House Price Perceptions and the Housing Wealth Effect*

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Abstract

In this paper, I determine the impact of household house price perceptions on the housing wealth effect. I build a structural model of consumption and housing with endogenous home ownership choice, where house price perceptions differ by home ownership status: renters are fully informed about house price changes, but owners are not. I find that the average marginal propensity to consume out of housing wealth (MPCH) is 2.7 cents in a year out of a $1 housing wealth increase for owners, and this effect is approximately twice as large for owners with full information, on average. Along the cross-section of households, the MPCH is largest for owners who face the highest liquidity and debt constraints, as well as for renters who are most likely to want to purchase a home. I further apply my model to examine the effects of house price perceptions on the transmission of a monetary policy tightening event. I determine that the debt and house price channels become increasingly important in the consumption response compared to the saving channel when the probability of updating perceptions rises in the economy. Focusing on the house price channel, my model predicts that the effectiveness of monetary policy transmission increases at higher levels of perception updating probability.

Key words: housing wealth effect, expectations, consumption, borrowing, house prices, monetary policy
JEL Codes: G51, G4, E21, E52

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1 Introduction

The housing wealth effect, defined as the consumption change of households in response to a change in their housing wealth, is central to our understanding of how the housing market affects the broader economy. In terms of policy, the responsiveness of household consumption to house price changes represents one of the central asset price channels of monetary policy transmission available to central banks. Even though a number of empirical and theoretical papers have focused on quantifying the housing wealth effect[1], the literature assumes that households fully perceive, so are fully informed of and attentive to house price changes and the resulting change in their own housing wealth, and consequently decide whether to change their consumption or not[2].

However, there is a growing literature that examines how households deviate from the full information paradigm and how they are not fully attentive to changes in economic variables and asset prices[3]. Households' perceptions with respect to house prices in particular are of special interest, because of the information structure of the housing market: households perceive house price changes differently by home ownership status, since the information structure of housing leads renters to observe price changes through their rent payments, whereas owners do not receive the same information[4].

In this paper, I determine the effect of household perceptions of house price changes on the housing wealth effect. I follow a structural approach, in which I incorporate perceptions in a structural model of consumption and housing, with endogenous homeownership choice. I model perceptions such that they differ by home ownership status: renters are fully informed about house price changes, but owners are not. Specifically, owners perceive house price changes driven by business cycle dynamics that are correlated with their income, but perceive house price changes that are independent to the business cycle only occasionally. My model therefore allows me to quantify the housing wealth effect and the impact of perceptions on the effect, as well as study the consumption response to changes in housing wealth along the cross-section of households. I further apply my framework to examine the effects of house

[1] Average estimates of the marginal propensity to consume out of housing (MPCH) vary significantly in the literature, as estimated by Mian et al. (2013), Aladangady (2017), Paiella and Pistaferri (2017), Guren et al. (2020), Disney et al. (2010), Graham and Makridis (2023) among others.

[2] Carroll et al. (2011) consider the excess smoothness of aggregate consumption growth, but by instrumenting current aggregate consumption growth with predicted consumption growth from past realizations.

[3] Examples include Anagol et al. (2021) who examine how randomly experienced noise drives household investment in the stock market, Abel et al. (2013) show that consumers pay selective attention to the stock market because of the information costs involved and Roth and Wohlfart (2020) present empirical evidence suggesting that households are inattentive and have imperfect information of economic variables.

[4] Kindermann et al. (2021) focus on the house price expectation formation of owners and renters, referred to by Kuchler et al. (2022) in their review as well.

price perceptions on monetary policy transmission.

Using the American Community Survey and the NYFed Survey of Consumer Expectations, I begin the analysis by documenting 3 stylized facts. First, household perceptions of annual house price changes at the metropolitan level track actual annual house price changes, but underreact with respect to the size of the changes. When regressing perceived changes to actual, I estimate a coefficient of only 34%. Second, I show that this underreaction increases monotonically in absolute value for greater annual house price changes with respect to their historical standard deviation. The interpretation of this relationship is that households exhibit a degree of 'stickiness' in their perceptions, as both positive and negative house price changes are perceived to be smaller in absolute value than they are. Third, I trace out the term structure of expectations for owners and renters separately and find that both groups extrapolate their expectations of future house prices and rents respectively. Renters appear to do so more than owners.

I then move on to develop a structural model, which builds on the basic infinite horizon permanent income hypothesis model. I solve the model in partial equilibrium, with households deciding their non-housing and housing consumption based on their CRRA utility function and with their income subject to idiosyncratic and aggregate productivity shocks. Households are allowed to borrow, are subject to collateral and liquidity constraints, and make an endogenous housing decision between owning and renting. The novel feature in my model is the inclusion of house price perceptions. Renters' perception of house prices and house price changes track the actual values exactly, whereas owners perceive only house price changes that co-move with the aggregate component of their income, but perceive house price changes that are independent to the business cycle only occasionally. In terms of house price expectations and house price perceptions for non-updaters, households extrapolate house prices based on their last observed house price level and annual growth rate.

