.

Figure 2: Illustration of Lemma 2



Heterogeneity in θ can reconcile the time series of user costs and rent, but that heterogeneity also introduces additional terms into the price index, which are captured by parts (ii) and (iii) of Lemma 2. Part (ii) considers a change in market rents with no change in homeownership and zero trend rent growth. In this case, using owners' equivalent rent for owners still gets the contribution of shelter inflation right.[8] The left panel of Figure 2 demonstrates that when homeownership doesn't change, the shift right in the downward-sloping line exactly equals the change in the user cost.

Part (iii) of Lemma 2 and the right panel of Figure 2 consider a change in the user cost, due to an unexpected and (in expectation) permanent increase in the mortgage rate. Using owner-equivalent rent now gets shelter inflation wrong, since by assumption market rents have not changed.[9] Intuitively, a slight rewriting of the latter two terms in Proposition 2 shows two contributions: $h_{t+1}\left(\theta^*_{t+1} - \theta^*_t\right)$, the increase in the user cost for those that continue to own after the interest rate increase, and $(h_t - h_{t+1})\,\mathbb{E}_\theta\left[\theta - \theta^*_t | \theta^*_t \leq \theta < \theta^*_{t+1}\right]\bar{R}_t$, the foregone consumer surplus

[8] When $\bar{R}_{t+1} = \bar{R}_t$, rent change on the balanced growth path is zero, as is total shelter inflation. Non-zero trend rent growth introduces the additional term $\mathbb{E}_\theta\left[\theta \geq \theta^*_{t+1}\right]\left(\bar{R}_{t+1} - \bar{R}_t\right)$ coming from the change in non-pecuniary utility for owners. This term arises because trend growth implies rents grow faster than the rest of the economy (the numeraire) and a balanced growth path requires non-pecuniary utility from owning to be a fixed proportion of trend rent and hence a growing share of the total economy.

[9] Of course, in general equilibrium a change in the user cost could affect rents (Gete and Reher, 2018; Abramson, De Llanos and Han, 2025). Our simple supply side rules out this general equilibrium channel and takes the path of rents as exogenous in order to focus on the welfare implications of a divergence between the user cost and rents highlighted by Figure 1. If rents did change, it would simply add a term $R_{t+1} - R_t$ to the right side of the equation in part (iii) of Lemma 2.

as agents who previously owned now rent. The latter term is second order. The reason is that this frictionless model features a strong form of selection, wherein the agents induced to change tenure have θ close to θ_t^*. This logic echoes the standard result that substitution across products has a second-order effect on the price index (Deaton and Muellbauer, 1980).

Having demonstrated why fixed-utility shelter inflation may depart from the growth of owner-equivalent rent, we now turn to measurement of θ.

3 Price Index

Conventional price indexes arise from the problem of a static expenditure function as in Section 2. The analog in a dynamic setting is the change in the value function. However, this object is not directly observable, nor is it comparable to conventional price indexes, which measure the transfer required to hold period utility and not the present value of utility fixed when prices change.

This section has four objectives. First, we nest a dynamic tenure choice decision in a joint maximization problem with nondurable consumption in order to rigorously define consumption-equivalent non-pecuniary utility from owning. Since our focus remains on tenure choice and the welfare implications of changes in shelter costs, we make assumptions to keep the choice of nondurable consumption relatively simple and standard. Second, we characterize the change in welfare when shelter costs change in terms of the paths of nondurable consumption expenditure and tenure choice and the distribution of θ as measured in the previous section. Third, we introduce a method to convert the value function change into a per-period price index impulse response comparable to the impulse response of a static price index. The impulse response of the price path depends on the change in lifetime expenditure on shelter, the intertemporal marginal propensities to consume out of non-housing wealth, the change in non-pecuniary utility due to any change to the overall homeownership rate, and changes to the efficiency of allocation of homeownership across individuals with varying preference for owning. Fourth, we obtain the shelter price path as the sum of past impulse responses and, with consumption smoothing, shelter inflation as the annuitized value of the revision to lifetime shelter expenditure plus a non-pecuniary component. The next sections implement these formulas using a quantitative model calibrated to the survey evidence and other moments of the data.

3.1 Adding Dynamics and Nondurable Goods

We enrich our tenure choice framework to incorporate dynamics and nondurable goods. Dynamics arise because in reality home buyers obtain long-term fixed rate mortgages and renters and owners face moving costs including broker fees for new renters and real estate commissions for home sellers. Our quantitative model in Section 5 will include all of these elements, which we track by denoting s as the time since the last move. We also generalize to additional dimensions of heterogeneity such as the expected duration before moving and liquidity constraints, which we write compactly as a vector of types denoted Θ. We let a bold vector $\mathbf{y}_t = (y_{t-\infty}, \ldots, y_t)$ denote the realizations of a variable y through date t. As in Section 2, $\beta_{t,t+j}$ denotes the inverse of the gross real interest rate between dates t and $t+j$. Then given a sequence of shelter costs and mortgage market parameters $\mathbf{W}_t$ (e.g. $\mathbf{W}_t = \left[\mathbf{R}_t, \mathbf{P}_t^H, \mathbf{i}_t, \ell_t\right]$), an agent with tenure path $\mathcal{H}_t$ and duration s_t has net shelter outlays at date t of $X\left(\mathcal{H}_t, s_t; \mathbf{W}_t\right)$.[10]

We start by setting up a general consumption-saving problem and subsequently make assumptions that simplify the consumption-saving component, allowing us to focus on shelter welfare. Agents consume a composite non-durable good C with price normalized to one in all periods and have non-housing wealth (including discounted future income) A.[11] Period utility over the non-durable good is $u(C_t)$. Non-pecuniary utility from homeownership in utils is $v(\tilde{\theta})$ with $v'(.) > 0$; we will shortly derive consumption-equivalent utility from homeownership as used elsewhere in the paper. Agents discount future utility using the subjective discount factor $\tilde{\beta}_{t,t+j}$. The date t maximization problem for an agent of type Θ_t with assets A_t and previous tenure $\mathcal{H}_{t-1}$ of duration

[10] For example, X_t equals the mortgage payment $d_{t|t-s}$ for an owner who obtained a mortgage s periods ago, $o(1-\ell_t)\, P_t^H + d_{t|t}$ for someone who transitions from renting to owning, or $M_{t|t-s} - (1-\psi_{1-})\, P_t^H + (1+\psi_{0+})\, R_t$ for someone who transitions from owning to renting with remaining mortgage balance $M_{t|t-s}$, real estate commission ψ_{1-}, and broker fee ψ_{0+}.

[11] Setting the price of the non-durable good to one is without loss of generality until we place restrictions on the sequence of real interest rates $\beta_{t,t+j}$.

s_{t-1} is:

$$\tilde{V}_t\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) \equiv \tilde{V}\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right)$$
$$= \max_{\{C_{t+j}, \mathcal{H}_{t+j}, s_{t+j}\}_{j=0}^{\infty}} \mathbb{E}_t\left[\sum_{j=0}^{\infty} \tilde{\beta}_{t,t+j}\left(u\left(C_{t+j}\right) + \mathcal{H}_{t+j} v\left(\tilde{\theta}_{t+j}\right)\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right] \tag{11}$$

$$\text{s.t. } A_t = \mathbb{E}_t\left[\sum_{j=0}^{\infty} \beta_{t,t+j}\left(C_{t+j} + X\left(\mathcal{H}_{t+j}, s_{t+j}; \mathbf{W}_{t+j}\right)\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right]. \tag{12}$$

The expectation operator incorporates uncertainty over both the agent's future idiosyncratic type Θ and expectations of future aggregate prices W_{t+j}.[12]

To clearly separate the contribution of shelter to welfare from the more general consumption-savings problem, we rule out precautionary saving due to uncertainty over future shelter costs. Appendix C presents the more general case with uncertainty and incomplete markets, which we refer to as we obtain results below. Thus, assume that agents can diversify idiosyncratic shelter risk from their type changing and that they behave as if they have perfect foresight over aggregate prices (which we continue to denote using the expectations operator).[13] With abuse of notation, let $\{C_{t+j}, \mathcal{H}_{t+j}, s_{t+j}\}_{j=0}^{\infty}$ now denote the sequences of optimal choices satisfying equations (12) and (B.2). Using the budget constraint in (12), we can then write the value function as the sum of a non-durable consumption term that depends only on wealth net of expected shelter expenditure, and a housing utility term:

$$\tilde{V}_t\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) = \tilde{V}_t^C\left(A_t - V_t^X\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)\right) + \tilde{V}_t^{\theta}\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right), \tag{13}$$

[12] The maximization problem contains an additional constraint that the sequences of $\mathcal{H}$ and s obey the law of motion that s increments when an agent does not move and resets to 0 when she does. Furthermore, our model in Section 5 contains idiosyncratic shocks that nudge an agent to move and liquidity constraints that prevent an agent from buying, in which case the expectation operator also incorporates uncertainty over these future forcing variables. We also require trend rent growth μ small enough that the right hand side of equation (12) is finite.

[13] That is, under perfect foresight $\mathbb{E}_t\left[C_{t+j} | \Theta, \mathcal{H}, s; \mathbf{W}_t\right]$ denotes deterministic consumption at date $t+j$ given current state variables and the future path of W.

where:

$$\tilde{V}_t^C\left(A_t - V_t^X\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)\right) \equiv \mathbb{E}_t\left[\sum_{j=0}^{\infty} \tilde{\beta}_{t,t+j} u\left(C_{t+j}\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right], \tag{14}$$

$$V_t^X\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) \equiv \mathbb{E}_t\left[\sum_{j=0}^{\infty} \beta_{t,t+j} X\left(\mathcal{H}_{t+j}, s_{t+j}; \mathbf{W}_{t+j}\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right], \tag{15}$$

$$\tilde{V}_t^\theta\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) \equiv \mathbb{E}_t\left[\sum_{j=0}^{\infty} \tilde{\beta}_{t,t+j} \mathcal{H}_{t+j} v\left(\tilde{\theta}_{t+j}\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right]. \tag{16}$$

Thus, $\tilde{V}_t^C(.)$ denotes the present value of utility from non-durable consumption, $V_t^X(.)$ denotes the present value of non-durable consumption expenditure, and $\tilde{V}_t^\theta(.)$ denotes the present value of non-pecuniary utility from shelter.

3.2 Changes in Welfare

Suppose at date t there is an unexpected change to the house price, mortgage rate, rent, or down payment requirement denoted by dW_t, with persistence encoded in the expectation operator.[14] Define $dY_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) = Y_t\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) - \mathbb{E}_{t-1}\left[Y_t\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)\right] = Y\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t + d\mathbf{W}\right) - Y\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right)$ as the (possibly discrete) change in any object Y due to unexpected price changes at date t, where the dependence on A_t is suppressed. We assume the marginal utility of a dollar $\partial \tilde{V}_t^C\left(A_t - V_t^X\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)\right) / \partial A_t$ remains fixed in the neighborhood of shelter cost changes that we consider.[15] Then applying the d operator to equations (13) and (14) and dividing through by $\partial \tilde{V}_t^C(.) / \partial A_t$, we arrive at the welfare change in potentially measurable consumption-equivalent terms:

Proposition 3 *The welfare change in consumption-equivalent units is:*

$$dV_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) = -dV_t^X\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) + dV_t^\theta\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right), \tag{17}$$

[14] Changes to the interest path $\beta_{t,t+j}$ require additional care. One can decompose the total welfare change from a change in interest rates into (i) the change in welfare from interest rates changing holding fixed allocations and other prices (e.g. house prices) and (ii) the change resulting from allocations and other prices endogenously changing. If $\beta_{t,t+j}$ changes, we include the welfare change from part (ii) only. While this split is not uncontroversial (Reis, 2005), it conforms to all modern price indexes and also simplifies some of the exposition. In addition, at the cost of additional notation, the results that follow also apply to anticipated future changes. Besides notational convenience, our focus on changes to current prices also conforms more closely to existing price index practice.

[15] In the case of infinitesimal perturbations dW_t, this assumption holds automatically if $V_t^X(.)$ and $\tilde{V}_t^\theta$ are differentiable. Continuity of the space of types θ or, as in our implementation in Section 5, discrete θ and pecuniary i.i.d. shocks that augment $X(\mathcal{H}_{t+j}, s_{t+j}; \mathbf{W}_t)$ guarantee differentiability. For non-infinitesimal perturbations, this assumption introduces an approximation, again for the purpose of focusing on shelter alone rather than the full consumption-saving problem.

where $dV_t(.) = d\tilde{V}_t(.)/\left(\partial \tilde{V}_t^C(.)/\partial A_t\right)$ *and* $dV_t^\theta(.) = d\tilde{V}_t^\theta(.)/\left(\partial \tilde{V}_t^C(.)/\partial A_t\right)$. *Furthermore, the contribution of consumption-equivalent utility from owning can be written:*

$$dV_t^\theta\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) = \sum_{j=0}^{\infty} d\mathbb{E}_t \left[\beta_{t,t+j} \mathcal{H}_{t+j} \left(\frac{v\left(\tilde{\theta}_{t+j}\right)}{u'\left(C_{t+j}\right)}\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right]. \tag{18}$$

Equation (17) shows the total change in money-metric welfare consists of two components. The first component, $-dV_t^X\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)$, is the change in the present value of shelter outlays. This component closely resembles the main result in Fagereng et al. (2024). The second component, $dV_t^\theta\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)$, is the change in the consumption-equivalent non-pecuniary utility from owning. The second part of Proposition 3 uses the consumption Euler equation and envelope condition to unpack the utility component into the discounted sum of changes to the non-pecuniary utility from homeownership, expressed in consumption-equivalent terms by dividing by the marginal utility of nondurable consumption.

3.3 Consumption-Equivalent Utility

The term $v\left(\tilde{\theta}_{t+j}\right)/u'\left(C_{t+j}\right)$ in equation (18) maps naturally into the willingness-to-pay to own elicited in our survey. To make this connection explicit, we make functional form and parameter restrictions consistent with a balanced growth path. Let $u(C) = \log(C)$ and $\tilde{\beta}_{t,t+1}/\beta_{t,t+1} = 1 + \mu$ so that consumption grows at the same rate as trend real rent, $C_{t+1}/C_t = \bar{R}_{t+1}/\bar{R}_t = 1 + \mu$ for all types. Let $b\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right) \equiv C\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right)/\bar{R}$ denote the ratio of nondurable consumption to trend rent. Then consumption-equivalent utility from owning takes the form:

$$v\left(\tilde{\theta}\right)/u'\left(C_t\right) = v\left(\tilde{\theta}\right) b\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right) \bar{R}_t = \theta \bar{R}_t, \tag{19}$$

where $\theta \equiv v\left(\tilde{\theta}\right) b\left(A_t, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right)$ directly characterizes the non-pecuniary utility from owning.

Using equation (19), we could in principle use repeated surveys of willingness-to-pay together with the path of homeownership and shelter outlays to directly evaluate equations (17) and (18). In practice, we do this exercise in the context of a quantitative calibrated model in the next sections.

3.4 Price Index Impulse Response

Translating the change in the value function into contributions to a per-period price index requires distributing $dV_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)$ across periods. Many possible paths of offsetting transfers exist. Two natural paths to consider use the timing of the household's change in shelter outlays or the timing of the change in nondurable consumption expenditure. These paths have a close connection, since a household receiving transfers to offset shelter outlays period-by-period and facing unchanged interest rates would change its consumption plan to exactly offset the period-by-period change in nondurable consumption. This result holds even in more general consumption/savings settings than ours, because a sequence of transfers that restores the household's previous income will lead it to choose exactly the same nondurable consumption path as before the shelter cost change. We choose to directly assign transfers to when nondurable consumption would otherwise change, plus the per-period change to consumption-equivalent utility from homeownership changes. That way, the price index moves exactly when the agent's period utility would otherwise change, as in the static case. Effectively, we also force recipients to consume the transfers when they receive it.[16]

To characterize the impulse response of nondurable consumption expenditure, note that the intertemporal budget constraint (12) requires a change in the path of nondurable consumption expenditure equal in present value to $-dV_t^X\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)$. In particular:

$$\mathbb{E}_t\left[dC_{t+j} | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right] = -\underbrace{\left(\frac{d\mathbb{E}_t\left[C_{t+j} | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right]}{dA_t}\right)}_{\equiv m_j} dV_t^X\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right). \tag{20}$$

The term in parentheses is simply the horizon j intertemporal marginal propensity to consume out of non-housing wealth, labeled m_j. As in Auclert, Rognlie and Straub (2024), it depends on the details of the utility function over consumption and the interest rate available to the agent.[17] Impos-

[16] That is, even with consumption-smoothing preferences, the transfer will fluctuate over time due to the compensation for the non-pecuniary component of shelter utility. In the more general setting with uncertainty and incomplete markets presented in Appendix C, the timing of transfers matters to the consumption path beyond just their present value. In this case, we prefer to think of the transfers as dollar-equivalent utils that do not otherwise affect the consumption/saving problem.

[17] Technically, writing equation (20) with the intertemporal marginal propensity to consume requires a consumption welfare function that is homogeneous of degree one, such that consumption in each period scales with total wealth. In the more general problem with uncertainty and incomplete markets studied in Appendix C, we instead define the full matrix of IMPCs $\{m_{j,k}^{i,\ell}\}$ that relate consumption in state i at date $t+j$ to income or shelter cost changes in state ℓ at date $t+k$. The appearance of the marginal propensity to consume out of non-housing wealth

ing balanced growth path consumption growth of μ, $dC_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) = db_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)\bar{R}_t$ and $m_j = \left(1-\beta\left(1+\mu\right)\right)\left(1+\mu\right)^j$. We can now define the response of the price of shelter to changes to $\mathbf{W}_t$.

Proposition 4 *Let $dP_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right)$ denote the $t+j$ transfer equal to the utility change due to dW_t. Then:*

$$dP_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) = \overbrace{m_j dV_t^X\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)}^{\textit{Nondurable consumption change}} - \overbrace{d\mathbb{E}_t\left[\mathcal{H}_{t+j}\theta_{t+j}|\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right]\bar{R}_{t+j}}^{\textit{Housing utility change}}. \quad (21)$$

Let $G_t\left(\Theta, \mathcal{H}, s\right)$ denote the (endogenous) date t distribution of types and $\mathbb{E}_{\{\Theta,\mathcal{H},s\}}$ the cross-sectional average using the measure $G_t\left(\Theta, \mathcal{H}, s\right)$. The aggregate transfer required to keep consumption-equivalent utility fixed is:

$$dP_{t+j}\left(dW_t\right) = \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[m_j dV_t^X\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) - d\mathbb{E}_t\left[\mathcal{H}_{t+j}\theta_{t+j}|\mathcal{H}_{t-1}, s_{t-1}; \Theta\right]\bar{R}_{t+j}\right]. \quad (22)$$

The balanced growth path price is the income equivalent of flow shelter utility:

$$\bar{P}_t = \mathbb{E}_{\Theta,\mathcal{H},s}\left[\bar{X}\left(\mathcal{H}_t, s\right) - \mathcal{H}_t\theta\right]\bar{R}_t, \quad (23)$$

where $\bar{X}\left(\mathcal{H}_t, s\right)$ denotes detrended shelter expenditure on the balanced growth path. The date $t+j$ price level is $P_{t+j} = \bar{P}_{t+j} + dP_{t+j}$.

Equation (21) characterizes the transfer path for a single *ex ante* type. By construction, the present value of the path of transfers equals the change in the value function: $\sum_{j=0}^{\infty}\beta_{t,t+j}dP_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, d\right.$ $\left. = -dV_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)\right.$.

Equation (22) characterizes the aggregate transfer path. The first term contains the average change in expenditure on the nondurable good due to the shelter price change at date t. The second term contains the average change in consumption-equivalent utility. Equation (22) mirrors Proposition 2 but applies to price paths rather than the static change in the price.

The aggregate price consists of the balanced growth path price and the additional transfer. The balanced growth path price is the income equivalent of shelter utility. Shelter inflation on the

echoes Proposition 1 in Berger et al. (2017). Equation (20) differs in that it applies to the present value of shelter outlays rather than the house price and in a setting with non-convex moving costs.

balanced growth path is simply $1+\mu$. Equivalently, gross inflation between t and $t+j$ comprises the trend component $(1+\mu)^j$ and the deviation from trend $dP_{t+j}/\bar{P}_{t+j}$.

Further insight into the non-pecuniary utility term $\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[d\mathbb{E}_t\left[\mathcal{H}_{t+j}\theta_{t+j}|\mathcal{H}_{t-1},s_{t-1};\Theta_t\right]\right]$ comes from the following decomposition. Let $\theta_t^* = F_\theta^{-1}(1-h_t)$ denote the cutoff θ for owning that would obtain if there were no transaction costs or other sources of heterogeneity, as in Section 2. Then:

$$\begin{aligned}\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[\mathcal{H}_t\theta_t\right] &= h_t\mathbb{E}_\theta\left[\theta\right] + \mathrm{Cov}_{\{\Theta,\mathcal{H},s\}}\left(\mathcal{H}_t\theta_t\right) \\ &= h_t\mathbb{E}_\theta\left[\theta|\theta>\theta_t^*\right] + \left(\mathrm{Cov}_{\{\Theta,\mathcal{H},s\}}\left(\mathcal{H}_t\theta_t\right) - \mathrm{Cov}_\theta^*\left(\mathcal{H}_t\theta_t;h_t\right)\right), \end{aligned} \tag{24}$$

where $\mathrm{Cov}_\theta^*\left(\mathcal{H}_t\theta_t;h_t\right) \equiv h_t\left(\mathbb{E}_\theta\left[\theta|\theta>\theta_t^*\right] - \mathbb{E}_\theta\left[\theta\right]\right)$ denotes the covariance given a homeownership rate h_t and perfect sorting. According to equation (24), changes to the non-pecuniary component reflect two forces. The first force, corresponding to changes in the first term of equation (24), is the change in non-pecuniary utility that would obtain with perfect sorting, as in Section 2. The second force, corresponding to changes in the second term, reflects changes in allocative efficiency of homeownership due to additional sources of heterogeneity and long-term contracts. Such misallocation will arise in our application of rising mortgage interest rates, as "mortgage lock" induces some incumbent owners with rates below new contract rates to remain homeowners despite experiencing a decline in θ while renters experiencing an increase in θ do not buy because of the rise in rates.

We make three remarks. First, the formulation in equation (21) nests the case of an agent who owns their home and never expects to move. This agent has a change $dV_t\left(\mathcal{H}_{t-1},s_{t-1};\Theta_t\right) = dV_t^X\left(\mathcal{H}_{t-1},s_{t-1};\Theta_t\right) = 0$. Since this agent does not change her nondurable consumption expenditure, she experiences zero inflation despite the change in house prices, as in Sinai and Souleles (2005) and Fagereng et al. (2024).