The parameters that define house price dynamics and house price perceptions are all estimated in partial equilibrium, outside the model. Specifically, the frequency with which owners update the component of house price growth that is independent to the business cycle is calibrated in partial equilibrium using the stylized facts. For the actual house price changes independent to the business cycle, the growth rate varies by metropolitan area and follows a Markov process with 3 states: low growth, high growth and no additional growth. The data for calibrating this process is the annual changes of the FHFA HPI at the metropolitan level, that I residualize by regressing the values against the national HPI changes, in order to isolate any national-level business cycle effects. The parameters that cannot be directly observable in the data, so the preference and housing transaction cost parameters, require moments produced from the structural model in order to be identified. Therefore, I estimate these parameters in the model, using the Generalized Method of Moments and empirical data from the Survey of Consumer Finances and the Current Population Survey, for the years 2013-2019. The estimation moments are chosen to reveal households' precautionary savings, their risk aversion, their preference of consumption over housing and the effective cost of completing a housing transaction. With this is mind, I use the quartiles of liquid assets over income for all households, owners and renters separately, debt to income, debt to home value, as well as the moving rate. By estimating the parameters, the model is able to produce moments that closely track the empirical counterparts.

After successfully matching the empirical moments, I perform an additional exercise in order to check the external validity of my model's predictions, particularly with respect to the primary moment that I want to study: the housing wealth effect. In order to do this, I choose an empirical context in which house price changes were driven by a source that acted independent to business cycle price variations. This source is the property acquisitions of institutional investors in Single Family Rentals (SFR). I use an instrumental variable approach to isolate the increase in house prices due to institutional investors, as well as to empirically estimate the elasticity of non-housing consumption to house prices. For house price data, I use the FHFA metropolitan HPI and for consumption I use the Kilts-Nielsen consumption data. Importantly, for the institutional investor property acquisition data, I focus on 5 large SFR investors, for whom I extract property portfolio data from their 10-K reports. I show empirically that households do not perceive the statistically and economically significant house price increase of approximately 1% for every 1,000 properties bought by investors in a year. The model prediction successfully matches the magnitude of the empirically estimated elasticity of consumption to a change in house prices, as driven by the investors, for owners and renters respectively.

I now apply the model to focus on the housing wealth effect. Overall, the estimate of the immediate average marginal propensity to consume out of housing (MPCH) is 2.7 cents in a year out of a 1 dollar increase in housing wealth for owners and -2.6 cents in a year out of a 1 dollar increase in house prices for renters. By simulating a counterfactual scenario in which all owners have full information about house price changes, the MPCH for owners is twice as high compared to the baseline prediction. In the cross-section of owners, the largest MPCH is predicted for homeowners with the lowest home values, as well as the largest liquidity and debt constraints. For renters, the ones who are most likely to want to purchase a home have the greatest response.

I continue by applying the model to examine the effects of house price perceptions on monetary policy transmission, by performing a monetary policy tightening experiment and studying the response of consumption one year after the policy shock. In the event of monetary policy tightening, there is a number of aggregate variables modelled in my framework that will be affected within a year after the shock, namely the deposit rate, the lending rate and house prices. Therefore, I proceed in two steps. First, the effects of a policy rate increase on interest rates and local house prices is estimated using local projections. Second, the consumption response to these changes in aggregate state variables is predicted using the estimated model.

The first result of the experiment shows how the transmission of monetary policy through the available channels differs based on the house price perception updating probability in the economy. The possible transmission channels in my model is the savings channel, the debt channel and the house price channel. I find that, as the perceptions updating probability increases, the savings channel becomes less determinant to the consumption response out of a policy shock and the debt and house price channels become more prominent, with the debt channel being the main driver of the consumption response when the probability that a household perceived the policy shock is high. These differences are mainly driven by the steady state wealth distribution of households with different levels of information rigidities. In an economy with a higher updating probability, more households will observe house price changes more often. As the incentive of household to move will change when house prices change, the better informed a household is, the more likely it is that they decide to move. As moving requires an adjustment cost, in steady state, households with higher updating probabilities will move more often, paying the costs out of their liquid assets. At the same time, because in the period examined house prices grew on average, if a household is better informed, they will be able to borrow higher amounts against their appreciated home values and will on average hold more debt.

Next, I focus on the housing price channel and how monetary policy transmission efficiency varies by updating probability and local house price change. I show that the consumption response of owners resulting from the house price channel increases in magnitude with the updating probability. This finding is as expected, since when more households are well informed, monetary policy is more efficiently transmitted. With respect to house prices, owners decrease their consumption the most when there is a large decrease in local house prices and a large policy shock, and they increase it the most for large house price increases and large shocks. But the consumption change is not symmetric with respect to the house price change, with owners' consumption response being much larger in absolute value out of a positive house price change compared to a negative change.

Finally, I consider the cross-section of households and decompose monetary policy transmission through each of the saving, debt and home price channels for owners and renters. To measure the change in consumption, I take the ratio of the dollar change in consumption due to each channel over the initial consumption level. Hence, in the cross-section, the results are driven by the interaction of each elasticity with the initial value of savings, debt and house prices respectively. Notably, I find that owners' overall consumption change is negative for low cash on hand and positive for high cash households. With respect to the debt channel, the consumption response decreases for increasing cash levels, but is low for the lowest cash decile as well. These households with limited cash are the households with the least valuable houses, and therefore the ones who will have very limited debt capacity and small debt balances.

The paper proceeds as follows. Section 2 provides a review of relevant literature, Section 3 presents the intuition behind why house price perceptions are important in estimating the housing wealth effect and Section 4 presents stylized facts on household perceptions of house price changes, as well as evidence on the term structure of expectations of house prices. This evidence informs the development of the model presented in Section 5 and estimated in Section 6. Section 7 focuses on the main untargeted moment of the model: the housing wealth effect. Section 8 discusses the housing wealth effect as predicted by the model, and highlights heterogeneity of the effect for different households, Section 9 decomposes the impact of perceptions on the MPCH for owners and renters respectively. Section 10 applies the model to determine the effects of a monetary policy tightening event in the presence of house price perceptions. Finally, Section 11 concludes.

2 Related Literature

There is a large literature that focuses on the housing wealth effect, estimating it following an empirical or theoretical approach. Considering first the empirical papers on this topic, the common challenge shared between them is that of finding an exogenous change to house prices, in order to isolate the change in consumption as a response to house prices only. The difficulty lies in the fact that house prices are endogenous objects in an economy, where some unobserved macroeconomic shock can affect aggregate productivity, as well as households' incomes and housing wealth simultaneously. Therefore, an attempt to estimate the housing wealth effect after such a shock will give inconsistent estimates.

Empirical papers address this issue by relying on national changes in house prices for the time-series variation in home values, along with geographic variation of these national changes at the local level. The seminal papers by Mian and Sufi (2011), Mian et al. (2013), as well as Saiz (2010) and Gyourko et al. (2008) use the fact that differential land availability and land use regulations will result in different housing supply elasticity across the US, resulting in turn to localities being more of less affected by the variation of house prices over the business cycle. Aladangady (2017) builds on this approach, but also takes into account credit constraints by interacting housing supply with interest rates to use as their instrument for exogenous house price variation. Guren et al. (2020) also rely on housing supply elasticity, but use what they call a sensitivity instrument, based on the systematic historical sensitivity of local house prices to regional housing cycles. A more recent paper by Graham and Makridis (2023) propose yet a different approach to ensure geographic variability of national house price changes, by taking advantage of the variability in the characteristics of local housing stock.

There is significance in choosing business cycle variation in house prices with respect to household perceptions, as a national housing boom or bust will be salient information to households throughout the country. An individual's attention to, and therefore perceptions and expectations of, prices and macroeconomic variables is not constant over time, but state-dependent and endogenous to business cycle variation. Coibion and Gorodnichenko (2015), Gorodnichenko (2008) and Mackowiak and Wiederholt (2012) show that agents' implied sensitivity to information rigidity varies with business cycle conditions or shocks to the aggregate economy. Since the attention to house price changes will differ for changes driven by the business cycle compared to changes that are independent to the business cycle, this needs to be taken into account when estimating the housing wealth effect.

Even more so, perceptions about local house price changes will depend more on households' personal experiences, for which there will be important heterogeneity (Bailey et al., 2018). In addition to this, relying on more salient national house price changes may lead to inconsistent estimates since country-wide house prices are correlated with national credit conditions (Campbell and Cocco, 2007). These considerations are explicitly accounted for in my model, where house prices are driven by both business cycle dynamics and dynamics independent to the business cycle. Households hold their own perceptions about house price changes that are independent to the business cycle, in order to allow correct estimates of the housing wealth effect out of exogenous house price changes.

On the theoretical end of the literature, papers rely on models of household consumption and housing, where the effect of a change in house prices on consumption is isolated by shocking house prices, while holding all other prices and shocks constant. Primary such papers in the literature include Campbell and Cocco (2007) and Attanasio et al. (2009). Until recently, the main challenge had been matching the empirically estimated magnitude of the housing wealth effect. For a model where households make their financial decisions based on the expected net present value of their assets, the permanent income hypothesis would suggest that their consumption response to a change in house prices should be small if any (Sinai and Souleles (2005) and Case et al. (2000) among others).

However, more recent papers have developed models incorporating housing choice, collateralized borrowing, housing adjustment costs and income uncertainty that are able to replicate the empirical findings, such as Berger et al. (2017), since households react more to positive changes in their housing wealth than they do to changes in their expected future rents[5]. My model incorporates all these elements to allow for a realistic setting within which to examine the housing wealth effect, both overall for households, as well as along different household dimensions, such as income level, borrowing capacity, liquid wealth and housing wealth. Moreover, I determine whether my model matches empirically observed consumption elasticities to housing wealth by producing my own estimates from an empirical setting where house prices moved independent to the business cycle, by institutional investor property purchases.