Second, at the cost of complicating the characterization of a balanced growth path, the intertemporal marginal propensities to consume could differ across types due to incomplete insurance markets. In that case, the deviation in the path of certainty equivalent nondurable consumption expenditure provides the sufficient statistic for distributing the change in welfare across time (see Appendix C).

Third, the shelter price index in equation (22) differs from a static price index in that it can depend on expected future price changes. A renter expecting to purchase in the future and

therefore affected by future house prices or mortgage rates provides one example. Likewise, house price appreciation enters into equation (21), while the traditional CPI excludes asset price changes. Such intertemporal dependence is unavoidable in a dynamic setting with a durable good. Of course, if every sale by a household with a capital gain also involves a purchase by a household at a higher price, then price appreciation washes out in the aggregate index in equation (22) (as in Bajari, Benkard and Krainer, 2005). This condition will not hold exactly for consumer inflation along a transition path with changing homeownership, in which case one side of the transaction may be a "private equity" agent converting between owner-occupied housing and rental housing. Moreover, house price appreciation also matters because it necessitates a hgiher mortgage payment, which does not wash out across households.

3.5 Historical Price Index

The analysis so far considers news about house prices, rents, or mortgage costs that arrives at a single date. A historical cost-of-shelter index must account for news arriving at many dates. Let $P_{-1} = \bar{P}_{-1}$ denote an initial date at which the price equals the balanced growth path level and normalize $\bar{R}_{-1} = 1$. Using equation (22), define the date t price deviation due to news at date 0:

$$dP_{t|0} = \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[m_t dV_0^X\left(\mathcal{H}_{-1}, s_{-1}; \Theta_0\right) + \left(\mathbb{E}_0 - \mathbb{E}_{-1}\right)\left[\mathcal{H}_t\theta_t\right]\bar{R}_t\right].$$

If the realized and expected costs change again at date 1, the new sequence of expected required transfers from date 1 forward, relative to the balanced growth path, consists of the deviations expected at date 0 plus additional deviations due to the news:

$$dP_{t|1} = dP_{t|0} + \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[m_{t-1} dV_1^X\left(\mathcal{H}_0, s_0; \Theta_1\right) + \left(\mathbb{E}_1 - \mathbb{E}_0\right)\left[\mathcal{H}_t\theta_t\right]\bar{R}_t\right].$$

This "summing impulse response functions" avoids double or under-counting the effect of changes in shelter costs at date 1 forward that already affect the date 0 price level due to consumption smoothing. The process iterates forward, yielding the following proposition.

Proposition 5 *Suppose $P_{-1} = \bar{P}_{-1}$ and normalize $\bar{R}_{-1} = 1$. Given a sequence of news surprises between date 0 and date t, the realized transfer at date t required to keep consumption fixed is:*

$$dP_t \equiv dP_{t|t} = \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[\sum_{j=0}^{t} m_j dV_{t-j}^X\left(\mathcal{H}_{t-j-1}, s_{t-j-1}; \Theta_{t-j}\right) + \left(\mathbb{E}_t - \mathbb{E}_{-1}\right)\left[\mathcal{H}_t\theta_t\right]\bar{R}_t\right]. \tag{25}$$

With log utility over nondurable consumption and a constant interest rate $1/\beta - 1$*, the de-trended change in the transfer depends only on consumption news at date* t *and the change in the non-pecuniary term:*

$$\frac{P_t}{\bar{R}_t} - \frac{P_{t-1}}{\bar{R}_{t-1}} = \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[(1-\beta(1+\mu))\, dV_t^X\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) + \left(\mathcal{H}_t\theta_t - \mathcal{H}_{t-1}\theta_{t-1}\right)\right]. \tag{26}$$

Thus, with log utility and consumption smoothing, the date t (de-trended) change in the price index equals the annuity value of the change in net shelter outlays plus the change in the non-pecuniary term. In particular, news at date 0 causes a jump in the price index as required by the change in shelter costs and the change in utility coming from changes in the homeownership rate. Thereafter, consumption smoothing implies that shelter inflation contains only changes to the utility term, unless further unexpected shocks to shelter costs occur.

4 Survey Evidence on Preferences for Owning

This section presents our survey evidence on preferences for owning versus renting. We surveyed 1000 individuals in January 2025 using the online platform Prolific, selected to be nationally representative by age, gender, and race. To assess possible reporting error, we re-surveyed a subset of the original respondents five weeks later.[18]

4.1 Benchmarking

Tables C.1 to C.3 compare the demographics of our survey respondents to the general population of household heads and their partners in the Current Population Survey and Survey of Income and Program Participation. Our survey over-weights college-educated respondents, but otherwise contains reasonable balance over age, gender, marital status, and number of children. Crucially, our survey contains a representative share of owners and renters and homeownership by age profile. We re-weight the sample to exactly match the SIPP age distribution of household heads and spouses given our focus below on this dimension. We confirm that this reweighting does not affect our main results.

[18] We require participants to own their property or live in privately rented accommodation. We exclude three individuals who restarted the survey after being screened out on this question, leaving a maximum of 997 observations in the main survey. Pre-registrations of the main and follow-up surveys are available at https://aspredicted.org/jxpb-q9m9.pdf and https://aspredicted.org/5nzv-z2r2.pdf, respectively.

Table C.4 compares the rent and owner's equivalent rent reported in our survey to the values reported in the Consumer Expenditure Survey. The distribution of owner's equivalent rent is quite similar. Our survey contains a similar median but slightly less variance of rent than the CEX.

Figures C.1 to C.4 compare the reasons why people last moved reported in our survey to similar questions asked in the Survey of Income Program and Participation (SIPP), American Housing Survey (AHS), and Current Population Survey Annual Social and Economic Supplements (CPS-ASEC), respectively. Our survey, the SIPP, and the CPS-ASEC offered the response "Wanted to own home, not rent" and in all three surveys this response was selected more than other by current owners. Of course, wanting to own does not distinguish financial from preference reasons, a task we turn to next. We also find suggestive evidence of preferences related to family structure as most important for changes from owning to renting.

4.2 Willingness-to-Pay to Own

We solicit respondents' willingness-to-pay (WTP) by asking them what additional financial windfall from not owning and investing in the market they would be willing to forgo in order to own. Appendix D provides screenshots of the relevant part of the survey. For current owners, we frame this scenario as a comparison between buying and renting and total wealth 10 years later, holding other aspects of life the same. For current renters, we add to the comparison a hypothetical inheritance of $25,000 to ensure that a down payment constraint does not prevent them from choosing to own. We show both groups a side-by-side comparison of living situation (own and pay down mortgage or rent), initial investment (down payment or invest in diversified portfolio), and terminal wealth composition (proceeds from sale net of mortgage repayment plus any additional savings or investment portfolio plus any additional savings). We then instruct the respondent to imagine that total wealth in both the owning and renting scenarios is the same after ten years and ask whether they would have chosen to buy or rent or are indifferent between the two options. For those opting to buy, we ask for the maximum additional wealth in the rental scenario at which they would still choose to buy (and symmetrically if they opted to rent).[19]

Three additional design details merit mention. First, we ask the WTP question after a series of

[19]The framing in terms of wealth after ten years is intended to focus the choice on non-pecuniary components. For example, in a different part of the survey some owners report that they prefer to own to avoid the uncertainty of rent fluctuations. A comparison of *ex post* terminal wealth should not reflect such *ex ante* uncertainty.

questions about why the person last moved and why they currently own or rent. This sequencing may prime respondents to think about tenure choice. We think of such priming as an advantage in stimulating more accurate responses. Nonetheless, our main findings remain robust in the follow-up validation, which did not first ask questions about reasons for tenure choice. Second, we randomized two aspects of this procedure: (i) whether we specify that the respondent would buy or rent exactly the same property or not, (ii) whether the respondent enters the maximum WTP using a slider or via a repeated incrementing loop. We control below for these features. Respondents told they would own or rent the identical house have slightly lower WTP; using a slider or ascending price list has no discernible impact. Third, about 18% of respondents chose the maximum possible WTP on the slider or loop; for these respondents we implemented a short (2 minute) follow-up survey about one week later to solicit a numeric value. We obtained a response rate of 94% in this follow-up survey and use the reported values for these respondents. We winsorize the WTP distribution in our preferred specification to mitigate the influence of extreme responses.

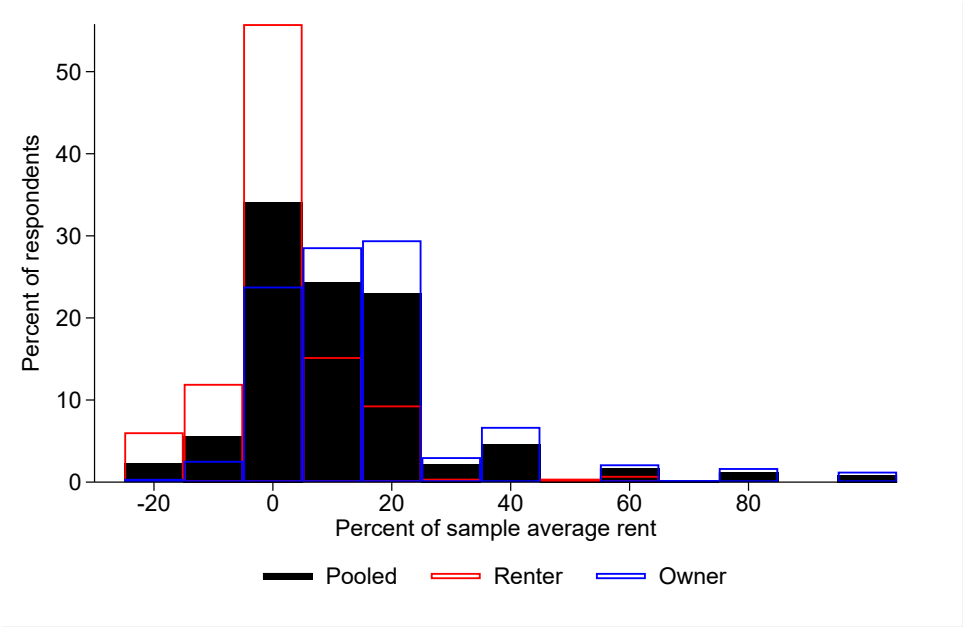
Figure 3 reports the distribution of annualized WTP in our baseline sample as a fraction of the sample average of rent or equivalent rent of \$2000 per month.[20] Overall, WTP is right-skewed, with a modal value near zero but a long right tail. Strikingly, current renters are much more likely to have negative or zero WTP while current owners account for most of the positive mass.

Table 1 reports regressions of WTP as a function of tenure, for various samples and weighting schemes. Column (1) includes all respondents with annualized WTP$\leq$ \$25k.[21] Owners exhibit a 13.4p.p. higher WTP/rent than renters and this difference is highly statistically significant. Columns (2)-(7) instead winsorize WTP/rent at the 2.5% and 97.5% level. Column (3) excludes respondents who fail the first attention check ("Type Attention is Key" into a text box), those who report in a follow-up screen that their selected WTP does not represent their true valuation (because either they clicked the wrong answer or were confused by the question), and those reporting own rent or equivalent rent less than \$500 or greater than \$15,000. This is our preferred

[20] For readability, the figure excludes twelve individuals with annualized WTP above \$25,000. The mean WTP/rent among these individuals is 1062%. Ten of the twelve excluded individuals are owners.

[21] Our full sample includes 15 individuals with WTP$>$ \$25k, of whom twelve own and three rent. Thus, including these individuals only increases the coefficient multiplying Owner, but also substantially increases the standard errors. Table C.5 repeats Table 1 when scaling WTP by the respondent's own rent or equivalent rent and finds similar results.

Figure 3: WTP Distribution



Notes: The figure reports the histogram of willingness-to-pay in our baseline sample as a share of the sample average of rent or equivalent rent. For readability the figure excludes twelve individuals with values of 125 or above.

sample. Column (4) additionally excludes 18-24 year-olds, as our life cycle calibration in Section 6 will begin at age 25. There are relatively few 18-24 year-olds in our sample, as most individuals in this group are not household heads, so the result changes little. Column (5) does not filter respondents by our baseline criteria but instead weights by respondents' self-reported confidence in their response (the observation difference from column (2) reflects respondents who did not answer this question). Column (6) does not re-weight by age. Column (7) also excludes respondents who failed a second attention check during the selection of their main reason for owning or renting. Finally, column (8) winsorizes more aggressively at the 10% and 90% level. Reassuringly, the owner WTP premium remains of similar magnitude and highly statistically significant across all of these sample restrictions.

Figure 4 unpacks some of the heterogeneity in WTP by reporting values by age range. WTP increases in age up to the 45-54 year-old bin, falls slightly among 55-64 year-olds, and falls further among those 65+. The differences are economically meaningful; for example, the average 45-54 year-old has a WTP 7p.p. higher than the average 25-34 year-old. Factors such as family size and neighborhood preference may plausibly explain the rising desire to own in the first part of the life cycle. Conversely, the decline among older individuals coincides with some households choosing to

Table 1: Willingness-to-pay to Own and Homeownership

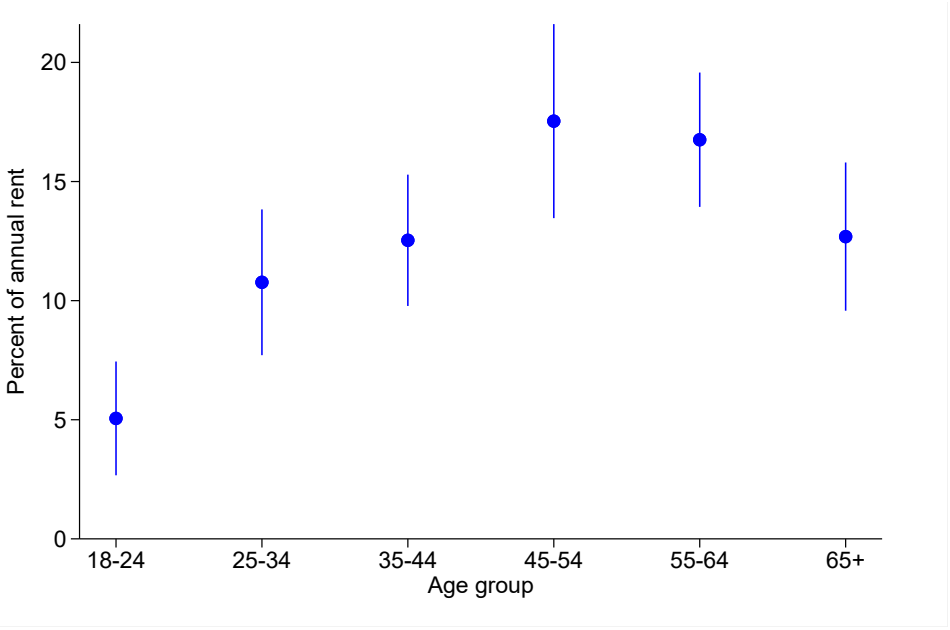
Dep. var.:	WTP to own/Sample average rent (%)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Owner	13.4**	13.4**	15.8**	16.0**	15.7**	15.2**	16.9**	12.3**
	(1.0)	(1.1)	(1.5)	(1.5)	(1.7)	(1.4)	(1.7)	(0.9)
Identical house	-1.7	-1.6	-2.9+	-2.9+	-1.9	-3.4*	-2.2	-1.6
	(1.2)	(1.4)	(1.6)	(1.7)	(2.1)	(1.6)	(1.9)	(1.1)
Loop	1.1	2.5	2.6	2.7	2.6	1.4	2.3	1.7
	(1.4)	(1.6)	(2.0)	(2.0)	(2.2)	(1.9)	(2.1)	(1.2)
Constant	2.0*	2.7**	2.9*	2.8*	4.3**	4.1**	2.8*	3.3**
	(0.8)	(0.9)	(1.2)	(1.2)	(1.3)	(1.1)	(1.3)	(0.8)
WTP$<100k$	✓							
Winsorized 2.5/97.5		✓	✓	✓	✓	✓	✓	
Winsorized 10/90								✓
Baseline sample			✓	✓		✓	✓	✓
No 18-24 year-olds				✓				
Confidence weighted					✓			
No age reweight						✓		
Addl. attention check							✓	
Observations	982	997	699	655	959	699	548	699

Notes: The dependent variable is the willingness-to-pay (WTP) to own scaled by the same average of rent. Column (1) excludes respondents who reported a WTP greater than $25,000 per year. Columns (2)-(7) winsorize the dependent variable at the 2.5 and 97.5 quantiles. Column (8) winsorizes the dependent variable at the 10 and 90 percentiles. Baseline sample excludes respondents who reported No (confused) or No (misclicked) to the question on valuation accuracy. Confidence weighted weights by self-reported confidence the answer. No age reweight does not reweight the sample to match the SIPP age distribution. The additional attention check excludes respondents who failed the first attention check. The variable Identical house is an indicator for the hypothetical specifying an identical property in terms of location, size, quality, and features. Loop is an indicator for answering the WTP question using a loop instead of a slider. Heteroskedastic-robust standard errors in parentheses.

downsize as their children become adults. We use both the overall ownership premium documented in Table 1, and the life-cycle pattern documented in Figure 4, to discipline our quantitative model in Section 6.

Appendix D.5 describes the follow-up survey. In brief, about 5 weeks after the main survey we made a new survey available to a randomly-selected 300 respondents from the main survey and received 230 responses, for a response rate of 77%. We did not inform respondents the surveys were linked and masked the connection by asking a series of questions about different trade-offs around living arrangements, such as the WTP for greater outdoor space or a shorter commute. We also include a simpler version of the WTP to own question. The correlation coefficient between the WTP to own in the original and follow-up surveys was 0.50. Our calibration will treat the

Figure 4: Mean WTP By Age Group



Notes: The figure reports the mean and 90% confidence interval of WTP by age in the baseline sample corresponding to column (4) of Table 1.

imperfect correlation as reflecting response error and adjust the survey moments accordingly, as described in Appendix D.5.

5 Quantitative Model

While the results in the previous section in principle allow for measuring welfare changes directly in the data, the associated expenditure and tenure changes and covariances with utility from owning involve extremely high information requirements. In this section, we develop a quantitative life-cycle model to generate these patterns. Section 6 calibrates the model using the survey evidence from Section 4 and other moments of the data.

5.1 Additional Elements

We extend the model in Section 2 to incorporate long-term rental and mortgage contracts, moving costs, and additional sources of heterogeneity. The supply side remains the same as in Section 2, with exogenous rents, the capitalization of rentals giving $P_t^R = c_t R_t$, and a conversion cost $g(h)$.[22]

[22]Given data on homeownership, house prices, and rents, implementing the price index (22) requires specifying a supply side only to determine expectations of future house prices and rents. Thus, survey data on household expectations of these variables would allow computation of welfare in our model in a partial equilibrium setting that

Long-term contracts and moving costs. Home buyers obtain fixed payment amortizing 30-year mortgages with loan-to-value at origination of ℓ_t. The fixed payment for a homeowner who bought at date $t-s$ with mortgage interest rate i_{t-s} is $d_{t|t-s}$, with original mortgage balance $M_{t|t} = \ell_t P_t^H$. The mortgage balance evolves recursively until payoff:

$$M_{t+1|t-s} = M_{t|t-s} - (d_{t|t-s} - i_{t-s} M_{t|t-s}) = (1 + i_{t-s}) M_{t|t-s} - d_{t|t-s}, \tag{27}$$

with $M_{t|t-s} = d_{t|t-s} = 0$ for $s \geq 30$ years.[23] A fraction ξ of owners receive the option to refinance each period, which if exercised resets the interest rate and loan-to-value, with the agent paying in or cashing out the difference from their current mortgage. Owning also involves a flow cost f_t to cover maintenance, depreciation, taxes, and insurance. Agents incur fixed costs when moving: moving into a new rental requires a "broker fee" of $\psi_{0+} R_t$ and selling a home involves a "real estate commission" of $\psi_{1-} P_t^H$.

Additional heterogeneity. We introduce three additional dimensions of heterogeneity in addition to the preference for owning θ. First, while all agents have the option to move each period, some agents receive an additional "nudge". These nudges take the form of a one-time payment ψ_λ to remain in the same house and reflect job opportunities or other life events that favor relocation independently of the preference for owning or renting. The probability of receiving a nudge differs across agents, with an agent of type λ having probability λ. Fixing θ, higher λ pushes agents toward renting, since in our calibration moving costs are higher for owners than for renters, $\psi_{1-} P_t^H > \psi_{0+} R_t$.

Second, agents differ in their ability to buy. An agent with $\zeta = 1$ cannot make a down payment or qualify for a mortgage and hence cannot buy, while unconstrained agents have $\zeta = 0$.

Third, we add a life-cycle dimension, indexed by age a. An agent's age affects her transition probabilities to obtain a new θ, λ, or ζ.

exactly matches the survey expectations. This step could appeal to statistical agencies charged with measuring shelter costs. For the same reason, we view the simple supply side as a device to illustrate the model's quantitative implications.

[23] Iterating : $M_{t|t-s} = (1+i_{t-s})^s M_{t|t-s} - \sum_{j=0}^{s-1} (1+i_{t-s})^j d_{t|t-s} = (1+i_{t-s})^s M_{t|t-s} - \frac{d_{t|t-s}((1+i_{t-s})^s - 1)}{i_{t-s}}$. Using the boundary condition $M_{t|t-30} = 0$, $d_{t|t-s} = \frac{i_t (1+i_{t-s})^{30} M_{t,t-s}}{(1+i_{t-s})^{30} - 1}$.

Timing. Refinances and moves occur at the beginning of the period. Renters then pay rental costs and owners pay their mortgage and realize utility. Finally, agents age and draw new values of θ, λ, ζ according to the age-specific transition probabilities.

5.2 Value Functions

Let $\Theta = \{\theta, \lambda, \zeta, a\}$ denote the vector of types and $\mathbf{W}_t$ continue to denote the path of aggregate prices and mortgage market parameters. We work directly with value functions in dollars and non-pecuniary utility $\theta \bar{R}_t$. This choice fully separates the housing tenure decision from the consumption-savings problem and avoids the complication of calibrating and jointly solving the consumption-saving process. We denote by $V_t^{\mathcal{H}}(\Theta, s) = V(\Theta, \mathcal{H}, s; \mathbf{W}_t)$ the value function (in dollars and evaluated at the time of rent/mortgage payments) for an agent of type Θ with tenure $\mathcal{H}$ who last moved s periods ago, where $V(\Theta, \mathcal{H}, s; \mathbf{W}_t)$ continues to satisfy equation (17).