The papers above, both empirical and theoretical, provide estimates of consumption elasticity to housing wealth and marginal propensity to consume that vary significantly, as they use different empirical settings or solve models with different assumptions. However, in all the papers above, it is assumed that households perceive the corresponding change in house prices used and choose to change their consumption to a larger or smaller degree as a response to it. I already discussed how using the business cycle in empirical work for house price variation will lead to investigating the housing wealth effect in selective conditions where households are more attentive than usual. But there is a growing strand of literature which shows that households hold imperfect perceptions about changes in macroeconomic variables (Anagol et al. (2021), Abel et al. (2013) and Roth and Wohlfart (2020) among others).

Importantly, households also seem to adjust their expectations and financial decisions based on their perceptions instead of realizations, as would be expected. For example, Cavallo et al. (2017) find that survey respondents' past recalled price changes were more predictive of expected inflation rates than the corresponding actual inflation changes. Specifically for housing, Adelino et al. (2018) show that individuals who perceive housing as a risky asset are approximately 12% more likely to rent rather than own and are much more likely plan

[5]Theoretical papers have also developed general equilibrium models in order to examine the changes in consumption within the context of a recession, such as is the case with Midrigan and Gorea (2017) and Kaplan et al. (2020).

to rent rather than buy their house when they choose to move.

Focusing on household perceptions, and concurrent expectation formation and financial decisions is of particular interest in the context of housing prices, since there is an observable difference in the way different households are informed about house price growth: their ownership status. Renters observe house price changes and the corresponding cash flows of the housing asset through their rent payments, whereas owners do not. Kindermann et al. (2021) show empirically that, as a result, renters had more accurate average house price expectations during a housing boom event, but also more dispersed. In my model, house price perceptions are modelled differently for owners and renters. Owners update their perceptions of house prices only occasionally, whereas owners update their perceptions in all periods. The calibration of the updating probability is done using household house price perception data and is one of the main stylized facts presented in this paper, which also informs the model setup.

Even without considering the difference between household perceptions and realizations, there is a strand of literature that has examined household house price expectations and their effect on household consumption. Landvoigt (2017) and Kaplan et al. (2020) incorporate beliefs in their respective theoretical models and present their impact. Finally, Browning et al. (2013) and Campbell and Cocco (2007) separate expected from unexpected house price changes using historical price data and quantify the consumption response, and Paiella and Pistaferri (2017) incorporate survey data to quantify the consumption effect of unexpected housing wealth changes.

3 Intuition: House Price Perceptions and the Housing Wealth Effect

In this section, I discuss the intuition behind why house price perceptions are important in determining the housing wealth effect for owners and renters, using a simplified model of consumption and housing.

Set Up: Take two households, one that owns a home and one that rents, who in period t decide their non-housing consumption c_t and housing h_t. The household state variables are their cash on hand m_t and their income y_t. Owners have an additional state variable, their housing wealth w_t. The aggregate state variable is the current house price level P_t^H and the interest rate on savings and debt is r. Each household is subject to a borrowing constraint: $1-\theta$ is the borrowing limit for owners against the value of their house and σ is the maximum allowed debt to income for renters. Renters decisions are also conditional on $\bar{R}$, the rent to price ratio.

Owner's Problem: The owner's consumption and housing today is the solution to the following:

$$v(m_t, y_t, w_t, P_t^H; r,\theta) = \max_{c_t,h_t}\{u(c_t, h_t) + \beta\mathbb{E}_t[v(m_{t+1}, y_{t+1}, w_{t+1}, P_{t+1}^H; r, \theta)]\}$$

subject to:

$$a_t = m_t - c_t \text{ where } -a_t \leq (1-\theta)w_t$$

$$w_{t+1} = h_t P_{t+1}^H$$

$$m_{t+1} = y_{t+1} + (1+r)a_t$$

Optimal Consumption:

$$c^{owner} = c(m_t, y_t, w_t, P_t^H; r, \theta)$$

Optimal Housing:

$$h_{owner} = c(m_t, y_t, w_t, P_t^H; r, \theta)$$

Renter's Problem: The renter's consumption and housing today is the solution to the following:

$$v(m_t, y_t, P_t^H; r, \sigma, \bar{R}) = \max_{c_t}\{u(c_t) + \beta\mathbb{E}_t[v(m_{t+1}, y_{t+1}, P_{t+1}^H; r, \sigma, \bar{R})]\}$$

subject to:

$$a_t = m_t - c_t - \bar{R}P_t^H \text{ where } -a_t \leq \sigma y_t$$

$$m_{t+1} = y_{t+1} + (1+r)a_t$$

Optimal Consumption:

$$c^{renter} = c(m_t, y_t, P_t^H; r, \sigma, \bar{R})$$

House Prices and Consumption: I now take a log-linear approximation of the optimal consumption function for each of the households around the initial steady state. Taking the annual difference as well brings us to the following, staring from owners:

$$\Delta c_{t+1}^{owner} = \alpha_0 + \alpha_1 \Delta w_{t+1} + \alpha_2 \Delta P_{t+1}^H + \alpha_3 \Delta m_{t+1} + \alpha_4 \Delta y_{t+1} + \epsilon_{t+1}$$