We start by defining the value when acquiring a new residence. Let $V_t^{0+}(\Theta)$ and $V_t^{1+}(\Theta)$ denote the values when moving to a rental or owned home, respectively:

$$\overbrace{V_t^{0+}(\Theta)}^{\text{Move to rent}} = \overbrace{-\psi_{0+} R_t}^{\text{Broker fee}} + \overbrace{V_t^{0}(\Theta, 0)}^{\text{New rental value}}, \tag{28}$$

$$\underbrace{V_t^{1+}(\Theta)}_{\text{Move to own}} = \underbrace{-(1-\ell_t) P_t^H}_{\text{Down payment}} - \underbrace{\infty \times \zeta}_{\text{Liquidity restriction}} + \underbrace{V_t^{1}(\Theta, 0)}_{\text{New owner value}}. \tag{29}$$

The element $\infty \times \zeta$ encodes the liquidity constraint as an infinite shadow cost of making a down payment. The value of moving, $V_t^{+}(\Theta)$, is the maximum over renting and buying:

$$V_t^{+}(\Theta) = \max\left\{V_t^{0+}(\Theta), V_t^{1+}(\Theta)\right\}. \tag{30}$$

We next define the value of a refinance option as the maximum over refinancing and declining the refinancing option, where refinancing pays out (or in) the change in the mortgage balance net of the refinancing fee and resets the effective tenure in the house s to 0:

$$V_t^{\text{refi}}(\Theta, s) = \max\left\{(1-\psi_r)\,\ell_t P_t^H - M_{t|t-s} + V_t^{1}(\Theta, 0), V_t^{1}(\Theta, s)\right\}. \tag{31}$$

The value functions for renting and owning encompass utility net of costs at date t plus the

expected discounted continuation value, where y' denotes next period's value of $y \in \{\lambda, \Theta\}$:

$$\begin{aligned}
\text{Rent:} \quad V_t^0(\Theta, s) &= -R_t + \beta_t \mathbb{E}_{\Theta'|\Theta}\big[\lambda' \max\left\{V_{t+1}^+(\Theta'), V_{t+1}^0(\Theta', s+1) - \psi_\lambda\right\} \\
&\quad + (1-\lambda') \max\left\{V_{t+1}^+(\Theta'), V_{t+1}^0(\Theta', s+1)\right\}\big], \qquad (32) \\
\text{Own:} \quad V_t^1(\Theta, s) &= \theta \bar{R}_t - d_{t|t-s} - f_t \\
&\quad + \beta_t \mathbb{E}_{\Theta'|\Theta}\big[\lambda' \left(\max\left\{(1-\psi_{1-}) P_{t+1}^H - M_{t+1|t-s} + V_{t+1}^+(\Theta'), V_{t+1}^1(\Theta', s+1) - \psi_\lambda\right\}\right) \\
&\quad + (1-\lambda')\, \xi \max\left\{(1-\psi_{1-}) P_{t+1}^H - M_{t+1|t-s} + V_{t+1}^+(\Theta'), V_{t+1}^{\text{refi}}(\Theta', s+1)\right\} \\
&\quad + (1-\lambda') \max\left\{(1-\psi_{1-}) P_{t+1}^H - M_{t+1|t-s} + V_{t+1}^+(\Theta'), V_{t+1}^1(\Theta', s+1)\right\}\big]. \qquad (33)
\end{aligned}$$

For renters, flow utility is the cost of rent and the continuation value is the maximum over the moving value and remaining in the same unit for an additional period otherwise, possibly paying the additional cost to stay. For owners, flow utility is the non-pecuniary component less the mortgage payment and flow cost of owning. Their continuation value if selling combines net sale proceeds $(1-\psi_{1-}) P_{t+1}^H - M_{t+1|t-s}$ and the moving value $V_{t+1}^+(\Theta')$, which they compare to $V_{t+1}^{\text{refi}}(\Theta', s+1)$ if given the option to refinance and to the value $V_{t+1}^1(\Theta', s+1)$ of remaining in the same unit for an additional period otherwise, again possibly paying the additional cost to stay.

Finally, we augment each discrete choice in a max operator in equations (30) to (33) with i.i.d. Type 1 EV(σ_ε) idiosyncratic shocks received each period. These shocks reflect transitory, idiosyncratic forces such as the inherent randomness of housing search in the case of equation (30) (e.g. negotiating a slightly higher or lower transaction price). They also add computational tractability by making the value functions differentiable even when θ takes discretized values. For example, in the case of moving, they imply a fraction $\exp\left(V_t^{1+}(\Theta)/\bar{R}_t\sigma\right) / \left(\exp\left(V_t^{0+}(\Theta)/\bar{R}_t\sigma\right) + \exp\left(V_t^{1+}(\Theta)/\bar{R}_t\sigma\right)\right)$ of movers of type Θ choose to buy if $\zeta = 0$.

6 Calibration

This secion describes our calibration. We treat 2019 as the model steady state and a period lasts one year. Section 6.1 explains the life-cycle component. Section 6.2 uses the survey evidence from Section 4 to parameterize the age-specific θ transition process. Section 6.3 uses moments from the Survey of Consumer Finances (SCF) to parameterize the life-cycle process for the liquidity constraint ζ. Section 6.4 sets several parameters using other external evidence. Section 6.5 sets

the remaining parameters to match moments calculated from the model's steady state.

Tables 2 and 3 list the full set of parameters and moments.

6.1 Life Cycle Process

All individuals belong to one of five age bins: 25-34, 35-44, 45-54, 55-64, or 65+. These bins match the age information contained in our survey.[24] Individuals born at age 25 draw from initial θ, ζ, and λ distributions, as described below, and make a tenure choice. Since we have an annual calibration, each period an individual ages up to the next group with probability 1/10 for ages below 65+. Individuals 65 and over die with probability 0.065, which gives a 65+ population share of 27% as in the SIPP. At death, an owner sells her home and is replaced by a "child" aged 25. Value functions incorporate the utility of offspring, such that the infinite horizon maximization problem at the start of Section 3 and the value functions (32) and (33) continue to hold inclusive of transitions from age 65 to age 25. However, because newborns make a fresh tenure choice, the decisions of the old do not affect the utility of their offspring.

6.2 Life Cycle θ Process Using Survey

Newly-born individuals draw θ from a normal distribution $N(m_\theta, \sigma_\theta)$. An agent of age a either has her θ grow by Δ_θ or "crash" with age-specific probability $\delta_\theta(a) = \delta_{\theta,0}a^2$, for $a \in \{1,2,3,4,5\}$, in which case she draws a new θ from $N(m_\theta, \sigma_\theta)$. Thus, $\mathbb{E}[\theta'|\theta, a] = (1-\delta_\theta(a))(\theta + \Delta_\theta) + \delta_\theta(a)N(m_\theta, \sigma_\theta)$. The growth component Δ_θ captures life-cycle changes such as family size or neighborhood preference, while the crash component $\delta(a)$ captures down-sizing motives later in life as well as other idiosyncratic changes. Absent the age dimension, when $\Delta_\theta = 0$ this process nests the i.i.d. redraw process in Section 2. When $\sigma_\theta = 0$, it generates an (approximately) exponential distribution with minimum value m_θ and rate parameter $\Delta_\theta/\delta_\theta$.[25]

We choose the parameters $\Delta_\theta, \delta_\theta, \mu_\theta, \sigma_\theta$ to match the five age-specific means of θ shown in

[24] Our survey contains a sixth age bin, 18-24. However, only 6.3% of our baseline sample and 2.8% of household heads in the SIPP belong to this age group (Table C.2). Since we do not model an endogenous rate of household formation, we choose to start individuals at age 25.

[25] To see this fact, let θ_0 denote an initial draw. For $x > \theta_0$, it takes in expectation $(x-\theta_0)/\Delta_\theta$ periods to reach $\theta = x$. Thus: $\mathbb{P}(\theta > x|\theta_0 \leq x) = (1-\delta_\theta)^{\frac{x-\theta_0}{\Delta_\theta}} \approx \exp(-(\delta_\theta/\Delta_\theta)(x-\theta_0))$. Then for any re-draw distribution $G(\theta_0)$, $\mathbb{P}(\theta > x) = G_\theta(x)\int(1-\delta_\theta)^{\frac{x-\theta_0}{\Delta_\theta}} dG_\theta(\theta_0) + (1-G_\theta(x)) \approx G_\theta(x)\int \exp(-(\delta_\theta/\Delta_\theta)(x-\theta_0))\, dG_\theta(\theta_0) + (1-G_\theta(x))$.

Table 2: Parameters

Name	Description	Value	Source
Panel (a): θ process $\mathbb{E}[\theta'\|\theta,a] = (1-\delta_\theta(a))(\theta+\Delta_\theta) + \delta_\theta(a)N(m_\theta,\sigma_\theta)$			
Δ_θ	Growth if no re-draw	0.006	Table 3 Panel (a)
$\delta_\theta(a)$	Re-draw probability	$0.003 \times a^2$	Table 3 Panel (a)
m_θ	Mean of starter distribution	0.050	Table 3 Panel (a)
σ_θ	S.d. of starter distribution	0.126	Table 3 Panel (a)
Panel (b): ζ process $\mathbb{P}[\zeta'=0\|\zeta=1,a] = \Phi(z_0 + z_1 \times (a))$			
ζ_0	Constrained at birth	0.631	Table 3 Panel (b)
z_0	Probit intercept	-1.684	Table 3 Panel (b)
z_1	Probit slope	-0.122	Table 3 Panel (b)
Panel (c): Externally calibrated			
μ	Growth rate of rents	0.01	2000- 2019 real rent growth
ψ_{0+}	Fee for new rental	$R/12$	1 month rent
ψ_{1-}	Fee for selling home	$0.05P^H$	Broker fee
ℓ	Loan-to-value at origination	0.87	Adelino, Schoar and Severino (2018)
τP^H	Taxes and insurance	$0.023P^H$	CEX
$1/\beta - 1$	Discount rate	0.02	Steady state interest rate
i	Mortgage rate	0.025	Mortgage spread
ξ	Refinance opportunity	$1-(1-.166)$	Berger et al. (2021)
o^R	Rental operating cost	0.242	BEA I-O Use
c	Rental inverse cap. rate	15.16	Net cap. rate 0.05
γ_1	Slope of conversion supply curve	1.79	Greenwald and Guren (forthcoming) + c
γ_0	Intercept of conversion cost	$P^H/P^R - \gamma_1 h$	$P^H/R = 14.6$ (CEX)
Panel (d): Internally estimated with full model steady state			
$[\lambda_{25-34}, \lambda_{35-44}, \lambda_{45-54}, \lambda_{55-64}, \lambda_{65+}]$	Forced moving hazard by age	[0.333,0.238, 0.190,0.155,0.106]	Table 3 Panel (c)
$p_{\lambda+}$	No forced mobility to forced mobility transition probability	0.0012	Table 3 Panel (c)
$p_{\lambda-}$	Forced mobility to no forced mobility transition probability	0.0009	Table 3 Panel (c)
σ_ε	Idiosyncratic cost shock	0.082	Table 3 Panel (c)
$f - \tau P^H$	Residual carrying cost	$0.353R$	Table 3 Panel (c)

Table 3: Targeted Moments

Moment	Description	Source	Data	Model
	Panel (a): θ process moments			
$\mathbb{E}_\theta[\theta \vert a \subseteq (25,34]]$	Age 25-34 mean θ	Survey	10.8	9.9
$\mathbb{E}_\theta[\theta \vert a \subseteq (35,44]]$	Age 35-44 mean θ	Survey	12.5	14.3
$\mathbb{E}_\theta[\theta \vert a \subseteq (45,54]]$	Age 45-54 mean θ	Survey	17.5	16.5
$\mathbb{E}_\theta[\theta \vert a \subseteq (55,64]]$	Age 55-64 mean θ	Survey	16.8	16.1
$\mathbb{E}_\theta[\theta \vert a \geq 65]$	Age 65+ mean θ	Survey	12.7	13.4
$SD[\theta \vert a \subseteq (25,34]]$	Age 25-34 St. dev. θ	Survey	13.9	13.9
	Panel (b): ζ process moments			
$\mathbb{P}_\Theta[\zeta = 1 \vert a \subseteq (25,34]]$	Age 25-34 constrained share	SCF, Zillow	27.7	28.0
$\mathbb{P}_\Theta[\zeta = 1 \vert a \subseteq (35,44]]$	Age 35-44 constrained share	SCF, Zillow	23.1	21.9
$\mathbb{P}_\Theta[\zeta = 1 \vert a \subseteq (45,54]]$	Age 45-54 constrained share	SCF, Zillow	16.9	18.2
$\mathbb{P}_\Theta[\zeta = 1 \vert a \subseteq (55,64]]$	Age 55-64 constrained share	SCF, Zillow	15.9	15.8
$\mathbb{P}_\Theta[\zeta = 1 \vert a \geq 65]$	Age 65+ constrained share	SCF, Zillow	13.8	13.5
	Panel (c): Full steady state moments			
$\mathbb{P}_\Theta[\mathcal{H}' = 0, s' = 0 \vert \mathcal{H} = 0, a \subseteq (25,34]]$	Age 25-34 rent-to-rent rate	SIPP	21.3	21.3
$\mathbb{P}_\Theta[\mathcal{H}' = 0, s' = 0 \vert \mathcal{H} = 0, a \subseteq (35,44]]$	Age 35-44 rent-to-rent rate	SIPP	14.2	14.2
$\mathbb{P}_\Theta[\mathcal{H}' = 0, s' = 0 \vert \mathcal{H} = 0, a \subseteq (45,54]]$	Age 45-54 rent-to-rent rate	SIPP	11.3	11.3
$\mathbb{P}_\Theta[\mathcal{H}' = 0, s' = 0 \vert \mathcal{H} = 0, a \subseteq (55,64]]$	Age 55-64 rent-to-rent rate	SIPP	9.6	9.6
$\mathbb{P}_\Theta[\mathcal{H}' = 0, s' = 0 \vert \mathcal{H} = 0, a \geq 65]$	Age 65+ rent-to-rent rate	SIPP	7.3	7.3
$\mathbb{P}_\Theta[\mathcal{H}' = 1 \vert \mathcal{H} = 0]$	Rent-to-own	SIPP	4.8	4.8
$\mathbb{P}_\Theta[\mathcal{H}' = 0 \vert \mathcal{H} = 1]$	Own-to-rent	SIPP	1.5	1.5
$\mathbb{E}_\Theta[\theta \vert \mathcal{H} = 1] - \mathbb{E}_\Theta[\theta \vert \mathcal{H} = 0]$	WTP premium for owners	Survey	16.0	12.8
$\mathbb{E}_\Theta[\mathcal{H}]$	Homeownership rate	HVS	66.7	65.1

Figure 4 and listed in Panel (a) of Table 3 as well as the standard deviation of θ in the 25-34 year-old age bin.[26] Despite the relative parsimony of the calibration, it matches well the hump-shaped age profile of average θ.

6.3 Life Cycle ζ Process Using SCF

Liquidity constraints that prevent some individuals from buying are an important feature of reality. At the same time, for the reasons outlined at the start of Section 3, we do not wish to incorporate a full consumption-saving problem. We therefore calibrate a simple life-cycle process for being liquidity constrained, $\zeta = 1$. A newborn is constrained with probability ζ_0. Each period a constrained individual becomes unconstrained with age-specific probability $\mathbb{P}\left[\zeta' = 0 | \zeta = 1, a\right] = \Phi\left(z_0 + z_1 \times a\right)$, where Φ denotes the cumulative normal distribution and z_0 and z_1 are parameters.

We define liquidity constraints in the data as having financial assets plus home equity less than 3.5% of the average value of a home in the bottom third of the home price distribution. The 3.5% threshold is the minimum downpayment for an FHA mortgage.[27] We measure financial assets and home equity by age group using the 2019 SCF.[28] We obtain the value of a home in the bottom third of the price distribution from the Zillow All Homes—Bottom Tier series. We choose ζ_0, z_0, z_1 to best match the fraction of constrained individuals in each age bin shown in Panel (b) of Table 3.

6.4 Externally-calibrated Parameters

We externally set the growth rate of rents to 1% at an annualized rate, the value of real (deflated by the non-shelter CPI) rent growth over 2000-2019. The values for ψ_{0+} and ψ_{1-} correspond to a broker fee of 1 month rent when moving into a new rental and a sales commission of 5% when selling a house. We set the loan-to-value at origination to 0.87, which Adelino, Schoar and Severino (2018) show has remained about the median value throughout the 2000s. We set the discount rate to 2% and the mortgage rate to 2.5%. A fraction $\xi = 1/6$ of owners have the opportunity to

[26] Using the information in our follow-up survey, we adjust the standard deviation for the presence of measurement error, as described in Appendix D.5. In brief, the correlation between WTP in the original and follow-up survey is 0.5. If individuals report their true θ plus i.i.d. measurement error, then the naive standard deviation exceeds the true standard deviation by a factor of $\sqrt{2}$.

[27] Since little else in our model depends on heterogeneity in the down payment, we model all purchasers as starting with a single loan-to-value ℓ. However, the proper comparison to the liquid asset distribution is the minimum down payment in the data of 3.5% applied to the value of a starter home.

[28] We use the definitions of financial assets and home equity given by the variables `FIN` and `HOMEEEQ` in `https://www.federalreserve.gov/econres/files/bulletin.macro.txt`.

refinance each year (Berger et al., 2021). We split the carrying cost of owning into a component that scales the current house price, τP^H, and a remainder $f - \tau P^H$ that scales trend rent. We calibrate the part that scales the house price using the CEX such that owners pay $\tau = 2.3\%$ of the current value of their home every year in property taxes and insurance, and estimate the residual component below.

For the supply side, we assume $P_t^H/P_t^R = 1 + g(h_t) = \gamma_0 + \gamma_1 h_t$. Thus, $\partial\left(P_t^H/R_t\right)/\partial h_t = \gamma_1 c_t$. We set the net capitalization rate to 0.05 and $1 - o^R = 75.8\%$ as the ratio of gross operating surplus to gross output in the tenant occupied housing sector (U.S. Bureau of Economic Analysis, 2025, 2017 detailed Use table), giving a gross inverse capitalization rate of $c = P^R/R = (1 - o^R)/0.05 = 15.16$.[29] Greenwald and Guren (forthcoming) estimate $\partial\left(P_t^H/R_t\right)/\partial h_t$ (for annual rent) following shocks to mortgage availability that plausibly keep c_t fixed.[30] Using a value of 30 together with $c = 15.16$ implies $\gamma_1 = 1.98$. Given this value, we set γ_0 to achieve a ratio of home price to rent of 14.6 based on the CEX.

6.5 Internally-calibrated Parameters

We estimate the remaining nine parameters jointly using nine steady state moments of the full model.[31] Seven of these parameters pertain to the forced moving hazard, λ. Individuals have either $\lambda = 0$ or an age-specific λ_a. Individuals of all ages with $\lambda = 0$ transition to their λ_a with probability $p_{\lambda+}$ while individuals with $\lambda > 0$ transition to $\lambda = 0$ with probability $p_{\lambda-}$, giving a fraction $p_{\lambda+}/(p_{\lambda+} + p_{\lambda-})$ of individuals of any age with $\lambda > 0$. Due to moving costs, in our model individuals only undergo rent-to-rent or own-to-own moves when forced to. Thus, the moments most closely related to the age-specific values $\{\lambda_a\}$ are the age-specific hazard rates for completing a rent-to-rent move, $\mathbb{P}_\Theta\left[\mathcal{H}' = 0, s = 0 | \mathcal{H} = 0, a\right]$, estimated from the SIPP (see Appendix E for

[29] Standard practice in the commercial real estate sector is to quote a capitalization rate as net operating income divided by market value, or $(1 - o^R)R/P^R$ in our notation. The value of 0.05 comes from Costar for highly related rental properties.

[30] Greenwald and Guren (forthcoming) report estimates using two separate measures of homeownership. Using the Home Vacancy Survey they find coefficients in the range of 6 to 12 across horizons while using their own measure constructed by merging deeds records with occupancy they find coefficients of 30 or higher. We are grateful to Adam Guren for providing us the precise values plotted in figures 3(c) and 3(d) of Greenwald and Guren (forthcoming).

[31] The nine moments contain seven transition hazards, the WTP premium for owners in column (4) of Table 1, and the homeownership rate. We minimize the equal-weighted distance between the logs of the model and data transition rates and the levels of the premium and homeownership moments.

details).[32] With λ_a varying flexibly by age, the model hits these targets almost exactly for any population share $p_{\lambda+}/(p_{\lambda+}+p_{\lambda-})$. The values imply a declining forced move hazard in age.

Conditional on the already-calibrated θ and ζ processes, the parameters $p_{\lambda+}$ and $p_{\lambda-}$ together with the idiosyncratic cost standard deviation σ_ε determine the scale of gross flows across owning and renting. Intuitively, agents only change tenure when their type changes or when receiving a large enough idiosyncratic cost shock during a forced move. The hazard rates for switching from owning to renting and renting to owning, $\mathbb{P}_\Theta\left[\mathcal{H}'=1|\mathcal{H}=0\right]$ and $\mathbb{P}_\Theta\left[\mathcal{H}'=0|\mathcal{H}=1\right]$, therefore discipline these parameters. In addition, these parameters affect the overall degree of sorting into homeownership by θ, since $p_{\lambda+}/(p_{\lambda+}+p_{\lambda-})$ determines the population share subject to forced move shocks and σ_ε the within-type tenure variance. The regression coefficient from column (4) of Table 1, which translates into $\mathbb{E}_\Theta\left[\theta|\mathcal{H}=1\right]-\mathbb{E}_\Theta\left[\theta|\mathcal{H}=0\right]$, therefore also disciplines these parameters. We obtain a fraction $p_{\lambda+}/(p_{\lambda+}+p_{\lambda-})\approx 1/4$ with $\lambda>0$ and a standard deviation of the idiosyncratic cost draw when moving equivalent to about 2 months of rent.

The final parameter is the second component of the flow cost of owning, $f-\tau P^H$, which represents maintenance and depreciation costs. These costs do not scale with the house price out of steady state. All else equal, a higher total carrying cost f reduces homeownership and a lower flow cost increases homeownership. Thus, we additionally target the homeownership rate.[33] We obtain a value of $f-\tau P^H=34\%$ of annual rent. Together with τ, owners pay a steady state cost of $f/P^H=0.35\times R/P^H+\tau=4.7\%$ of the house price every year. This value closely matches the sum of property taxes, insurance, and maintenance of 3.5% in the CEX and depreciation of residential buildings of roughly 1% per year in the NIPA, despite not targeting the latter two categories directly.[34]

The owner θ premium and homeownership rate moments reveal a slight tension in the calibration. In the neighborhood of the estimated parameters and given the right tail of the θ distribution,

[32] We target only the rent-to-rent rates because some own-to-own moves in the data may reflect the build-up of equity and a housing quality ladder absent from our model.

[33] In environments without birth and death, the tenure transition hazards imply a homeownership rate due to the stock/flow relationship $(1-h)\,\mathbb{P}_\Theta\left[\mathcal{H}'=1|\mathcal{H}=0\right]=h\mathbb{P}_\Theta\left[\mathcal{H}'=0|\mathcal{H}=1\right]$. This relationship does not hold in our environment because individuals born at age 25 have much higher likelihood of renting than individuals dying at age 65+. Thus, the homeownership rate moment contains additional variation beyond the transition hazards.

[34] Depreciation of residential fixed assets in the NIPA is 1.3% per year. This value applies only to the structures part of residential property and excludes routine maintenance expenditure. Our calculation of the user cost in Figure 1 adds 1p.p. per year of depreciation on top of maintenance as recorded in the CEX, following the approach in Garner and Verbrugge (2009).

pushing the homeownership rate higher reduces the owning premium.[35] This tension explains why both homeownership and the owning premium in the model fall slightly short of the data. In evaluating this discrepancy, it merits keeping in mind that the higher premium in the data in part reflects the tails of the θ distribution, as winsorizing more aggressively reduces the premium to 12.3 (see Table 1 column (8)), close to the model value. Our life-cycle θ process targets the mean θ by age and the variance of the 25-34 year-old group, but for parsimony lacks features such as idiosyncratic growth rates that would generate the fat tails at older ages seen in the data. At the same time, the individuals at the margin of changing tenure choice in response to cost shocks typically do not come from the right tail of the distribution, making this feature less important quantitatively for calculating changes in welfare.

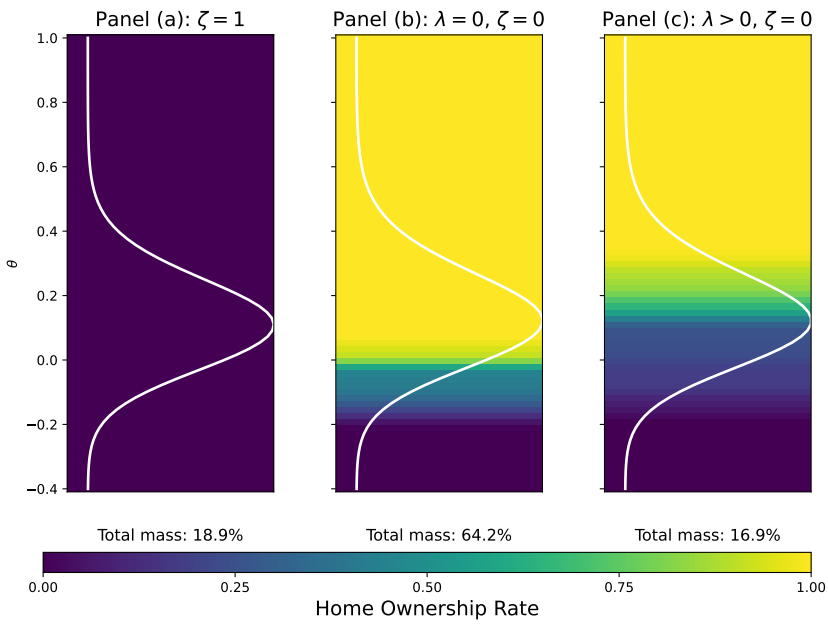
6.6 Additional Model Moments and Validation

Figure 5 illustrates the sorting into homeownership in steady state. Panel (a) contains the 19% of the population that is liquidity constrained, who by construction all choose to rent. Panel (b) contains the 35% of the population that is neither liquidity constrained nor subject to forced moves. Essentially all of these agents own if their θ is positive. Some agents with θ slightly negative also own, as they anticipate a growing θ as they age. Panel (c) contains the remaining 46% of the population, who are not liquidity constrained but are subject to forced move shocks. These agents value homeownership less because transaction costs of owners exceed those of renters. High θ agents with $\lambda > 0$ still own, especially among older cohorts with lower λ_a, but those with lower θ rent.

Figure 6 reports homeownership rates by age in the model and in the 2019 HVS. Nothing in the model's calibration directly targets moments associated with homeownership by age; the only age-related targets concern the age profile of θ directly from our survey, the age profile of liquidity constraints directly from the SCF, and the age profile of rent-to-rent mobility from the SIPP. The moments associated with homeownership — the rent-to-own and own-to-rent transition rates and homeownership — are not age-specific. Nonetheless, the model reproduces the upward-sloping, concave relationship between homeownership and age in the data. This success occurs because

[35] Intuitively, without transaction costs, a higher homeownership rate implies a lower cutoff θ^*. In distributions with right tails including the normal and exponential, the difference in average θ above and below a cutoff increases in the cutoff. This force dominates in the calibration.

Figure 5: Steady State Homeownership Heat Map



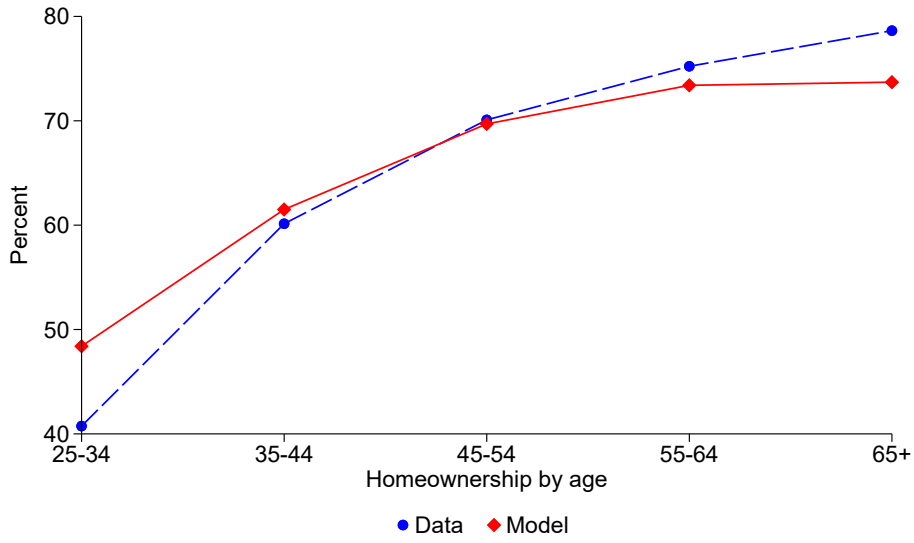
Notes: The figure shows the fraction of agents who own, by θ. Panel (a) restricts to agents with $\zeta = 1$ who cannot buy. Panel (b) restricts to agents with $\zeta = 0$ and not immediately subject to a forced move, $\lambda = 0$. Panel (c) restricts to agents subject to a forced move. The white curves overlaying each figure display the density of agents.

the increasing, concave relationship between θ and age, the decline in forced moves in age, and the decline in liquidity constraints in age all cause homeownership to rise.

Figure 7 considers a validation exercise in the spirit of Greenwald and Guren (forthcoming); Berger et al. (2023), who discipline their quantitative tenure choice models by simulating a first-time homebuyer tax credit (FTHC) and comparing to the evidence in Berger, Turner and Zwick (2020, p. 307). Berger, Turner and Zwick (2020) study the 2009-10 FTHC, which gave first-time buyers a refundable credit of $8,000. Using a kink design around the credit's income phase-out, they find that the policy increased the transition rate into homeownership among eligible renters by 59%. We mimic this policy in the model by offering renters age 25-34 a credit worth 3.68% of the steady state house price if they choose to buy (equivalent to $8000), with the credit available for one year. As the Berger, Turner and Zwick (2020) research design studies individuals around a kink, we perform this experiment in partial equilibrium, holding fixed the house price path relative to rents.

Figure 7 reports the paths of (exogenous) house prices (Panel (a)) and the impulse responses of the rent-to-own transition rate among eligible renters (Panel (b)) for three price path scenarios. In

Figure 6: Homeownership by Age in Model and Data

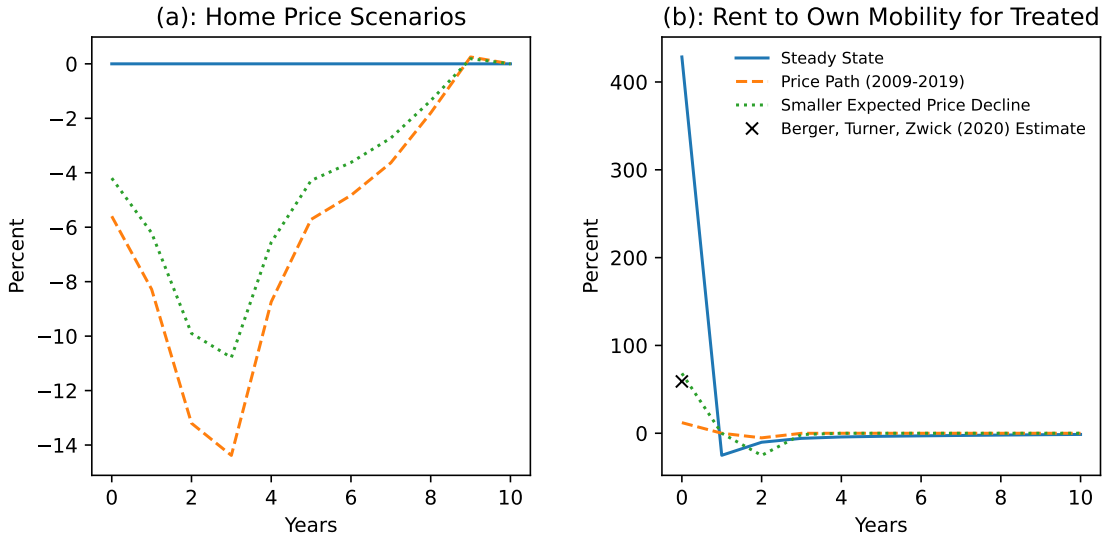


Notes: The figure plots the homeownership rate by age in the model and in the 2019 Housing Vacancy Survey.

all cases, we start the distribution of renters at the model's steady state, although we do not expect this feature to matter much. The solid blue line shows the paths when implementing a FTHC along the model's balanced growth path for house prices. In this scenario, the policy generates a quintupling of the rent-to-own transition rate in the first year, much higher than the increase in Berger, Turner and Zwick (2020). The large response occurs because the credit is sufficiently large that even renters with $\lambda > 0$ find it financially favorable to use the credit, despite their having a greater than 50% likelihood of having to move one year later and pay the associated transaction costs.

The same logic makes the take-up highly sensitive to the path of expected house prices. The dashed orange line in Panel (b) simulates a FTHC in a scenario in which house prices followed their actual path from 2008-2019, falling for four years before starting their rebound. The dash-dot green line simulates a FTHC in a scenario in which prices fell by 75% of their true value. Without comprehensive data on household expectations of prices starting in 2009, we view these two trajectories as plausible bounds of actual expectations. The FTHC take-up is substantially dampened in both scenarios and brackets the impact value of 59% found in Berger, Turner and Zwick (2020). The dampening occurs because in an environment with falling house prices, renters with $\lambda > 0$ now expect to sell at a loss when forced to move. The expected capital loss and

Figure 7: First-time Homebuyer Tax Credit in Model and Data



Notes: Panel (a) shows three partial equilibrium price path scenarios. Panel (b) shows the treatment effect on the ratio relative to the value in period -1 of the transition rate from renting to owning among renters age 25-34 when offered a credit equal to 3.68% of the steady state house price in period 0. The X denotes the value found in Berger, Turner and Zwick (2020, p. 307) in their analysis of the 2009-10 FTHC.

transaction cost associated with buying now exceed the credit, leaving high λ renters on the sidelines. Instead, take-up concentrates among individuals expecting to buy in the next several years anyway. We conclude that our calibrated model is consistent with the take-up evidence from the FTHC, although the sensitivity of this test to house price expectations erodes its sharpness.[36]

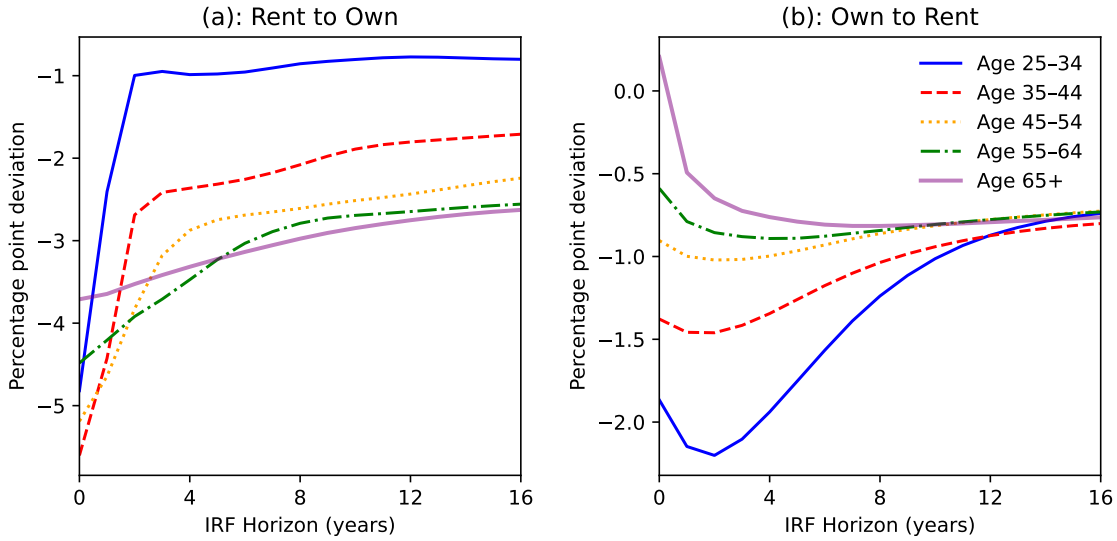
7 Application: Mortgage Rate Hike

We consider an increase in the mortgage rate starting from the model's steady state, motivated by the sudden increase in rates in 2022 in the U.S. Specifically, we model an unexpected, permanent 2p.p. increase in the mortgage rate i and report the de-trended impulse responses along the transition path. We keep the discount factor β fixed; lowering β would further amplify the results reported below.

Figure 8 shows the responses of transition rates across tenure status by age. With homeownership more expensive, rent-to-own transitions fall and own-to-rent transitions rise. The decline in rent-to-own rates reflects the higher carrying cost of owning when mortgage rates increase. The

[36]In addition, our model with binary ability to make a down payment is not well-suited to include the effect of the FTHC on relaxing down payment constraints emphasized by Berger et al. (2023). This channel would tend to increase the take-up of the FTHC.

Figure 8: Mobility Rates



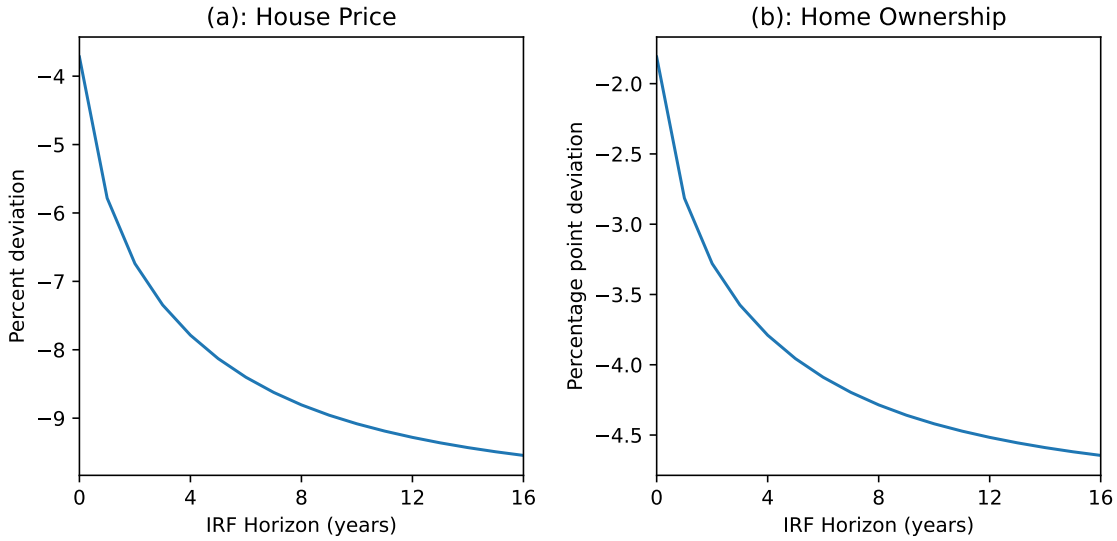
Notes: The figure shows the percentage point deviations from the balanced growth path of own-to-rent and rent-to-own flows in response to a 2 percentage point increase in the mortgage rate, by age bin.

increase in own-to-rent occurs among owners receiving λ shocks, who now face the higher mortgage rate. The non-instantaneous adjustment of these flows reflects mortgage rate lock (Liebersohn and Rothstein, 2025; Batzer et al., 2024; Fonseca and Liu, 2023); agents with low mortgage rates and who have not experienced a θ decline remain in their own homes until they receive a λ shock and have to move.

Figure 9 show the resulting paths of house prices and homeownership. Given our relatively simple supply side, these are tightly linked. Both house prices and homeownership fall on impact and continue to decline over several years. The non-instantaneous adjustment occurs because the own-to-rent flows remain elevated for several periods as agents with low mortgage rates wait for λ shocks to force them to move and because older agents eventually die and are replaced by newborns who face the higher mortgage rate. Of course, individuals anticipate the falling house prices. The reason they do not all sell ahead of the decline is that individuals with high enough θ value remaining as owners enough to offset the expected capital loss.[37]

[37] Actual real (deflated by non-shelter CPI) house prices rose 1.8% per year in 2022-2024. Likewise, the homeownership rate did not fall sharply. The impulse responses of the house price and homeownership therefore suggest the presence of other, offsetting forces in housing markets during that time. For example, an increase in work-from-home or an expectation of rising future construction costs of both owner-occupied and rental housing would increase current demand for owner-occupied housing. The actual changes reflect the combination of these forces and the impulse responses shown in Figure 9. Indeed, real house prices had increased 10.0% per year during 2020 and 2021, so the decline in actual price growth starting in 2022 relative to the 2020-2021 trend is quite large.

Figure 9: House Price and Home Ownership

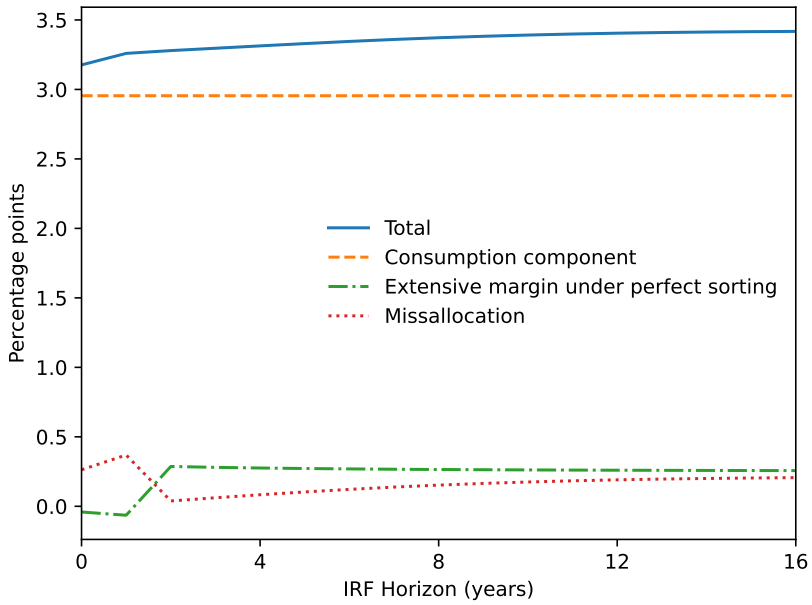


Notes: The left panel shows the percent deviation from the balanced growth path of the house price in response to a 2 percentage point increase in the mortgage rate. The right panel shows the percentage point deviation of the homeownership rate.

The solid blue line in Figure 10 shows the deviation in the overall shelter price relative to trend expenditure, $dP_{t+j}/\mathbb{E}_{\Theta,\mathcal{H},s}\left[\bar{X}\left(\mathcal{H}_{t+j},s\right)\right]\bar{R}_{t+j}$ using the notation of Proposition 4. The price deviation jumps 3p.p. on impact. Applying an expenditure weight of shelter of one-third, this jump contributes to an increase in the CPI of about 1p.p. The dashed orange line shows the contribution from the required decline in nondurable consumption (the first term in equation (22)), which accounts for about 60% of the increase. The dash-dotted green line and dashed red line show the contribution from foregone utility due to changes in homeownership (the second term), split as in equation (24) into a component reflecting the decline in homeownership with efficient sorting (dash-dotted green line) and the change in misallocation. The contribution from the efficient sorting term rises over time as homeownership falls. The contribution of misallocation is positive, but falls over time as homeownership declines. This time path reflects the slow unwinding of mortgage rate lock, as eventually lower θ owners sell to higher θ buyers.

Figure 11 compares our price index response, again shown in the blue solid line, to several alternatives. The dashed green line shows shelter costs using owners' equivalent rent, which does not change since rents remain unchanged by construction. The dash-dotted orange line shows the price index if we had not imposed smoothing of nondurable consumption and instead allocated

Figure 10: Shelter Inflation Relative to the Balanced Growth Path



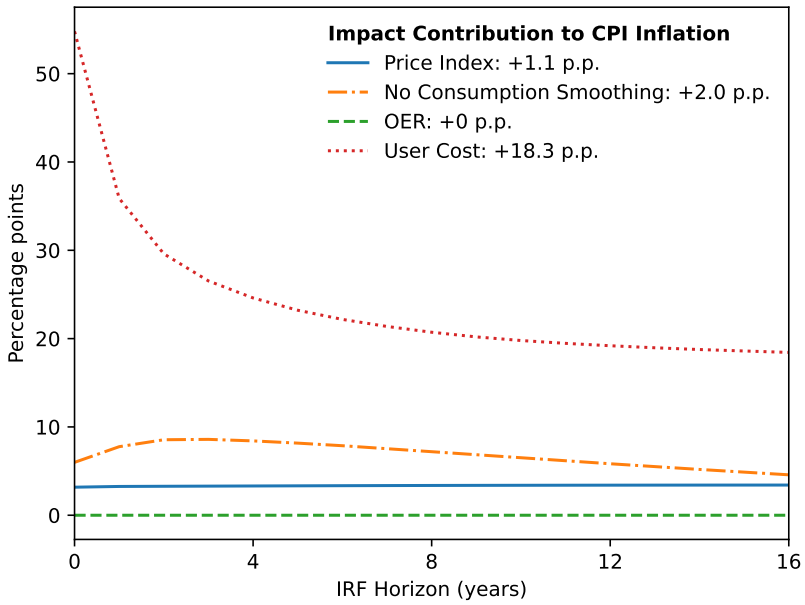
Notes: The blue line shows the deviation of the shelter price from the balanced growth path in units of trend expenditure on shelter. The dashed orange line shows the contribution from the required change in nondurable consumption. The dash-dotted green line shows the contribution from the change in homeownership with perfect sorting by θ. The dotted red line shows the contribution from the change in miscallocation of who owns by θ.

changes in spending to the period in which they occur. The impact decline reflects the liquidation of housing wealth, as some sellers transact with "private equity" who turn the houses into rentals. By construction the infinite-horizon integrals of the blue and dash-dot orange lines equate, but the transition dynamics differ sharply. Using an expenditure weight of one-third, this jump down would contribute to a reduction in CPI inflation of -7p.p. on impact, before turning positive. Finally, the dotted red line shows the one-period user cost (again scaled by trend shelter expenditure). The user cost rises sharply and would imply a 17p.p. jump in CPI inflation, reflecting both the fact that the higher interest payment applies immediately to all owners and the anticipation of further house price declines.