w_t is a function of P_t^H, since $w_{t+1} = h_t P_{t+1}^H$ and h_t is the endogenous housing choice. m_t also depends on P_t^H indirectly, through the collateral constraint $a_t \leq (1-\theta)w_t$. The owner will implicitly account for this through the continuation value in their optimization problem. Denoting Δw_{t+1}^{endog} as the change in housing wealth due to a change in h only, I can rewrite the expression for Δc_{t+1}^{owner} as:

$$\Delta c_{t+1}^{owner} = \alpha_0 + \alpha_1 \Delta w_{t+1}^{endog} + \alpha_2 \Delta P_{t+1}^H + \alpha_3 \Delta m_{t+1} + \alpha_4 \Delta y_{t+1} + \epsilon_{t+1}$$

Therefore, we can use this simplified expression to understand how house prices can impact household consumption. For owners, house price changes affect consumption through i) the owner's expectation of future house prices, ii) the tradeoff between housing and non-housing consumption, and iii) the collateral constraint. The housing wealth effect is equal to α_2.

For renters, their consumption depends on future house prices as well, through the continuation value in their optimization problem and their available future option of becoming owners. Thus, the corresponding expression for renters is:

$$\Delta c_{t+1}^{renter} = \beta_0 + \beta_1 \Delta P_{t+1}^H + \beta_2 \Delta m_{t+1} + \beta_3 \Delta y_{t+1} + \eta_{t+1}$$

The housing wealth effect equivalent for renters is equal to β_1.

House Prices Perceptions: Consider now how a household perceives current house prices and their expectations for future house prices. For an owner, the perception of current house prices is denoted as $\tilde{P}_t^H$. Assuming that the owner last observed house prices and house price growth ϕ^H in period $t-n$, their perception of current house prices will be an expectation, conditional on the most recently available information to them: the house price and house price growth in period $t-n$:

$$\tilde{P}_t^H = \mathbb{E}_{t-n}[P_t^H | P_{t-n}^H, \phi_{t-n}^H]$$

Similarly, the owner's expectation of the house price for the next period is conditional on the most recently available information to them, so the expectation of house prices in $t+1$ is $\mathbb{E}_t[P_{t+1}^H | P_{t-n}^H, \phi_{t-n}^H]$.

On the other hand, renters observe changes in house prices through their rent payments, that equal $\bar{R} P_t^H$. As a result, renters observe prices P_t^H and price changes $\phi_{t+1}^H = P_{t+1}^H - P_t^H$ in all periods and their expectations for future house prices are conditional on the most recently available information.

4 Stylized Facts

This section presents stylized facts i) on the relationship between actual and perceived house price changes, ii) on the magnitude of the difference between perceived and actual house price changes, and iii) on expectations of future house prices. Each of these facts provides empirical evidence that informs the model assumptions and particularly how house price perceptions are incorporated in the model.

Throughout the paper, I focus on the period between 2013 and 2019 unless otherwise stated, and I define house price perceptions for owners as how much they think their house is worth and for renters how much they think houses are worth on average in their area. For the perception data used in this section, I use the American Community Survey (ACS) and specifically the response of home owners when asked to estimate how much in their property would sell for if it were for sale at the time of the survey. The data is provided annually as a median value at the metropolitan level, therefore refers to the value of a median-valued home in the area. For households' perceptions of house price changes, I use the annual change in house price perceptions. For the corresponding values of actual house prices, I use the Zillow Home Value Index (ZHVI) at the metropolitan level, which provides the typical $ home value for houses that are in the median range of home values. Similarly to the perceptions data, I use the annual change in the value to calculate the actual annual house price change. Note that the following findings also hold when using the FHFA All-Transactions metropolitan index, that is estimated using sales prices and appraisal data.

For the patterns on house price expectations, I use the New York Federal Reserve Survey of Consumer Expectations. For owners, I use the available information on respondents' expectation about house prices in their zip code one year and five years in the future. For renters, I use data on their expected rent in one and five years in the future. I continue in this section by presenting each of the three stylized facts that inform the modeling of house price perceptions in this paper.

Fact 1. Household perceptions of house price changes track, but underreact to actual house price changes

The first stylized studies the relationship between perceived and actual annual house price changes at the metropolitan level. To determine the relationship, I estimate the following regression:

$$\Delta p_{j,t}^{H,perceived} = \beta_0 + \beta_1 \Delta p_{j,t}^{H,actual} + \xi_j + \zeta_t + \epsilon_{j,t} \tag{1}$$

where $\Delta p_{j,t}^{H,perceived}$ is the household median perceived house price growth at the metropolitan level and $\Delta p_{j,t}^{H,actual}$ is the corresponding median actual house price growth. I run the expression without controls, as well as including ξ_j, the metropolitan area fixed effects and

ζ_t, the year fixed effects. The results are shown in Table 1.