8 Cost-of-shelter Index 2019-2024

The previous section showed that our approach to measuring the cost-of-shelter differs sharply from rent growth or the one-period user cost following a rise in the mortgage rate. We now construct historical shelter cost changes consistent with observed data on house prices, rents,

Figure 11: Inflation Under Alternative Shelter Price Indexes



Notes: The figure shows several measures of deviations of shelter costs from the balanced growth path in units of trend expenditure on shelter. The solid blue line shows our preferred price as defined in equation (22). The dashed green line shows owners' equivalent rent, which remains unchanged by construction. The dash-dot orange line shows the price without imposing smoothing of nondurable consumption. The dotted red line shows the one-period user cost. The legend reports the implied contribution to overall CPI inflation in the first year based on a shelter expenditure weight of one-third.

mortgage rates, expectations of each of these, and the homeownership rate.

The first step of this process requires choosing a base year in which the economy starts on the balanced growth path, including the steady state allocation of household types to tenure choice by duration. The year 2019 is a natural choice, as Chodorow-Reich, Guren and McQuade (2024) argue it marks the return to normalcy following the 2000s housing cycle and it provides several of our calibration moments.

In each successive year thereafter, we give our model households the actual house price, rent, and mortgage rate, non-shelter inflation (which affects real mortgage balances), as well as expectations into the infinite future of these variables. We obtain expectations of mortgage rates from the Treasury yield curve and the term structure of inflation expectations from the Federal Reserve Bank of Cleveland. We use these expectations together with data on house prices and rents to fit rolling Bayesian VARs, from which we obtain expectations of house prices and rents out 15 years, after which we gradually bring expectations back to the model's balanced growth path.

Appendix F provides additional details of these steps as well as the time series of the resulting expectations. In particular, the Bayesian VAR yields house price expectations reasonably consistent with survey expectations, but with the necessary advantage of providing the entire term structure of expectations each year. The realized house prices and these auxiliary forecasts can be made internally consistent with rational expectations by assuming a complying set of realizations of and expectations about the intercept of the supply curve γ_0, but we do not need to solve for this path for what follows.

We also give households sequences of time-varying carrying costs to match the path of homeownership, which we interpret as residual demand shocks that affect tenure choice but do not directly affect the price index. Demand systems almost always require such auxiliary "taste" shocks to match the dynamics of expenditure and prices.[38] We do not include these aggregate taste changes in the price index (in contrast to the changes across individuals in a stable population from the θ process). This treatment is consistent with Baqaee and Burstein (2022), who show that to do otherwise requires assumptions on cardinal utility. It differs from Redding and Weinstein (2019), who make precisely such assumptions.

Given the actual house price, rent, mortgage rate, time-varying carrying costs, and expectations of these variables, $\mathbb{E}_t \mathbb{W}_\infty$, households make their decisions about whether to rent or own. Iterating forward in this fashion, we obtain the distribution of owning and renting by duration and type for each year after 2019. By construction, these distributions also match total homeownership. Together with the realizations of prices and expectations, they form the necessary ingredients to produce the historical cost-of-shelter characterized by Proposition 5.

9 Conclusion

We have argued that a proper cost-of-living price index should account for the costs associated with owning a home and peoples' preferences for owning instead of renting. Furthermore, it should reflect the inherently dynamic considerations involved in shelter payments when transaction costs, fixed rate mortgages, and sticky rents link costs over time. In response to an increase in mortgage

[38] For example, they may represent increased desire for homeownership due to the higher prevalence of work-from-home post-COVID. Without these, the large swings in prices and mortgage rates in the data together with the relatively elastic effective slope of the demand curve coming from our calibration would generate counterfactually large changes in homeownership.

rates, our shelter price index departs from both owners' equivalent rent, which does not directly respond by construction, and the one-period user cost, which is highly volatile.

Our analysis deliberately abstracted from uncertainty in order to deliver an analytic price index formula with minimal measurement requirements. Future work could relax this assumption in quantitative applications and introduce idiosyncratic income risk and borrowing constraints into the consumption-saving problem as well as aggregate risk of rents or other elements of shelter costs changing.

Our price index could create difficulties for central banks insofar as it creates a direct transmission from higher interest rates into higher inflation. We think this concern does not survive scrutiny, for two reasons. First, our analysis connects higher interest rates to a higher cost-of-living, whether or not the official CPI acknowledges this fact. Second, central banks need not target a comprehensive cost-of-living index, just as they already focus on core measures that exclude food and energy. Bianchi, McKay and Mehrotra (2025) argue for excluding shelter costs. Future work could extend their results to a setting that contains dynamic contracts and preference heterogeneity such as ours. A question of particular interest is how optimal monetary policy should change with prevalent features of the mortgage contract such as a fixed or variable rate.

Finally, a reconsideration of shelter inflation opens many questions beyond those pursued here. How should the 1930-1960 integration of mortgage markets and resulting drastic increase in homeownership (Angelova and D'Amico, 2024) affect measurement of real income growth in that period? What happens when the population distribution of tastes change, for example due to population aging or the advent of work-from-home? What are the welfare consequences of the upward trend in the age of first-time home-buying in the U.S.? We leave these applications to future work.

References

Abramson, Boaz, Pablo De Llanos, and Lu Han. 2025. "Monetary Policy and Rents." Working paper, Columbia Business School and University of Wisconsin-Madison.

Adelino, Manuel, Antoinette Schoar, and Felipe Severino. 2018. "The Role of Housing and Mortgage Markets in the Financial Crisis." *Annual Review of Financial Economics*, 10(1): 25–41.

Alchian, Armen A., and Benjamin Klein. 1973. "On a Correct Measure of Inflation." *Journal of Money, Credit and Banking*, 5(1): 173–191.

Ambrose, Brent W., N. Edward Coulson, and Jiro Yoshida. 2023. "Housing Rents and Inflation Rates." *Journal of Money, Credit and Banking*, 55(4): 975–992.

Ameriks, John, Joseph Briggs, Andrew Caplin, Matthew D. Shapiro, and Christopher Tonetti. 2020. "Long-Term-Care Utility and Late-in-Life Saving." *Journal of Political Economy*, 128(6): 2375–2451.

Angelova, Victoria, and Leonardo D'Amico. 2024. "The Making of a National Mortgage Market and Its Effects on American Cities." Working paper.

Astin, John, and Jill Leyland. 2023. "Measuring Inflation as Households See It: Next Steps for the Household Costs Indices."

Auclert, Adrien, Matthew Rognlie, and Ludwig Straub. 2024. "The Intertemporal Keynesian Cross." *Journal of Political Economy*, 132(12): 4068–4121.

Bajari, Patrick, C. Lanier Benkard, and John Krainer. 2005. "House prices and consumer welfare." *Journal of Urban Economics*, 58(3): 474–487.

Baqaee, David, Ariel Burstein, and Yasutaka Koike-Mori. 2024. "Sufficient Statistics for Measuring Forward-Looking Welfare." National Bureau of Economic Research Working Paper 32567.

Baqaee, David R, and Ariel Burstein. 2022. "Welfare and Output With Income Effects and Taste Shocks*." *The Quarterly Journal of Economics*, 138(2): 769–834.

Batzer, Ross, William M. Doerner, Jonah Coste, and Michael Seiler. 2024. "The Lock-In Effect of Rising Mortgage Rates." *SSRN Electronic Journal*. Available at SSRN: https://ssrn.com/abstract=5021709 or http://dx.doi.org/10.2139/ssrn.5021709.

Berger, David, Konstantin Milbradt, Fabrice Tourre, and Joseph Vavra. 2021. "Mortgage Prepayment and Path-Dependent Effects of Monetary Policy." *American Economic Review*, 111.

Berger, David, Nicholas Turner, and Eric Zwick. 2020. "Stimulating Housing Markets." *The Journal of Finance*, 75(1): 277–321.

Berger, David, Tianfang Cui, Nick Turner, and Eric Zwick. 2023. "Stimulating Durable Purchases: Theory and Evidence."

Berger, David, Veronica Guerrieri, Guido Lorenzoni, and Joseph Vavra. 2017. "House Prices and Consumer Spending." *The Review of Economic Studies*, 85(3): 1502–1542.

Bianchi, Javier, Alisdair McKay, and Neil Mehrotra. 2025. "How Should Monetary Policy Respond to Housing Inflation?"

Bolhuis, Marijn A, Judd N. L Cramer, Karl Oskar Schulz, and Lawrence H Summers. 2024. "The Cost of Money is Part of the Cost of Living: New Evidence on the Consumer Sentiment Anomaly." National Bureau of Economic Research Working Paper 32163.

Campbell, John Y., and João F. Cocco. 2007. "How do house prices affect consumption? Evidence from micro data." *Journal of Monetary Economics*, 54(3): 591–621.

Chodorow-Reich, Gabriel, Adam M Guren, and Timothy J McQuade. 2024. "The 2000s Housing Cycle with 2020 Hindsight: A Neo-Kindlebergerian View." *The Review of Economic Studies*, 91(2): 785–816.

Deaton, Angus, and John Muellbauer. 1980. *Economics and consumer behavior.* Cambridge ;:Cambridge University Press.

Dougherty, Ann, and Robert Van Order. 1982. "Inflation, Housing Costs, and the Consumer Price Index." *The American Economic Review*, 72(1): 154–164.

Fagereng, Andreas, Martin Holm, Matthieu Gomez, Benjamin Moll, Emilien Gouin-Bonenfant, and Gisle Natvik. 2024. "Asset-Price Redistribution."

Farhi, Emmanuel, Alan Olivi, and Iván Werning. 2022. "Price Theory for Incomplete Markets." National Bureau of Economic Research Working Paper 30037.

Fonseca, Julia, and Lu Liu. 2023. "Mortgage Lock-In, Mobility, and Labor Reallocation." *Jacobs Levy Equity Management Center for Quantitative Financial Research Paper.* * (March 24, 2023).

Garner, Thesia I., and Randal Verbrugge. 2009. "Reconciling user costs and rental equivalence: Evidence from the US consumer expenditure survey." *Journal of Housing Economics*, 18(3): 172–192. Special Issue on Owner Occupied Housing in National Accounts and Inflation Measures.

Gete, Pedro, and Michael Reher. 2018. "Mortgage Supply and Housing Rents." *The Review of Financial Studies*, 31(12): 4884–4911.

Gillingham, Robert. 1983. "Measuring the Cost of Shelter for Homeowners: Theoretical and Empirical Considerations." *The Review of Economics and Statistics*, 65(2): 254–265.

Gillingham, Robert, and Walter Lane. 1982. "Changing the treatment of shelter costs for homeowners in the CPI." *Monthly Labor Review.*

Greaney, Brian, Andrii Parkhomenko, and Stijn Van Nieuwerburgh. 2025. "Dynamic Urban Economics."

Greenwald, Daniel, and Adam M. Guren. forthcoming. "Do Credit Conditions Move House Prices?" Working Paper, Boston University.

Guren, Adam M, Alisdair McKay, Emi Nakamura, and Jon Steinsson. 2020. "Housing Wealth Effects: The Long View." *The Review of Economic Studies*, 88(2): 669–707.

Gürkaynak, Refet S., Brian Sack, and Jonathan H. Wright. 2007. "The U.S. Treasury yield curve: 1961 to the present." *Journal of Monetary Economics*, 54(8): 2291–2304.

International Monetary Fund, International Labour Organization, Statistical Office of the European Union (Eurostat), United Nations Economic Commission for Europe, Organisation for Economic Co-operation and Development, and The World Bank. 2020. "Consumer Price Index Manual: Concepts and Methods." International Monetary Fund.

International Monetary Fund, International Labour Organization, Statistical Office of the European Union (Eurostat), United Nations Economic Commission for Europe, Organisation for Economic Co-operation and Development, and The World Bank. 2025. "Consumer Price Index Manual: Theory."

Jordà, Òscar, Katharina Knoll, Dmitry Kuvshinov, Moritz Schularick, and Alan M Taylor. 2019. "The Rate of Return on Everything, 1870–2015*." *The Quarterly Journal of Economics*, 134(3): 1225–1298.

Kaplan, Greg, Kurt Mitman, and Giovanni L. Violante. 2020. "The Housing Boom and Bust: Model Meets Evidence." *Journal of Political Economy*, 128(9): 3285–3345.

Kuchler, Theresa, Monika Piazzesi, and Johannes Stroebel. 2023. "Chapter 6 - Housing market expectations." In *Handbook of Economic Expectations*. , ed. Rüdiger Bachmann, Giorgio Topa and Wilbert van der Klaauw, 163–191. Academic Press.

Liebersohn, Jack, and Jesse Rothstein. 2025. "Household mobility and mortgage rate lock." *Journal of Financial Economics*, 164: 103973.

Piazzesi, Monica, and Martin Schneider. 2016. "Chapter 19 - Housing and Macroeconomics." In . Vol. 2 of *Handbook of Macroeconomics*, , ed. John B. Taylor and Harald Uhlig, 1547–1640. Elsevier.

Poole, Robert, Frank Ptacek, and Randal Verbrugge. 2005. "Treatment of Owner-Occupied Housing in the CPI."

Poterba, James M. 1984. "Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach." *The Quarterly Journal of Economics*, 99(4): 729–752.

Redding, Stephen J, and David E Weinstein. 2019. "Measuring Aggregate Price Indices with Taste Shocks: Theory and Evidence for CES Preferences*." *The Quarterly Journal of Economics*, 135(1): 503–560.

Reis, Ricardo. 2005. "A Dynamic Measure of Inflation." National Bureau of Economic Research Working Paper 11746.

Shiller, Robert J., and Anne K. Thompson. 2022. "What Have They Been Thinking? Homebuyer Behavior in Hot and Cold Markets: A Ten-year Retrospect." *Brookings Papers on Economic Activity*, Forthcoming.

Sinai, Todd, and Nicholas S. Souleles. 2005. "Owner-Occupied Housing as a Hedge Against Rent Risk*." *The Quarterly Journal of Economics*, 120(2): 763–789.

Steiner, Peter O. 1961. "Consumer Durables in an Index of Consumer Prices." In *The Price Statistics of the Federal Government.* , ed. Report of the Price Statistics Review Committee, 305–336. NBER.

U.S. Bureau of Economic Analysis. 2025. "Input-Output Accounts." (accesssed January 22, 2025).

U.S. Census Bureau. 2021. "2019 Survey of Income and Program Participation: Users' Guide." Reissued September 2023 ed., Washington, D.C.

Verbrugge, Randal. 2008. "The Puzzling Divergence Of Rents And User Costs, 1980-2004." *Review of Income and Wealth*, 54(4): 671–699.

Appendix:
Homeownership and the Cost of Living

Gabriel Chodorow-Reich, Edward Glaeser, Xavier Jaravel, Avi Lipton

A Construction of the User Costs in Figure 1

This appendix describes the computation of the user costs displayed in Figure 1, which have five main components: the cost of the mortgage, after interest deduction; the opportunity cost of investing the down-payment in financial markets; out of pockets costs; property taxes; and expected capital gains on housing.

Following Garner and Verbrugge (2009), we compute the user cost as follows:

$$uc_t = P_t^h \left(i_t^{\text{Mortgage}}(1-\tau_t^{\text{Fed}})(1-M_t) + i_t^{\text{Opportunity Cost}} M_t(1-\tau_t^{\text{Cap}}) + \tau_t^{\text{Property}}(1-\tau_t^{\text{Fed}}) + \phi_t^h - \mathbb{E}_t \pi_t^h \right),$$

where t indexes quarters and with the following components:

- P_t^h is the property value, which we measure at the household level in the Consumer Expenditure Survey. As in Garner and Verbrugge (2009), we use a regression approach to impute missing observations at the household level.
- i_t^{Mortgage} is the 30-year fixed mortgage rate; in each quarter, we compute the average value in the Freddie Mac's Primary Mortgage Market Survey.
- $i_t^{\text{Opportunity Cost}}$ capture the return on financial investment, which we set equal to the market yield on 10-year U.S. Treasury securities, retrieved from the Federal Reserve Bank of St. Louis, plus a 5% equity premium (Jordà et al., 2019).
- τ_t^{Fed} denotes marginal federal income tax rates, which we obtain from the Tax Foundation; indeed, mortgage interest is deductible for debt costs, whereas for equity, investors only receive after-tax interest earnings.
- τ_t^{Cap} denotes taxes rates on capital gains, set at 15%.
- ϕ_t^h are out-of-pocket costs scaled by the house price, defined as the sum of depreciation, maintenance and repair, and real estate insurance. Maintenance and repair, and real estate insurance are estimated using the CEX. Following Garner and Verbrugge (2009), depreciation is set at 1% of property value.[1]
- τ_t^{Prop} is the property tax, which we measure in the American Community Survey (ACS), dividing the property tax paid by the dwelling value;[2] we estimate property taxe rates at the MSA, state and federal levels, and then assign them to households in the CEX at the smallest available geographical unit.
- M_t is the down-payment ratio, measure in the American Housing Survey (AHS).
- $\mathbb{E}_t \pi_t^h$ is the expected changes in house prices. We report two versions of expected house price inflation. Version 1 uses realized house price changes according to the Freddie Mac House Price Index (FMHPI), which measures typical home price inflation, based on loans bought by Freddie Mac or Fannie Mae. It is a repeat transaction indices, which measures by comparing

[1] Garner and Verbrugge (2009) explain: "to ensure that our estimates line up with comparable measures from the Bureau of Economic Analysis (BEA) and from the Census, we add 1 percent of home value to our maintenance and repair estimates, which may be interpreted as adding an estimate of depreciation, or as an estimate of deferred major maintenance."

[2] Property taxes expenses are often missing in the CE and those present match hardly official statistics.

the price of the same property over several transactions, holding constant property type and location. Version 2 uses the median one-year ahead house price expectation in the New York Federal Reserve Survey of Consumer Expectations. In this survey, respondents are asked by how much the average home price will change nationwide over the next 12 months. This measure of inflation is available only from the third quarter of 2013 only.

Importantly, the user cost does not include transaction costs (broker fees, etc.).

B Model Appendix

B.1 Proof of Proposition 1

We need to verify that equations (3), (4) and (6) hold with $h_t = h, \theta_t^* = \theta$. Dividing both sides of equation (3) by $R_t = \bar{R}_t$ and imposing constant ρ gives:

$$\frac{\rho P_t^H}{\bar{R}_t} = 1 + (\theta_t^* - 1). \tag{B.1}$$

From equation (4), constant c and $g(h)$ imply a constant ratio P_t^H / R_t and hence the left hand side of equation (B.1) is constant. From equation (5), constant h also implies constant θ^* and hence the right hand side of equation (B.1) is also constant.

B.2 Proof of Proposition 2

The change in the price is given by the sum of the terms in equation (9) multiplied by their respective population shares. This is simply:

$$\begin{aligned}
P_{t+1} - P_t &= (1 - h_t)(R_{t+1} - R_t) \\
&\quad + h_{t+1}\left(R_{t+1} - R_t + \left(\theta_{t+1}^* \bar{R}_{t+1} - \theta_t^* \bar{R}_t\right)\right) - \int_{\theta_{t+1}^*}^{\infty} \theta \left(\bar{R}_{t+1} - \bar{R}_t\right) dF_\theta(\theta) \\
&\quad + (h_t - h_{t+1})\left(R_{t+1} - R_t - \theta_t^* \bar{R}_t\right) + \int_{\theta_t^*}^{\theta_{t+1}^*} \theta \bar{R}_t dF_\theta(\theta) \\
&= (R_{t+1} - R_t) + h_{t+1}\theta_{t+1}^* \bar{R}_{t+1} - h_t \theta_t^* \bar{R}_t + \mathbb{E}_\theta\left[\mathcal{H}_{t+1}(\theta)\,\theta\right]\bar{R}_{t+1} - \mathbb{E}_\theta\left[\mathcal{H}_t(\theta)\,\theta\right]\bar{R}_t.
\end{aligned}$$

We could also have arrived at this expression by defining:

$$P_t = -U_t = R_t + h_t \theta_t^* \bar{R}_t - \mathbb{E}_\theta\left[\mathcal{H}_t(\theta)\,\theta\right]\bar{R}_t.$$

B.3 Proof of Proposition 3

The application of the definition of dY to equations (13) and (14) gives:

$$d\tilde{V}_t(\Theta, \mathcal{H}, s) = d\tilde{V}_t^\theta(\Theta, \mathcal{H}, s) - \left(\frac{\partial \tilde{V}_t^C(\Theta, \mathcal{H}, s)}{\partial A_t}\right) dV_t^X(\Theta, \mathcal{H}, s).$$

Dividing this equation through by the marginal utility of a dollar $\partial \tilde{V}_t^C(.)/\partial A_t$ gives equation (17) in the main text. To arrive at equation (18), we use from the consumption-savings problem the envelope condition $\partial \tilde{V}_t^C(\Theta, \mathcal{H}, s)/\partial A_t = u'(C_t(\Theta, \mathcal{H}, s; \mathbf{W}_t))$ and the Euler equation $u'(C_t(\Theta, \mathcal{H}, s; \mathbf{W}_t)) = \mathbb{E}_t\left[\tilde{\beta}_{t,t+j}\beta_{t,t+j}^{-1}u'(C_{t+j})\,|\Theta, \mathcal{H}, s; \mathbf{W}_t\right]$, which together give:

$$\frac{\tilde{\beta}_{t,t+j}v(\theta_{t+j})}{\partial \tilde{V}_t^C(.)/\partial A_t} = \frac{\beta_{t,t+j}v(\theta_{t+j})}{u'(C_{t+j})}.$$

Note that we have used here the certainty-equivalence property assumed in Section 3.1. Using this condition and the definition of $\tilde{V}_t^\theta(\Theta, \mathcal{H}, s)$ in equation (16) gives the first equality in equation (18). The second equality follows from the definition of the covariance.

B.4 Proof of Proposition 4

Equation (21) follows from equations (18) to (20). Equation (22) simply aggregates equation (21).

B.5 Proof of Proposition 5

Equation (25) follows directly from iterating forward. For example, at date 2:

$$dP_{t|2} = dP_{t|1} + m_{t-2}\left(V_2^X - V_{2|1}^X\right) + \left(\mathbb{E}_2 - \mathbb{E}_1\right)\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[\mathcal{H}_t\theta_t\right]\bar{R}_t.$$

Equation (26) follows from imposing the definition $m_j = (1-\beta(1+\mu))(1+\mu)^j$. Specifically, since:

$$\begin{aligned} dP_{t-1} &= \sum_{j=0}^{t-1} m_j\left(V_{t-j-1}^X - V_{t-j-1|t-j-2}\right) + \left(\mathbb{E}_{t-1} - \mathbb{E}_{-1}\right)\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[\mathcal{H}_{t-1}\theta_{t-1}\right]\bar{R}_{t-1} \\ &= \sum_{j=1}^{t} m_{j-1}\left(V_{t-j}^X - V_{t-j|t-j-1}\right) + \left(\mathbb{E}_{t-1} - \mathbb{E}_{-1}\right)\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[\mathcal{H}_{t-1}\theta_{t-1}\right]\bar{R}_{t-1}, \end{aligned}$$

the de-trended change can be written:

$$\begin{aligned} \frac{P_t}{\bar{R}_t} - \frac{P_{t-1}}{\bar{R}_{t-1}} &= \frac{dP_t}{\bar{R}_t} - \frac{dP_{t-1}}{\bar{R}_{t-1}} \\ &= \frac{m_0}{\bar{R}_t}\left(V_t^X - V_{t|t-1}^X\right) + \sum_{j=1}^{t}\left(\frac{m_j}{\bar{R}_t} - \frac{m_{j-1}}{\bar{R}_{t-1}}\right)\left(V_{t-j}^X - V_{t-j|t-j-1}^X\right) + \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[\mathcal{H}_t\theta_t - \mathcal{H}_{t-1}\theta_{t-1}\right] \\ &= \left(1-\beta(1+\mu)\right)\left(V_t^X - V_{t|t-1}^X\right) + \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[\mathcal{H}_t\theta_t - \mathcal{H}_{t-1}\theta_{t-1}\right], \end{aligned}$$

since $m_j/\bar{R}_t = m_{j-1}/\bar{R}_{t-1} = (1-\beta(1+\mu))(1+\mu)^{j-t}/\bar{R}_0$. Thus, the date t (de-trended) change in the price index depends only on news realized in period t about current and future shelter expenditure and changes to the non-pecuniary component between $t-1$ and t. This Markov property does not hold for a fully general IMPC profile, in which case the change in dP requires tracking the history of shocks.

C Price Index with Incomplete Markets and Uncertainty

This Appendix extends the framework of Section 3 to a setting with uncertainty and incomplete markets. Importantly, we continue to assume that changes to shelter prices do not feedback into changes in the state-contingent marginal utility of nondurable consumption or the intertemporal price across dates and states. That is, we consider small changes to shelter prices or the limit where shelter is a small part of the overall budget.

C.1 Setup

The date t maximization problem for an agent of type Θ_t with income Z_t, non-housing wealth A_{t-1}, and previous tenure $\mathcal{H}_{t-1}$ of duration s_{t-1} is:

$$\begin{aligned}\tilde{V}_t\left(A_{t-1},\mathcal{H}_{t-1},s_{t-1};\Theta_t\right) &\equiv \tilde{V}\left(A_{t-1},\mathcal{H}_{t-1},s_{t-1};\Theta_t,\mathbf{W}_t\right)\\ &= \max_{\{C_{t+j},\mathcal{H}_{t+j},s_{t+j}\}_{j=0}^{\infty}} \mathbb{E}_t\left[\sum_{j=0}^{\infty}\tilde{\beta}_{t,t+j}\left(u\left(C_{t+j}\right)+\mathcal{H}_{t+j}v\left(\tilde{\theta}_{t+j}\right)\right)|\mathcal{H}_{t-1},s_{t-1};\Theta_t,\mathbf{W}_t\right],\end{aligned} \tag{B.2}$$

now subject to a sequence of budget constraints:

$$C_{t+j}+X\left(\mathcal{H}_{t+j},s_{t+j};\mathbf{W}_{t+j}\right)+\beta_{t+j,t+j+1}^{-1}A_{t+j}=A_{t+j-1}+Z_{t+j}. \tag{B.3}$$

We allow for up to N_t possible paths of realized states up to date t, indexed by $i=1,2,\ldots,N_t$. Aggregate shelter costs W_t, household income Z_t, and the idiosyncratic parameter Θ_t may all depend on the realized state history. Thus, Y_{t+j}^i is the value of a variable Y at date $t+j$ given a specific history of states and the expectation operator stands for $\mathbb{E}_t\left[Y_{t+j}\right]=\sum_i \pi_{t+j|t}^i Y_{t+j}^i$ for a set of date-state probabilities $\left\{\pi_{t+j|t}^i\right\}$ given information at date t.

A solution to this problem yields a full set of contingent allocations $\left\{C_{t+j}^i,X_{t+j}^i,\mathcal{H}_{t+j}^i\right\}$ of consumption, shelter expenditure, and tenure choice at each date and state history. This solution obeys a set of Euler equations:

$$u'\left(C_{t+j}^i\right)=\tilde{\beta}_{t+j,t+j+1}\beta_{t+j,t+j+1}^{-1}\mathbb{E}_{t+j}^i\left[u'\left(C_{t+j+1}\right)\right]\ \forall i,j.$$

Let $\Lambda_{t,t+j}^i\equiv\tilde{\beta}_{t,t+j}u'\left(C_{t+j}^i\right)/u'\left(C_t\right)$ denote the household's stochastic discount factor relating marginal utility in state i at date $t+j$ to marginal utility at date t. Formally, the no-feedback assumption stated at the outset amounts to assuming the set $\left\{\Lambda_{t,t+j}^i\right\}$ is invariant to changes in shelter costs. Correspondingly, we fix the path of real interest rates and let $\beta_{t,t+j}\equiv\prod_{k=0}^{j-1}\beta_{t+k,t+k+1}$.

C.2 Changes in Welfare

Consider some change dW_t that affects current shelter costs and/or future shelter costs along some paths, keeping the idiosyncratic components of the problem fixed. With this change, a new set of contingent allocations arises. Define dY_{t+j}^i as the difference in a variable Y in state i at date $t+j$

across the old and new allocations. Using $du\left(C^i_{t+j}\right) = u'\left(C^i_{t+j}\right) dC^i_{t+j}$, we have:

$$dV_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) \equiv \frac{d\tilde{V}_t\left(A_{t-1}, \mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)}{u'\left(C_t\right)}$$
$$= \mathbb{E}_t\left[\sum_{j=0}^{\infty} \Lambda_{t,t+j}\left(dC_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) + d\mathcal{H}_{t+j}\frac{v\left(\tilde{\theta}_{t+j}\right)}{u'\left(C_{t+j}\right)}\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right], \tag{B.4}$$

where $dC^i_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) = \sum_{k=0}^{\infty}\sum_{\ell=1}^{N} m^{i,\ell}_{t+j,t+k} dX^{\ell}\left(\mathcal{H}^{\ell}{}_{t+j+k}, s^{\ell}_{t+j+k}; \mathbf{W}^{\ell}_{t+j+k}\right)$ and $m^{i,\ell}_{t+j,t+k}$ denotes the intertemporal state-specific marginal propensity to consume in state i at date $t+j$ given a change in income or shelter expenditure in state ℓ at date $t+k$.

The state-IMPCs must obey equation (B.3), i..e.:

$$dC^i_{t+j} + dX\left(\mathcal{H}^i_{t+j}, s^i_{t+j}; \mathbf{W}^i_{t+j}\right) + \beta^{-1}_{t+j,t+j+1} dA^i_{t+j} = dA^i_{t+j-1}.$$

Furthermore, fixing a path of states i that WLOG we index with i each date:

$$dV^{X^i}_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) \equiv \sum_{j=0}^{\infty} \beta_{t,t+j} dX\left(\mathcal{H}^i_{t+j}, s^i_{t+j}; \mathbf{W}^i_{t+j}\right)$$
$$= -\sum_{j=0}^{\infty} \beta_{t,t+j} dC^i_{t+j} + \sum_{j=0}^{\infty} \beta_{t,t+j}\left(dA^i_{t+j-1} - \beta^{-1}_{t+j,t+j+1} dA^i_{t+j}\right)$$
$$= -\sum_{j=0}^{\infty} \beta_{t,t+j} dC^i_{t+j}. \tag{B.5}$$

Thus, we still have the result that the expected present value of changes in consumption expenditure discounted at the risk-free rate equals the present value of changes in spending on shelter. However, the path of nondurable consumption changes required to restore utility discounts with the agent's stochastic discount factor $\Lambda_{t,t+j}$ rather than the financial discount rate, as in Farhi, Olivi and Werning (2022). For example, a shelter cost increase in a state of the world where the household has lower permanent income causes a larger welfare decline than the same shelter cost increase in a state of the world with higher permanent income. With complete markets, matters simplify on this dimension. Let $\beta^i_{t,t+j}$ denote the date t price of the Arrow-Debreu security providing \$1 in state i at date $t+j$. With complete markets, $\beta^i_{t,t+j} = \Lambda^i_{t,t+j}$ and the value of changes in consumption discounted using $\Lambda^i_{t,t+j}$ in equation (B.4) and the value $\mathbb{E}_t\left[dV^{X^i}_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)\right]$ computed over all possible histories coincide.

Define $dC^{\Lambda}_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right)$ as the certainty equivalent change in consumption given shelter cost changes at date t, i.e. $\beta_{t,t+j} dC^{\Lambda}_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) = \mathbb{E}_t\left[\Lambda_{t,t+j} dC_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right)\right]$. Define $\theta\bar{R}_{t+j} \equiv v\left(\tilde{\theta}_{t+j}\right)/\mathbb{E}_t\left[u'\left(C_{t+j}\right)\right]$. Rewrite equation (B.4):

$$dV_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right) = \sum_{j=0}^{\infty} \beta_{t,t+j}\left(dC^{\Lambda}_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) + d\mathbb{E}_t\left[\left(\mathcal{H}_{t+j}\theta\bar{R}_{t+j}\right) | \mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right]\right). \tag{B.6}$$

We use the formulation in equation (B.6) to define the per-period price index.

C.3 Price Index Impulse Response

We define the price index response to news at date t using the certainty-equivalent for consumption:

$$dP_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) = -dC^{\Lambda}_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) - d\mathbb{E}_t\left[\left(\mathcal{H}_{t+j}\theta\right)|\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right]\bar{R}_{t+j}. \tag{B.7}$$

By construction, the present value of price deviations discounted using the risk-free rate, $\sum_{j=0}^{\infty}\beta_{t,t+j}dP_{t+j}\left(\mathcal{H}_{t-}\right.$ equals the value function deviation $dV_t\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)$. However, even without the fluctuations due to the θ term we can no longer literally interpret these price deviations as transfers. Indeed, their present value does not even equal the expected present value of changes in shelter expenditure $\mathbb{E}_t[dV_t^{X^i}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t\right)]$ discounted using the risk-free rate, which instead equals discounted expected consumption, not certainty equivalent consumption (see equation (B.5)).

Averaging over types:

$$dP_{t+j}\left(dW_t\right) = -\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[dC^{\Lambda}_{t+j}\left(\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, dW_t\right) + d\mathbb{E}_t\left[\left(\mathcal{H}_{t+j}\theta\right)|\mathcal{H}_{t-1}, s_{t-1}; \Theta_t, \mathbf{W}_t\right]\right]\bar{R}_{t+j}. \tag{B.8}$$

C.4 Historical Price Index

Now consider a sequence of news. Define $dY_{t+j|t}$ as the change in a variable Y at date $t+j$ in response to news at date t. At date 0, the set of transfers is:

$$dP_{t|0} = -\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[dC^{\Lambda}_{t|0}\left(\mathcal{H}_{-1}, s_{-1}; \Theta_0\right) + \left(\mathbb{E}_0 - \mathbb{E}_{-1}\right)\left[\mathcal{H}_t\theta_t\right]\bar{R}_t\right].$$

At date 1:

$$dP_{t|1} = dP_{t|0} - \mathbb{E}_{\{\Theta,\mathcal{H},s\}}\left[dC^{\Lambda}_{t|1}\left(\mathcal{H}_0, s_0; \Theta_1\right) + \left(\mathbb{E}_1 - \mathbb{E}_0\right)\left[\mathcal{H}_t\theta_t\right]\bar{R}_t\right].$$

The realized transfer at date t equals the sum of all past transfers:

$$dP_t = dP_{t|t} = -\mathbb{E}_{\{\Theta,\mathcal{H},s\}}\sum_{j=0}^{t}\left[dC^{\Lambda}_{t|t-j}\left(\mathcal{H}_{t-j-1}, s_{t-j-1}; \Theta_{t-j}\right) + \left(\mathbb{E}_t - \mathbb{E}_{-1}\right)\left[\mathcal{H}_t\theta_t\right]\bar{R}_t\right]. \tag{B.9}$$

Equation (B.9) mirrors equation (25) in the main text, except that with uncertainty and incomplete markets the price tracks revisions to the certainty equivalent value of consumption.

D Additional Survey Material

D.1 Demographic and Financial Benchmarking

Table C.1 compares demographic characteristics of our sample to the population as reported in the CPS. Table C.4 compares the distribution of rent and owners' equivalent rent in our sample to the population as reported in the CEX.

Table C.1: Demographic Characteristics Comparison to Current Population Survey

	Percent of household heads or spouses		
Sample:	CPS	Full survey	Baseline sample
18-24 years old	3.6	8.6	6.3
25-34 years old	15.7	17.2	15.9
35-44 years old	18.8	18.0	19.7
45-54 years old	17.2	17.8	19.0
55-64 years old	17.9	24.6	25.0
65+ years old	26.7	13.9	14.0
Female	52.1	50.8	51.6
Married	61.4	52.2	53.8
No children	60.4	67.4	69.0
1 child	17.0	15.6	15.5
2 children	14.5	12.3	11.7
3+ children	8.2	4.6	3.9
No college	32.5	9.5	9.7
Some college	25.2	27.9	28.6
BA	25.8	41.1	41.5
Graduate or professional	16.5	21.4	20.0

Notes: the table compares demographics in our survey to reference persons and their partners in the December 2024 Current Population Survey.

Table C.2: Demographic Characteristics Comparison to SIPP

	Percent of household heads or spouses								
	Pooled			Owners			Renters		
Sample:	SIPP	Full survey	Baseline sample	SIPP	Full survey	Baseline sample	SIPP	Full survey	Baseline sample
Owner	68.4	63.9	66.0						
18-24 years old	2.8	8.6	6.3	1.1	4.7	4.3	6.4	15.6	10.1
25-34 years old	14.4	17.2	15.9	9.4	12.4	11.5	25.3	25.6	24.4
35-44 years old	18.5	18.0	19.7	17.3	18.4	20.6	21.3	17.2	18.1
45-54 years old	17.5	17.8	19.0	18.1	18.8	19.5	16.1	15.8	18.1
55-64 years old	19.1	24.6	25.0	21.4	28.4	27.5	13.9	17.8	20.2
65+ years old	27.7	13.9	14.0	32.7	17.3	16.5	16.9	8.1	9.2
Female	52.5	50.8	51.6	53.0	50.9	52.8	54.4	50.4	49.2
Married	60.2	52.2	53.8	69.0	64.5	65.9	36.5	30.3	30.3
No children	61.6	67.4	69.0	60.4	64.1	65.1	64.2	73.3	76.5
1 child	17.0	15.6	15.5	17.8	15.9	16.3	15.3	15.3	13.9
2 children	13.9	12.3	11.7	14.9	14.3	13.4	11.9	8.9	8.4
3+ children	7.4	4.6	3.9	6.8	5.8	5.2	8.6	2.5	1.3
No college	31.0	9.5	9.7	27.2	8.6	8.7	39.2	11.1	11.8
Some college	25.8	27.9	28.6	25.8	26.7	29.3	25.6	30.0	27.3
BA	25.3	41.1	41.5	26.8	41.0	41.0	22.3	41.4	42.4
Graduate or professional	17.9	21.4	20.0	20.2	23.5	20.8	12.9	17.5	18.5

Notes: the table compares demographics in our survey to reference persons and their partners in the 2023 SIPP.

Table C.3: Homeownership by Age Comparison to SIPP

	Homeownership rate		
Sample:	SIPP	Full survey	Baseline sample
18-24 years old	27.6	34.9	45.5
25-34 years old	44.4	46.2	47.7
35-44 years old	63.6	65.4	68.8
45-54 years old	70.8	67.8	67.7
55-64 years old	76.9	73.9	72.6
65+ years old	80.7	79.1	77.6
25+ years old	69.5	66.6	67.3

Table C.4: Shelter Cost Comparison to Consumer Expenditure Survey

	Statistic				
Statistic:	P10	P25	P50	P75	P90
Owner equivalent rent					
CEX	1000	1500	2100	3000	3803
Full survey	800	1250	2000	3000	4000
Baseline sample	800	1300	2000	2800	3500
Rent					
CEX	400	853	1594	2433	4100
Full survey	562.5	910	1400	1900	2750
Baseline sample	675	960	1400	1900	2800

D.2 Reasons for Moving

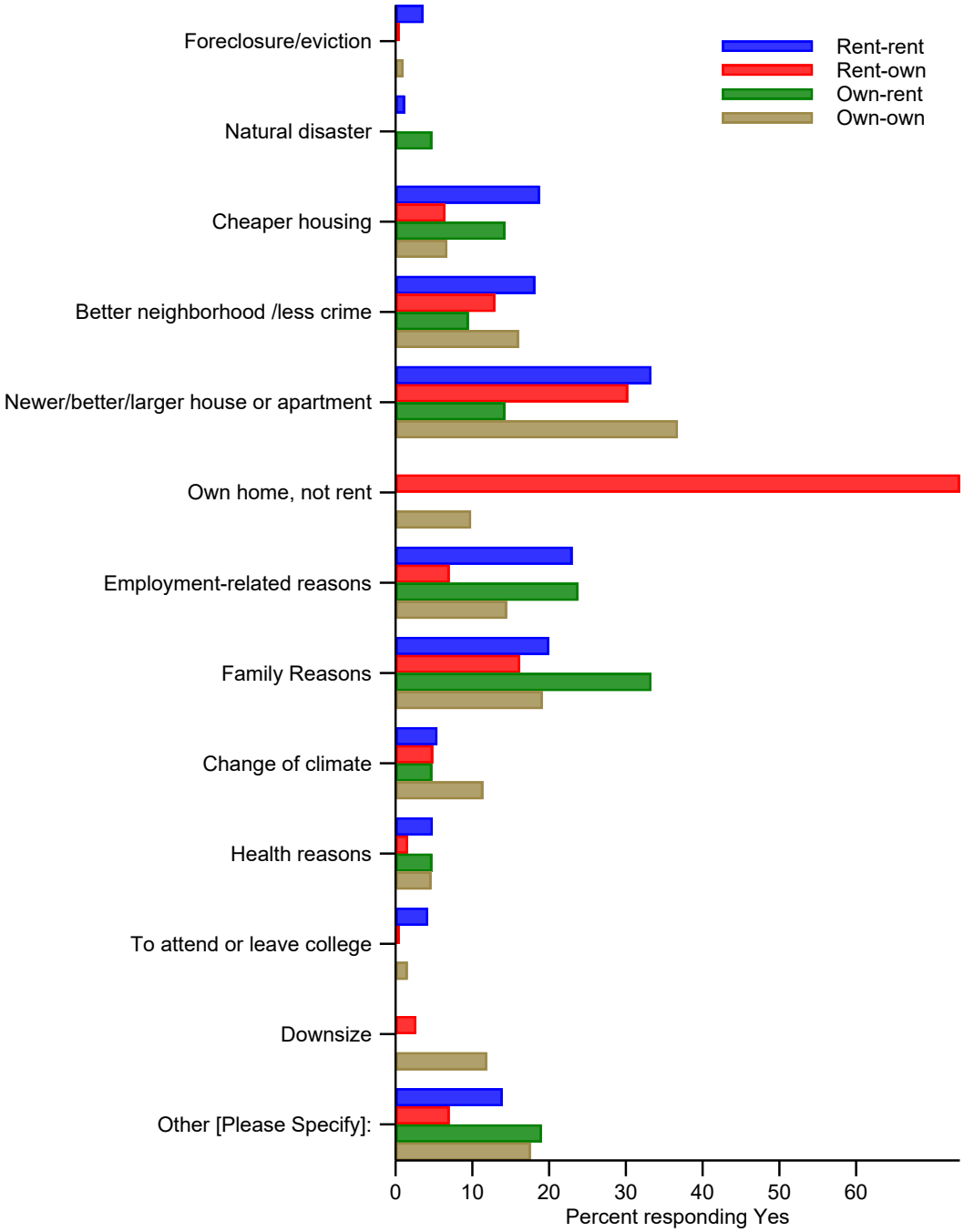
This appendix presents evidence on reasons for moving from our survey and from the SIPP, American Housing Survey (AHS), and Current Population Survey Annual Social and Economic Supplements (CPS ASEC).

Figure C.2 presents results from the SIPP question "What was the main reason you moved to this address?" (`EEHC_WHY`). The sample for this analysis coincides with Appendix E. Respondents can choose one answer.

Figure C.3 presents results from a similar question asked of recent (last two years) movers in the AHS (`RM*`). The sample for this is the AHS waves in 2015, 2017, and 2019. Unlike the SIPP, the AHS prefaces a series of questions with "People choose to move for a variety of reasons, either voluntary or non-voluntary" and respondents can choose multiple reasons.