	(1)	(2)
$\Delta p^{H,acutal}$	0.520***	0.339***
	(0.016)	(0.036)
Metro FE	No	Yes
Year FE	No	Yes
Adj. R^2	0.269	0.288
N	2910	2910

Table 1: Household Perceptions of House Price Changes, at the Metropolitan Level. *Notes*: Results for estimating equation 1. House price perceptions data are from the American Community Survey metropolitan-level data and actual house prices are from the Zillow HVI data for median valued homes at the metropolitan level, for years 2013-2019. Column 1 does not include fixed effects, Column 2 includes metropolitan area fixed effects and year fixed effects. Errors are clustered at the metropolitan area level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

Based on the regression estimates and after including fixed effects, I observe that households on aggregate do track actual house price changes in the metropolitan area they live in through their perceptions, but underreact to the magnitude of actual house price changes.

Fact 2. Household perceptions of house price changes are 'sticky'

Next, I investigate whether this underreaction of households to actual house price changes is the same in magnitude for different actual house price changes. I first calculate the historical 1-year standard deviation in the house price growth of each metropolitan area. These values provide the typical, given local historical data, annual house price change and a measure of previously observed house prices. Then, the annual changes over the 2013 to 2019 period are expressed with respect to the corresponding standard deviation. These values in turn provide a measure of how unlikely each data point for a house price change is for the area. For each of these observations, the difference between the perceived house price and the actual house price is calculated. The median difference between perceived an actual is plotted against binned values of annual house price changes, expressed in terms of the standard deviation of local historical house price growth and shown in Figure 1.

The Figure highlights that a) actual house price growth is higher than perceived house price growth for positive actual house price changes, and the reverse is true for actual negative house price changes, and b) this deviation increases monotonically with how larger in magnitude the actual house price change is than the historical data. The interpretation of Figure 1 is that households exhibit a degree of 'stickiness' in their perceptions, as both positive

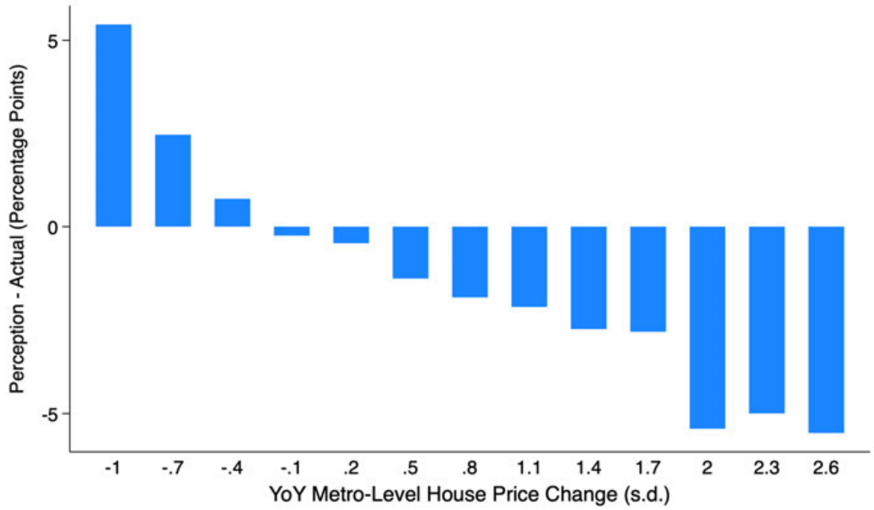


Figure 1: Difference of Perceived - Actual Annual House Price Growth, by Actual Annual House Price Growth Median Home Values, Metro-Level Changes. *Notes*: House price perceptions data are from the American Community Survey metropolitan-level data and actual house prices are from the Zillow HVI data for median valued homes at the metropolitan level, for years 2013-2019.

and negative house price changes are perceived to be smaller in absolute value than they are. From the graph, note that positive house price changes are better represented, since the period of the analysis is during an overall increase in house prices in the US.

This stylized fact provides insight into the perception of house price changes for household that have not updated their perceptions. In order to determine how households who do not update their house price perceptions during some period t, but last did n periods earlier, ideally we would need to have detailed panel data of house price perceptions. The available aggregated data however gives an approximation of the implied qualitative relationship between previously observed house prices and perceptions for current values.

Fact 3: Owners and renters extrapolate their expectations for future prices

For the last stylized fact, I use the available data from the NYFed Survey of Consumer Expectations to trace out the term structure of expectations for owners and renters. With respect to home owners, I use survey information about households' perception of the house price of a typical home in the zip code one year ago, at the time of the survey, as well as each household's expectation about its price one year and five years in the future. These prices are regressed against dummies indicating the year relative to the time of the interview in order to quantify how the perceived house price change over the last year affects households' expectations about house prices in one and five years respectively. In the regression, I also include household controls $X_{i,t}$, commuting zone and year fixed effects ξ_j, ζ_t, and the errors are clustered at the state level. The prices are adjusted for inflation and the observations are weighed by the survey weights, in order to get nationally representative results. The estimated coefficients for each year around the survey are plotted in Figure 2.