Figure C.4 presents results from a similar question asked of movers (in the previous year) in the CPS ASEC: "What was your main reason for moving?" (`NXTRES`). The sample for this is the 2015-2018 ASECs. Like the SIPP, respondents may choose only one answer. Unlike the SIPP and

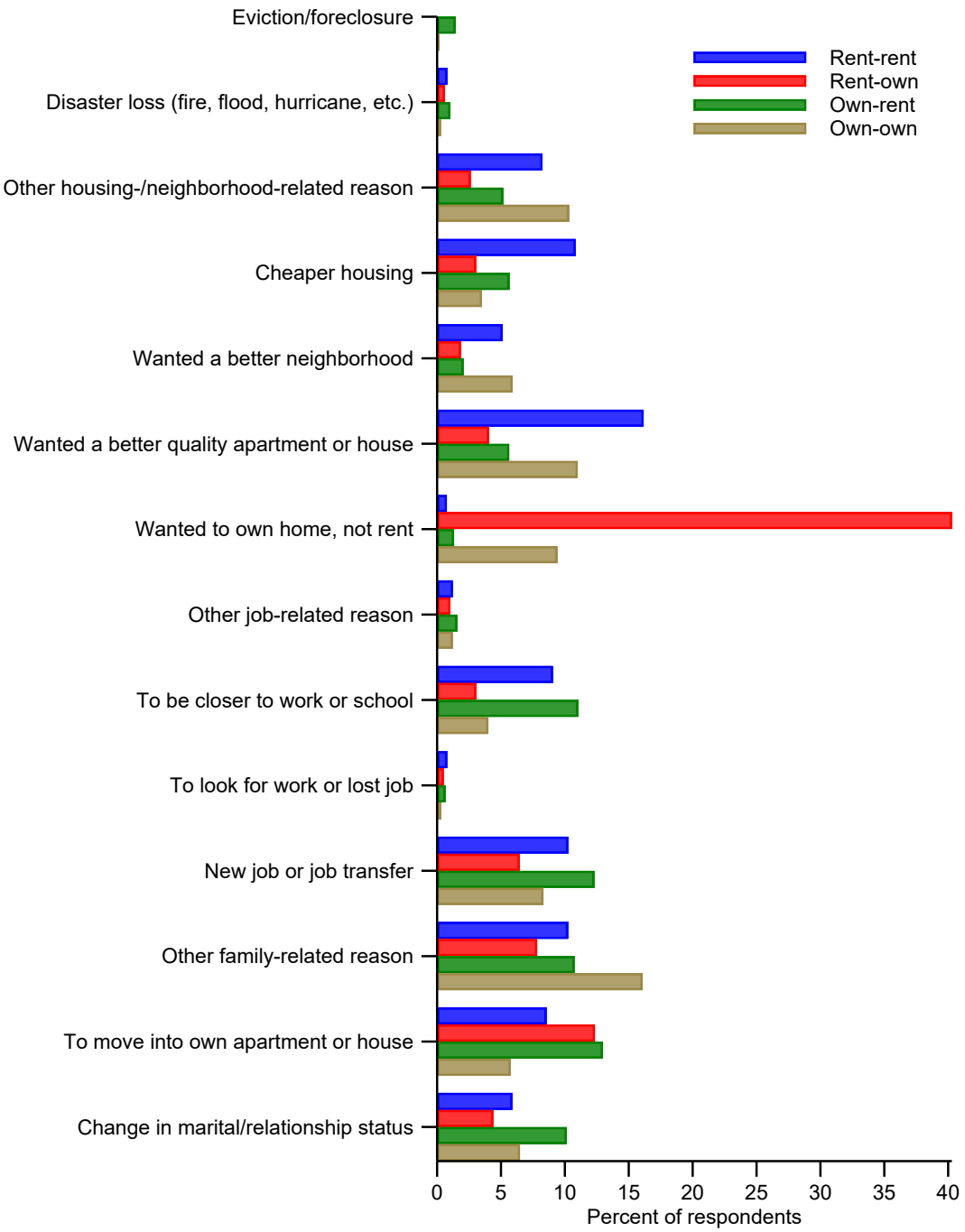
Figure C.1: Reason for Moving: Our Survey



Notes: Due to a survey module error, we did not offer current renters the option to select "downsize".

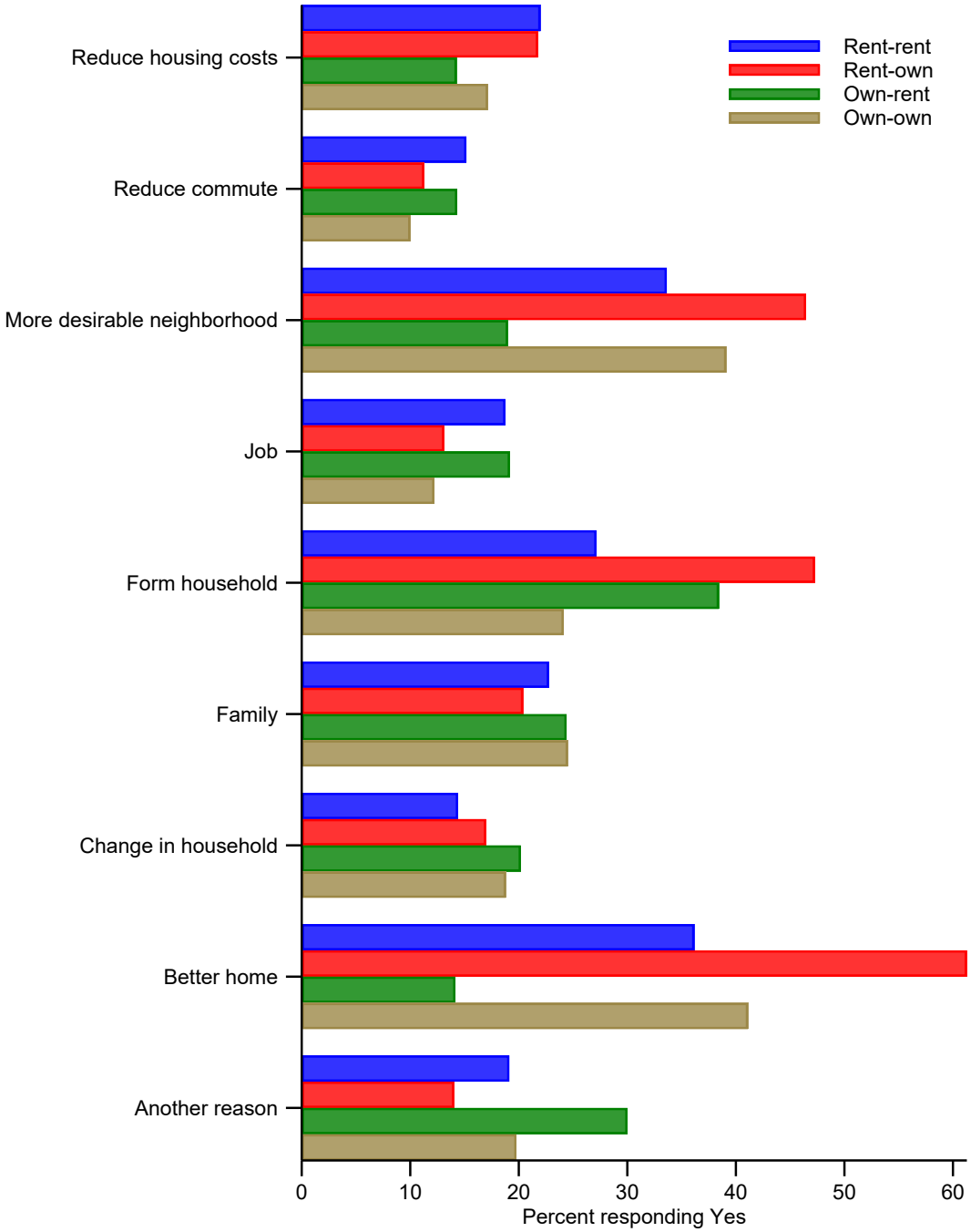
AHS, we cannot split respondents by whether they change tenure status as the CPS does not ask about the tenure of the previous residence.

Figure C.2: Reason for Moving: SIPP



Notes:

Figure C.3: Reason for Moving: AHS



Notes:

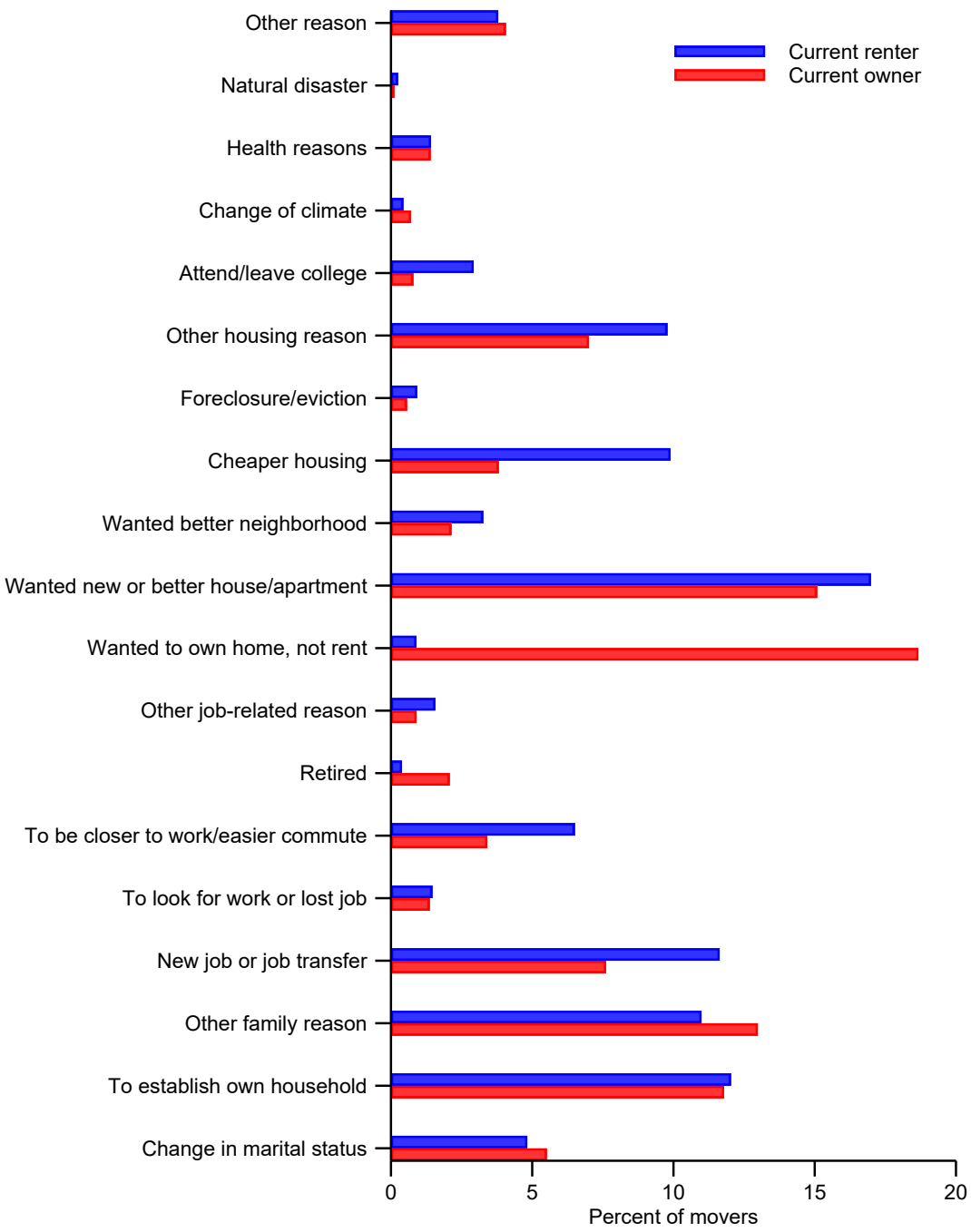
D.3 Willingness-to-pay Questions

Imagine the following scenario: When you bought your home, you also considered renting. Let's compare the outcome of your choice to buy a home with a hypothetical alternative where you chose to rent instead.

The Decision Point

When you bought your home, you faced a choice about where to

Figure C.4: Reason for Moving: CPS ASEC



Notes:

Imagine this hypothetical scenario: You've just inherited $25,000 from a distant relative. This amount is enough to cover a down payment on a home you might like to buy. You now face a significant financial decision.

The Decision Point

With this unexpected inheritance, you have two options:

1. **Buy a Home:** Use the inheritance as a down payment to

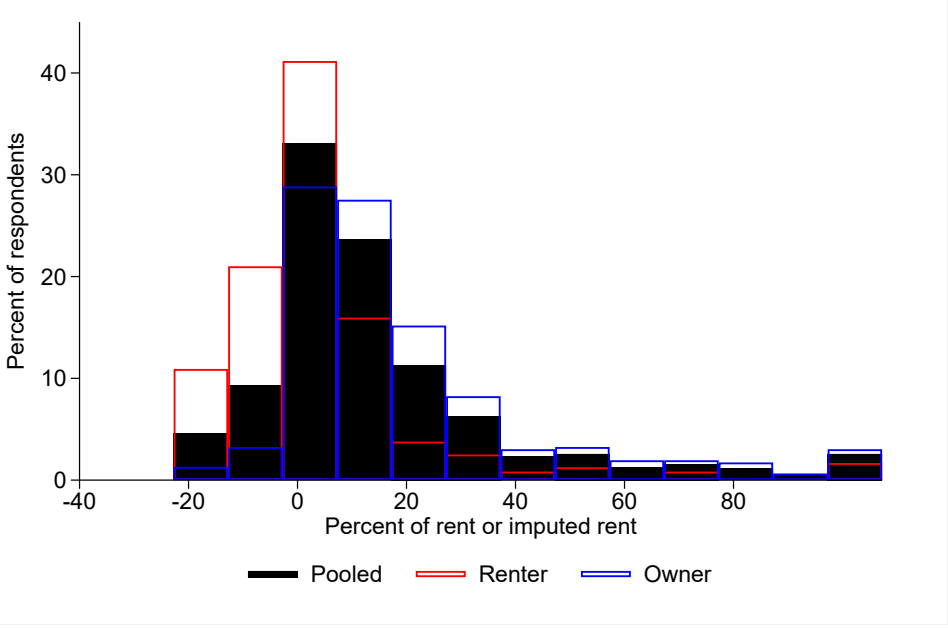
Homeownership (Your Actual Choice)	Rental Scenario (Hypothetical)
Living Situation: You lived in a home you owned for 10 years, paying off part of your mortgage	**Living Situation:** You would have been continuously living in a rented home for 10 years
Initial Investment: Down payment was used to purchase the home	**Initial Investment:** Down payment equivalent was invested in a diversified portfolio
Wealth Composition: Proceeds from home sale after paying off remaining mortgage + Any additional investments and savings	**Wealth Composition:** Initial investment portfolio value after 10 years + Any additional investments and savings

The Question

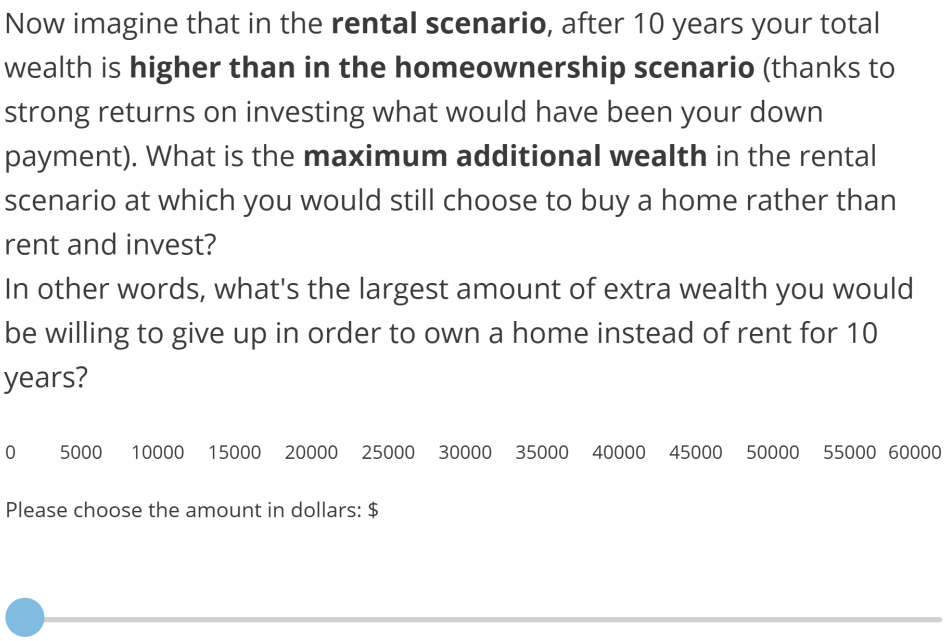
Assume that 10 years after your original housing decision, **your total wealth in both scenarios (homeownership and renting) is exactly the same** (after accounting for all costs and investment returns in each scenario). Given this assumption, if you could go back in time to when you made your original housing decision, would you choose to rent and invest instead of buy?

- (●) I would still choose to buy
- ( ) I would choose to rent and invest
- ( ) I'm indifferent between the two options

Figure C.5: WTP Distribution



Notes: The figure reports the histogram of willingness-to-pay as a share of the respondent's own rent or imputed rent. We winsorize the top and bottom 2.5% of observations.



D.4 Results With WTP Scaled by Own Rent

Table C.5 reports regressions of WTP scaled by actual or equivalent rent on homeownership.

Table C.5: Willingness-to-pay to Own and Homeownership

Dep. var.:	WTP to own/Own rent (%)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Owner	15.0**	14.3**	16.7**	16.9**	16.7**	15.9**	17.9**	12.0**
	(1.9)	(1.7)	(1.8)	(1.9)	(2.6)	(1.7)	(2.0)	(1.1)
Identical house	-1.2	-1.4	-1.7	-1.6	-3.5	-2.4	-1.7	-0.9
	(2.0)	(1.8)	(2.0)	(2.0)	(2.7)	(2.0)	(2.3)	(1.3)
Loop	0.4	2.2	0.7	1.0	2.0	-0.8	0.2	0.1
	(2.2)	(2.2)	(2.2)	(2.3)	(3.3)	(2.0)	(2.5)	(1.2)
Constant	2.7+	4.1**	3.4*	3.4*	7.5**	5.0**	3.5*	4.4**
	(1.6)	(1.4)	(1.5)	(1.6)	(2.1)	(1.4)	(1.7)	(1.0)
WTP$< 100k$	✓							
Winsorized 2.5/97.5		✓	✓	✓	✓	✓	✓	
Winsorized 10/90								✓
Baseline sample			✓	✓		✓	✓	✓
No 18-24 year-olds				✓				
Confidence weighted					✓			
No age reweight						✓		
Addl. attention check							✓	
Observations	978	993	699	655	958	699	548	699

Notes: The dependent variable is the willingness-to-pay (WTP) to own scaled by the respondent's rent or self-reported owner's equivalent rent. Column (1) excludes respondents who reported a WTP greater than $25,000 per year. Columns (2)-(7) winsorize the dependent variable at the 2.5 and 97.5 quantiles. Column (8) winsorizes the dependent variable at the 10 and 90 percentiles. Baseline sample excludes respondents who reported No (confused) or No (misclicked) to the question on valuation accuracy. Confidence weighted weights by self-reported confidence the answer. No age reweight does not reweight the sample to match the SIPP age distribution. The additional attention check excludes respondents who failed the first attention check. The variable Identical house is an indicator for the hypothetical specifying an identical property in terms of location, size, quality, and features. Loop is an indicator for answering the WTP question using a loop instead of a slider. Heteroskedastic-robust standard errors in parentheses.

D.5 Mis-reporting and Results From Follow-up Survey

D.5.1 Follow-up Survey

We launched an approximately 15 minute follow-up survey five weeks after the main survey.[3] We made the follow-up survey available to a randomly-selected 300 respondents of the main survey, excluding respondents who reported their WTP did not reflect their true valuation (whom we exclude from our baseline sample) and 89 respondents newly ineligible to participate in Prolific surveys because they are not U.S. nationals. We received 230 responses, for an overall response rate of 77%. We exclude one respondent who finished the survey in less than one minute (the next shortest response time is 00:03:40) and six respondents who did not complete the WTP portion, leaving 223 responses, or 74% of the potential sample.

The selected respondents were not told this survey was related to our earlier survey. To mask

[3]Specifically, we collected the main survey on January 9, 2025, the short follow-up to obtain numeric values for those who chose the slider or loop maximum over January 16-22, 2025, and launched the main follow-up on February 21, 2025.

any connection, the follow-up survey asked a series of questions about different trade-offs around living arrangements. For example, homeowners were asked in order: (i) their typical commute time; (ii) open-ended question about their decision to live with that commute; (iii) a WTP for a 10 minute reduction in commute time; (iv) an explanation of that amount; (v) the WTP to own question shown below including related open-ended questions; (vi) to select and explain household tasks done by a paid employee versus self; (vii) hobbies; (viii) outdoor space; (ix) number of bedrooms; a trade-off between indoor and outdoor space.

To assess whether interviewer bias might contaminate the follow-up, we asked respondents about what they thought was the purpose of the survey and whether any questions stood out as especially important. No respondent mentioned a connection to the earlier survey. Several mentioned that they found thinking through the various trade-offs as interesting and novel, suggesting they did not have explicit recall of the survey from five weeks earlier.

The WTP to own question was similar to but simpler than the version shown on the original survey. Figure C.6 shows the question for owners. We followed this question with a slider from \$0 to \$100,000 for the additional wealth required to induce the respondent to switch tenure.

The correlation coefficient between the WTP in the original survey (in dollars) and in the follow-up is 0.50. Restricting the sample to respondents who did not answer the short survey in the interim results in a correlation coefficient of 0.48. Thus, we find a meaningful correlation of responses across surveys.

D.5.2 Interpretation

To interpret the differences across the original and follow-up surveys, we provide the following cognitive uncertainty framework. An individual with a true value $\theta_i \sim N(\mu_\theta, \sigma_\theta^2)$ receives a signal of her true preference of $\theta_i + e_i$, with $e_i \sim N(0, \sigma_e^2)$ drawn independent of θ_i. The signal-to-noise ratio is:

$$b = \frac{\sigma_\theta^2}{\sigma_\theta^2 + \sigma_e^2}.$$

We consider two cases.

Case 1: naive. Individuals who do not recognize their cognitive uncertainty simply report $\hat{\theta}_i = \theta_i + e_i$. Then:

1. A regression of $\hat{\theta}$ on homeownership yields an unbiased coefficient of the true relationship. This result follows because e_i adds classical left hand side measurement error.

2. The cross-sectional variance is $Var\left(\hat{\theta}_i\right) = \sigma_\theta^2 + \sigma_e^2 = \sigma_\theta^2/b$. Thus, measurement error causes the cross-sectional variance to be inflated by a factor $1/b$.

3. If we elicit two values $\hat{\theta}_i^1$ and $\hat{\theta}_i^2$ for each individual with independent measurement error, then $Corr\left(\hat{\theta}_i^1, \hat{\theta}_i^2\right) = b$.

Case 2: sophisticate. An individual aware of her cognitive uncertainty shrinks her signal toward the mean and reports $\hat{\theta}_i = \mu_\theta + b(\theta_i + e_i - \mu_\theta)$. Then:

1. A regression of $\hat{\theta}$ on homeownership yields a coefficient attenuated by a factor b.

Figure C.6: Survey Follow-up WTP Text

*Think back to when you bought your home. Imagine that at the time, you ha
options:

1. **Buy a Home:**
    - Make down payment
    - Take out a mortgage
    - *Live there for 10 years, then sell*
2. **Keep Renting:**
    - Invest the down payment in a diversified portfolio
    - *Rent for 10 years*

Suppose after 10 years, **your total wealth would be exactly the same in scenarios** (accounting for all costs, home sale proceeds, and investment returns).
Which would you choose?

- ◯ Buy a home
- ◯ Keep renting and invest
- ◯ I would be indifferent

2. The cross-sectional variance is $Var\left(\hat{\theta}_i\right) = b^2\sigma_\theta^2 + \sigma_e^2 = b\sigma_\theta^2$. Thus, measurement error causes the cross-sectional variance to be attenuated by a factor b.

3. If we elicit two values $\hat{\theta}_i^1$ and $\hat{\theta}_i^2$ for each individual with independent measurement error, then $Corr\left(\hat{\theta}_i^1, \hat{\theta}_i^2\right) = b$.

Comparing across both cases, we have the following conclusions:

1. A regression of $\hat{\theta}$ on homeownership yields a weakly attenuated coefficient.

2. The cross-sectional variance $Var\left(\hat{\theta}_i\right)$ maybe larger or smaller than the true variance but is bounded (in the case of uncorrelated measurement error) by b and $1/b$.

3. $Corr\left(\hat{\theta}_i^1, \hat{\theta}_i^2\right) = b$. Using our survey, we thus have $b \approx 0.5$.

E SIPP Mover Analysis

This appendix describes our analysis of the SIPP. Unlike most government surveys (including the CPS, ACS, and AHS), the SIPP follows individuals who move from the originally-sampled address.

We use the 2014-2021 panels, which cover the years 2013-2020. We use 2020 only to compute moving rates for the last few months of 2019.

We define a move as a change in residence (variable `ERESIDENCEID`). The SIPP contains its own edited mover variable (`TMOVER`). In nearly all cases, `TMOVER` coincides with a change in residence. U.S. Census Bureau (2021, p. 64) explains the discrepancies: "However, in a small number of cases a change in `ERESIDENCEID` from one month to another may not be reflected on `TMOVER` and `TRESDUR`. In these instances, a respondent has changed residences from one month to another but reports always living at the residence he or she has moved to on the reason for move variable (`EEHC_WHY`). Because respondents' own definitions of what constitutes a move may differ from how the SIPP survey identifies a move, we have chosen to leave these apparent inconsistencies in the data." We use changes in residence directly in order to compute moving rates across horizons greater than 1 month. The variable `EEHC_TEN` determines whether a residence is owned or rented.

To focus on moves likely to involve a change in title or lease contract at the original residence, we restrict the sample to reference persons (`ERELRPE`=1,2), which U.S. Census Bureau (2021, p. 161) defines as "an owner or renter of record." If a household splits into multiple residences (for example, a child moves into her own apartment), we keep only the reference person in the original unit. We further restrict the sample to residences defined as houses or apartments (`TPRVLVQRT`=1). We compute statistics weighted by the monthly sample weight (`WPFINWGT`).

The size of the SIPP sample varies over time. There also is seasonality in moving hazards. To address these issues, we compute population shares and moving hazards by month, take averages for each of the 12 calendar months, and finally take averages over the calendar months.

Table E.1 reports population shares and moving hazards by whether the move involves a change in tenure.

F House Price, Rent, and Mortgage Rate Forecasts

We obtain forecasts of house price and rent growth using a Bayesian vector autoregression (BVAR). House price expectations are notoriously unruly (Shiller and Thompson, 2022; Kuchler, Piazzesi

Table E.1: Moving Rates

	Population share			Hazard rate		
	1 month	3 month	12 month	1 month	3 month	12 month
Rent stayer	33.80	32.43	26.41	98.47	95.28	81.48
Rent-to-rent	0.40	1.21	4.45	1.16	3.56	13.75
Rent-to-own	0.13	0.39	1.54	0.37	1.16	4.77
Own stayer	65.41	65.16	64.74	99.60	98.78	95.78
Own-to-rent	0.10	0.30	0.98	0.15	0.46	1.45
Own-to-own	0.16	0.50	1.87	0.25	0.76	2.77

Notes: the table shows the population share and hazard rates for 1-month, 3-month, and 6-month moves. The sample consists of household reference persons in the SIPP panels covering 2013-2019. For households with multiple residences and reference persons in a reference year, we keep only the original reference person. We construct population shares and hazard rates by month, take averages for each of the 12 calendar months, and finally take averages over the calendar months to account for uneven sample sizes and seasonality.

Table E.2: Moving Rates Age 25-34

	Population share			Hazard rate		
	1 month	3 month	12 month	1 month	3 month	12 month
Rent stayer	60.33	57.07	42.66	97.73	92.96	71.56
Rent-to-rent	1.07	3.32	12.72	1.74	5.39	21.30
Rent-to-own	0.33	1.01	4.26	0.53	1.65	7.14
Own stayer	37.88	37.39	36.05	98.98	96.84	89.29
Own-to-rent	0.22	0.64	1.89	0.58	1.67	4.71
Own-to-own	0.19	0.58	2.42	0.50	1.51	6.00

Notes: the table shows the population share and hazard rates for 1-month and 3-month moves. The sample consists of household reference persons in the SIPP panels covering 2013-2019. For households with multiple residences and reference persons in a reference year, we keep only the original reference person. We construct population shares and hazard rates by month, take averages for each of the 12 calendar months, and finally take averages over the calendar months to account for uneven sample sizes and seasonality.

Table E.3: Moving Rates Age 35-44

	Population share			Hazard rate		
	1 month	3 month	12 month	1 month	3 month	12 month
Rent stayer	41.04	39.38	32.02	98.37	95.05	80.17
Rent-to-rent	0.51	1.53	5.67	1.23	3.70	14.23
Rent-to-own	0.17	0.52	2.24	0.40	1.25	5.60
Own stayer	57.99	57.71	56.82	99.51	98.52	94.58
Own-to-rent	0.12	0.33	1.10	0.20	0.57	1.84
Own-to-own	0.19	0.54	2.16	0.32	0.92	3.59

Notes: the table shows the population share and hazard rates for 1-month and 3-month moves. The sample consists of household reference persons in the SIPP panels covering 2013-2019. For households with multiple residences and reference persons in a reference year, we keep only the original reference person. We construct population shares and hazard rates by month, take averages for each of the 12 calendar months, and finally take averages over the calendar months to account for uneven sample sizes and seasonality.

Table E.4: Moving Rates Age 45-54

	Population share			Hazard rate		
	1 month	3 month	12 month	1 month	3 month	12 month
Rent stayer	31.33	30.35	26.03	98.74	96.20	84.89
Rent-to-rent	0.30	0.89	3.45	0.96	2.83	11.33
Rent-to-own	0.11	0.31	1.16	0.34	0.98	3.78
Own stayer	68.05	67.79	66.98	99.68	99.02	96.56
Own-to-rent	0.10	0.26	0.82	0.15	0.38	1.18
Own-to-own	0.14	0.41	1.56	0.20	0.60	2.26

Notes: the table shows the population share and hazard rates for 1-month and 3-month moves. The sample consists of household reference persons in the SIPP panels covering 2013-2019. For households with multiple residences and reference persons in a reference year, we keep only the original reference person. We construct population shares and hazard rates by month, take averages for each of the 12 calendar months, and finally take averages over the calendar months to account for uneven sample sizes and seasonality.

Table E.5: Moving Rates Age 55-64

	Population share			Hazard rate		
	1 month	3 month	12 month	1 month	3 month	12 month
Rent stayer	24.83	24.19	21.33	99.00	96.86	86.86
Rent-to-rent	0.19	0.57	2.35	0.74	2.31	9.63
Rent-to-own	0.08	0.21	0.86	0.32	0.83	3.51
Own stayer	74.69	74.31	72.78	99.69	99.05	96.45
Own-to-rent	0.08	0.23	0.84	0.11	0.31	1.11
Own-to-own	0.17	0.49	1.84	0.22	0.65	2.44

Notes: the table shows the population share and hazard rates for 1-month and 3-month moves. The sample consists of household reference persons in the SIPP panels covering 2013-2019. For households with multiple residences and reference persons in a reference year, we keep only the original reference person. We construct population shares and hazard rates by month, take averages for each of the 12 calendar months, and finally take averages over the calendar months to account for uneven sample sizes and seasonality.

Table E.6: Moving Rates Age 65-79

	Population share			Hazard rate		
	1 month	3 month	12 month	1 month	3 month	12 month
Rent stayer	19.57	19.21	17.76	99.24	97.54	90.54
Rent-to-rent	0.12	0.36	1.41	0.59	1.85	7.26
Rent-to-own	0.05	0.12	0.43	0.24	0.63	2.19
Own stayer	80.07	79.61	78.15	99.73	99.13	97.19
Own-to-rent	0.06	0.17	0.61	0.07	0.21	0.76
Own-to-own	0.17	0.53	1.65	0.21	0.66	2.06

Notes: the table shows the population share and hazard rates for 1-month and 3-month moves. The sample consists of household reference persons in the SIPP panels covering 2013-2019. For households with multiple residences and reference persons in a reference year, we keep only the original reference person. We construct population shares and hazard rates by month, take averages for each of the 12 calendar months, and finally take averages over the calendar months to account for uneven sample sizes and seasonality.

and Stroebel, 2023). Our objective is not to resolve this debate using a BVAR. Rather, the purpose is to obtain a set of plausible forecasts, at each forecast horizon and for a long time series, that can be fed into our model to obtain a historical price index. Future work may improve on our statistical method or incorporate survey evidence.

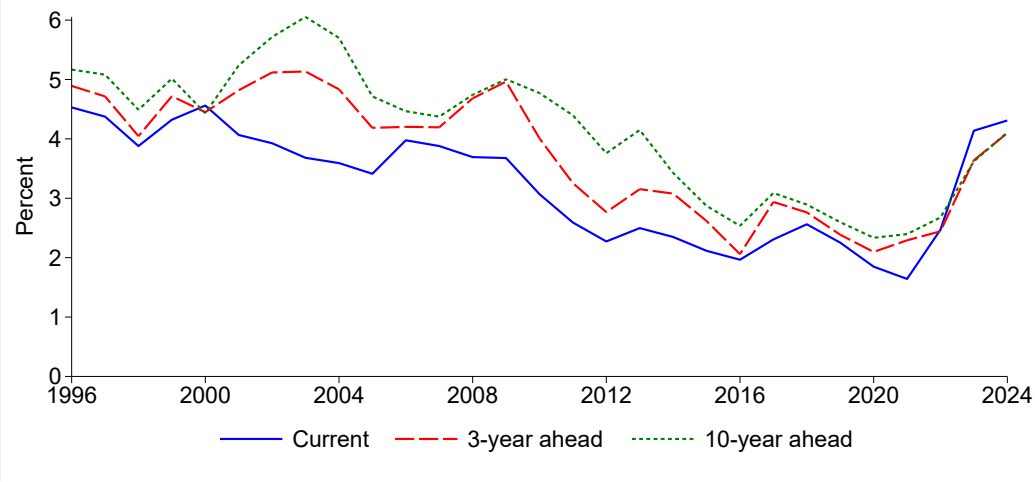
We construct a monthly data set that spans 1988-2025. Let $Y_t = \left(\log P_t^H, \log R_t, i_t\right)'$, where P_t^h is the real house price, R_t is real rent, and i_t is the real mortgage interest rate. We measure $\log P_t^h$ as the log of the Case-Shiller national house price index (FRED code CSUSHPISA) less the log of the non-shelter CPI (FRED code CUSR0000SA0L2) and $\log R_t$ as the log BLS primary rent index (FRED code CUSR0000SEHA) less non-shelter CPI.

We measure i_t as follows. We obtain the nominal mortgage interest rate as the Freddie Mac 30 year mortgage interest rate (FRED code MORTGAGE30US). We obtain expectations of the nominal mortgage rate from rolling 10 year projections of the mortgage rate on Treasury forward rates up to 15 years out from the updated Gürkaynak, Sack and Wright (2007) data set. Let S_{t+j} denote the share of mortgages originated at date t that remain in force at date $t+j$ (i.e. the mortgagee has not refinanced or moved). Consistent with our steady state calibration, we assume 4.2% of owners sell and a fraction $\xi = 23.4\%$ of mortgagees with a contract rate below the current mortgage rate refinance. We then have the law of motion $S_{t+j} = (1 - 0.042)\left(1 - \mathbb{P}_t\left\{i_{t+j} < i_t\right\} \times \xi\right) S_{t+j-1}$. We incorporate uncertainty into the mortgage rate forecast by assuming $i_{t+j} \sim N\left(\mathbb{E}_t\left[i_{t+j}\right], 0.015^2\right)$, where the forecast error standard deviation of 1.5p.p. is based on the time series of forecast errors. This gives a sample median expected mortgage duration of 9 years, with values as low as 5 years in years where the expected future mortgage rate is less than the current rate and values as high as 15 years when the expected mortgage rate is above the current rate. Given an expected mortgage duration of τ, we define the real mortgage interest rate as $1 + i_t = (1 + \text{nominal mortgage rate})/(1 + \mathbb{E}_t \pi_{t,\tau})$, where $\mathbb{E}_t \pi_{t,\tau}$ denotes expected inflation between t and $t+\tau$ from the Federal Reserve Bank of Cleveland. Effectively, we assume that mortgage interest rates are par yields and obtain the real mortgage rate as the par yield if there were no underlying inflation. Allowing for deviations from the par yield assumption does not meaningfully change the real mortgage rate series. Figure E.1 displays the current, 3-year ahead, and 10-year ahead forecasts of the real mortgage rate. Until about 2015, these forecasts reflect anticipated reversion of mortgage rates to higher levels than current. From about 2016 to the end of the sample, in contrast, rates are viewed as quite persistent.

We assume that the data are first-difference stationary with trend growth of house prices and rents of 1%, as in our model's steady state. Thus, let $\tilde{\Delta} Y_t = Y_t - Y_{t-1} - \begin{pmatrix} 0.01 & 0.01 & 0 \end{pmatrix}'/12$ denote the first difference of Y_t less the trend. For each month T starting with January 1996, we estimate the BVAR $\tilde{\Delta} Y_t = \sum_{\ell=1}^{12} B_\ell \tilde{\Delta} Y_{t-\ell} + e_t$ for a sample with all $t \leq T$ and a standard Minnesota-style prior. (Note that this specification does not include a constant term, as we already removed trend growth.) Specifically, the slope coefficients $\{B_\ell\}$ have a multivariate normal prior with zero mean (implying a random walk with trend in levels) and block-diagonal covariance matrix with entries $(\lambda_1/\ell^{\lambda_3})^2$ on the main diagonal and $(\hat{\sigma}_i^2/\hat{\sigma}_j^2) \times (\lambda_1 \lambda_2/\ell^{\lambda_3})^2$ for variables $i \neq j$ off the main-diagonal but with the same lag, where $\hat{\sigma}_i^2$ denotes the single variable empirical error variance. We set $\lambda_1 = 0.05, \lambda_2 = 0.5, \lambda_3 = 1$. The residuals e_t have an inverse-Wishart prior.

We define the dynamic forecast for growth at horizon h, $\mathbb{E}_T \tilde{\Delta} Y_{T+h}$, as the median of the posterior distribution of dynamic forecasts at horizon h. Summing these growth forecasts and adding back the trend gives the cumulative expected log change $\mathbb{E}_T\left[Y_{T+j} - Y_T\right] = \sum_{h=1}^{j} \mathbb{E}_T \tilde{\Delta} Y_{T+h} + \begin{pmatrix} 0.01 & 0.01 & 0 \end{pmatrix}' \times j/12$. We keep the $12, 24, 36, \ldots, 180$ month-ahead forecasts. We average these forecasts across months in the calendar year to obtain forecasts at annual frequency. Figure E.2

Figure E.1: Real Mortgage Rate Forecasts



Notes: the figure shows the mortgage rate forecasts at the horizons indicated.

displays the forecasts for one-year house price and rent growth over the next year, three years ahead, and ten years ahead. Notably, short-run house price expectations are much more volatile than rent expectations but dissipate quite rapidly. The one-year forecasts reflect BVAR expectations of short-run momentum in house prices, with higher expected growth near the peak of the early 2000s housing boom in 2004-06, the start of the housing rebound in 2013-14, and the COVID boom in 2021, and expectations of negative growth during the 2007-12 housing bust.

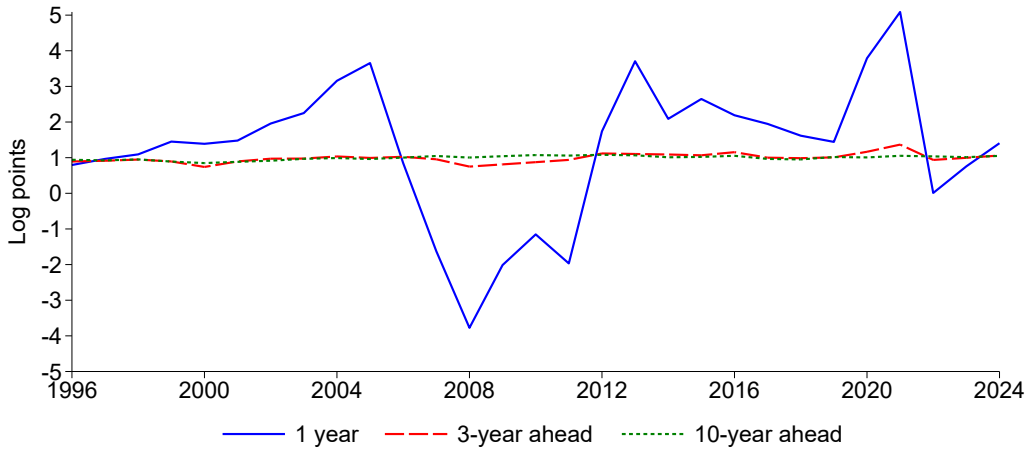
Figure E.3 compares the BVAR forecasts of log point changes in real house prices over the next year and three years ahead to forecasts at the same horizons in the Federal Reserve Bank of New York Survey of Consumer Expectations (SCE).[4] For expositional clarity, we demean each series over the overlapping sample of 2013-2025. Three main features stand out. First, in both the BVAR and the SCE, the three-year ahead forecast is substantially attenuated relative to the one-year forecast. The Bayesian shrinkage of the VAR coefficients is crucial to achieving this attenuation; in fact, without the Bayesian shrinkage in a few months T the VAR coefficients would not satisfy the stability criterion and hence imply wild long-run forecasts. Second, the BVAR and SCE 1-year forecasts have similar time series patterns. Both of these features provide some external validation to the BVAR. The main exception to the time series overlap is 2020, when the BVAR forecast rises and the SCE forecast falls. Given the complicated within-year timing in 2020 and the fact that the BVAR does not know about COVID, we find this miss excusable. Third, the one-year forecasts have different means over the overlapping sample period, with the sample average forecast from the BVAR above the one-year forecast from the SCE. This difference could reflect different non-housing price deflators (non-shelter CPI in the BVAR, unspecified in the SCE), the tendency of households to over-estimate general price inflation and hence under-estimate real house price growth, or some other factor.

We make three final comments. First, the rolling estimation implies that the forecasts use only data available in real-time (with the caveat that we use the published versions of the data as of August 2025 and not the real-time releases). Second, the estimation in first differences does not constrain the levels of house prices, rents, and mortgage rates to obey any cointegrating

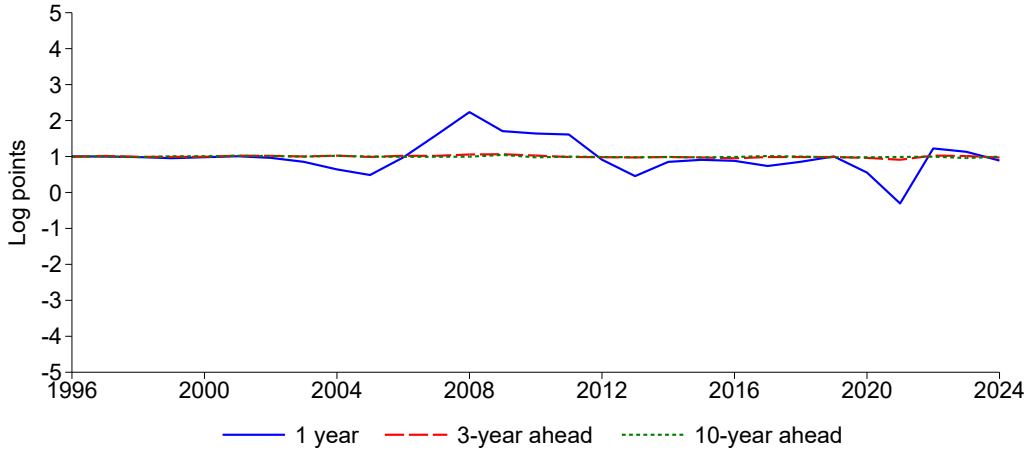
[4]The SCE forecast lines are the median of the SCE main module house price point forecasts at each horizon less the median of the SCE inflation forecast at the same horizon, averaged across calendar months in the year.

Figure E.2: House Price and Rent BVAR Forecasts

(a) House Prices



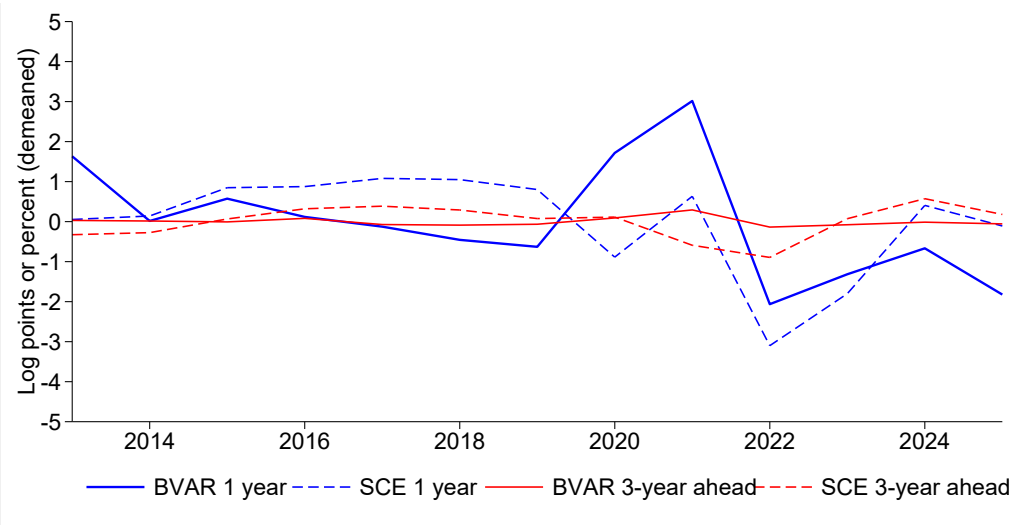
(b) Rents



Notes: the figure shows the BVAR forecasts of log point changes in real house prices and rents at the horizons indicated, inclusive of trend growth.

relationships. Given the large swings in the price-rent ratio during our sample and the ongoing debate over its origins, we view this flexibility as a virtue. Third, we do not obtain mortgage rate forecasts from the VAR, but rather directly from the Treasury yield curve and inflation expectations, as explained above.

Figure E.3: House Price Forecasts Versus SCE



Notes: the figure compares the BVAR forecasts of log point changes in real house prices at the one and three-year horizons (not cumulative) to forecasts at the same horizons in the Federal Reserve Bank of New York Survey of Consumer Expectations.