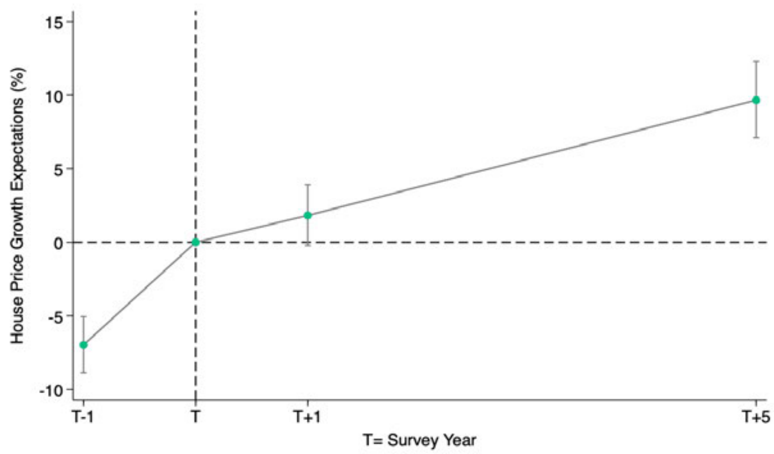


Figure 2: Household house price expectations, owners. *Notes*: The specification includes household controls, commuting zone and year fixed effects. Errors are clustered at the state level. The prices are adjusted for inflation and the observations are weighed by the survey weights, in order to get nationally representative results. Confidence intervals for 95% statistical significance.

From the figure, we see that over the analysis period, households perceived a change in local house prices of around 5% and their expected house price change from today's level is extrapolated to just under 5% for one year and approximately 10% for 5 years out.

With respect to renters, I use the information available on households' rent when they moved in, at the time of the survey, as well as what they expect their rent to be in one and five years in the future. The analogous regression to the one ran for owners is estimated, using the corresponding household controls and fixed effects. Since the past rent information is for when households moved in, but move-in years vary, I focus on households that first rented out their current residence 2 years prior to the interview time. The estimated coefficients are shown in Figure 3.

Note that in the renters' case, although rents on average increased by 2.33% for the survey respondents, they expect an increase of 3.92% in a year and 13.74% in 5 years time compared to today. The above empirical evidence points to the fact that renters not only extrapolate their past experience on their rent changes, but also expect larger rent increases in the future.

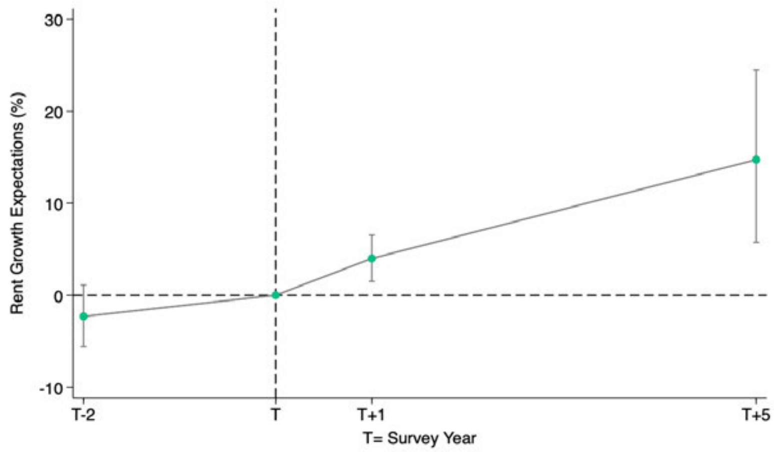


Figure 3: Household house price expectations, renters. *Notes*: The specification includes household controls, commuting zone and year fixed effects. Errors are clustered at the state level. The rent prices are adjusted for inflation and the observations are weighed by the survey weights, in order to get nationally representative results. Confidence intervals for 95% statistical significance.

5 Model

In this section, I develop a structural model, which builds on the basic infinite horizon permanent income hypothesis model. Households decide their non-housing and housing consumption based on their CRRA utility function and with their income subject to idiosyncratic and aggregate productivity shocks. Households are allowed to borrow, are subject to collateral and liquidity constraints, and make an endogenous housing decision between owning and renting. The novel feature in my model is the inclusion of house price perceptions. Renters' perception of house prices and house price changes track the actual values exactly, whereas owners perceive only house price changes that co-move with the aggregate component of their income, but perceive house price changes that are independent to the business cycle only occasionally. In terms of house price expectations and house price perceptions for non-updaters, households extrapolate house prices based on their last observed house price level and annual growth rate. Because the aim of this model is to determine the partial equilibrium household consumption response to a change in house values, interest rates, wages and house prices are exogenously set.

5.1 Household Set Up and Preferences

In the model, the economy is inhibited by a continuum of infinitely lived households, indexed by i. Households face a constant probability of death in each period and when they die they are replaced, with their wealth being proportionally distributed to the surviving households. In each period t, households must choose whether to be renters or home owners, the number of housing units $h_{i,t}$ they want to own, as well as their non-housing consumption $c_{i,t}$. Renters cannot choose their housing units, as they all secure one unit of housing $\bar{h}$ when renting. Note that the housing units $h_{i,t}$ are interpreted as the physical size and the quality of the house, and consumption $c_{i,t}$ denotes units of the consumption good with a price normalized and fixed to one.

Their choice of $c_{i,t}$ and $h_{i,t}$ is such that households maximize their expected lifetime CES utility derived by Constant Relative Risk Aversion preferences over non-housing consumption $c_{i,t}$ and housing services $h_{i,t}$.

$$u(c_{i,t}, h_{i,t}) = \frac{1}{1-\rho}(c_{i,t}^{\alpha} h_{i,t}^{1-\alpha})^{1-\rho} \tag{2}$$

where ρ is the coefficient of relative risk aversion and α is the elasticity of substitution between non-housing consumption and housing. The assumption of the Cobb-Douglas aggregator over housing services and consumption is significant in home owners decision between preferring utility gain from consumption or housing.

5.2 Household Income

Households in each period are endowed with a single unit of labor $l_{i,t}$ that is supplied inelastically and for which they are paid a constant effective wage rate w, which as mentioned earlier is exogenously determined. Household income is then:

$$y_{i,t} = w l_{i,t} \tag{3}$$

The effectiveness of household labor is driven by aggregate and idiosyncratic productivity levels P_t and $p_{i,t}$ respectively, similarly to Carroll et al. (2020).

Aggregate productivity P_t grows by the constant aggregate productivity factor in the economy Γ and is subject to permanent productivity shocks Ψ_t, that are independent and identically distributed with a mean of 1. Therefore, aggregate productivity is:

$$P_{t+1} = \Gamma P_t \Psi_{t+1} \tag{4}$$

Its idiosyncratic counterpart $p_{i,t}$ is also subject to permanent shocks, this time at the idiosyncratic level, $\psi_{i,t}$, which are similarly distributed as Ψ_t, with $\mathbb{E}_t[\psi_{i,t+n}] = \mathbb{E}_t[\Psi_{i,t+n}] = 1$, $\forall n > 0$. So idiosyncratic productivity is defined as:

$$p_{i,t+1} = p_{i,t}\psi_{i,t+1} \tag{5}$$

Effective labor productivity is a function of $p_{i,t}$ and P_t, subject to transitory shocks at the idiosyncratic and aggregate level with $\theta_{i,t}$ and Θ_t. These shocks again are independent and identically distributed with a mean of 1. $l_{i,t}$ equals following:

$$l_{i,t} = \theta_{i,t}\Theta_t p_{i,t} P_t \tag{6}$$

5.3 Liquid Assets

Households have access to a savings account with balance $a_{i,t}$, that evolves according to their income and their decided level of non-housing and housing consumption without incurring any adjustment costs. This account earns a rate of return r^{save}, which equals the risk-free rate r plus some spread $g^{\text{save}} > 0$.

5.4 House Prices and Rents

The house price per unit housing $P^H_{j,t+1}$ fluctuates over time and is driven by business cycle dynamics, as well as other dynamics that evolve independently to the business cycle. All house prices grow by constant growth factor Γ^H and are subject to permanent house price shocks Ψ^H_t. These shocks are perfectly positively correlated with the permanent productivity Ψ_t shocks that impact household income. They shocks are mean one i.i.d. and their correlation to aggregate productivity shocks allows for house prices and aggregate incomes to co-move, as occurs over the business cycle.

In addition to these components, house price growth in each area j is impacted by dynamics independent of the business cycle, which, significantly for the model setup, are uncorrelated to household incomes in the model. This specification permits for the model to be used to predict household financial behavior changes to house prices only, holding all income variation constant. These dynamics are summarized by the growth rate ϕ^H_t that follows a bounded random walk:

$$\Pr[\phi^H_{j,t+1} = \phi^H_{j,k} | \phi^H_{j,t} = \phi^H_{j,n}] = \Xi_{n,k} \tag{7}$$

where k and n are state indices for the corresponding finite Markov chain. The use of a Markov chain for modelling ϕ^H serves the purpose of giving these additional growth rates some but not full predictability. Therefore, if a household does not observe the full time series of ϕ_t, they will still be able to track house price growth, but will underreact to growth changes that they were not attentive to.

By incorporating all the aforementioned components, the price of one unit of housing $P^H_{j,t}$ in area j during period t is governed by the following process:

$$P^H_{j,t+1} = \Gamma^H \Psi^H_{t+1} \phi^H_{j,t+1} P^H_{j,t} \tag{8}$$

This transition equation governs the actual value of a house but not the perceived house value for households that do not update their house price perceptions. The next subsection elaborates further.

The price of rental housing follows house prices, with the ratio of the price of a unit of rental housing $R^H_{j,t}$ over the price of owning a unit of housing $P^H_{j,t}$ in area j defined as $\bar{R}$. Since renters can only gain utility from a single rental housing unit $\bar{h}$, the unit price of rental housing in period t equals the rental flow payment required by renters each period.

$$R^H_{j,t} = \bar{R}\bar{h}P^H_{j,t} \tag{9}$$

5.5 House Price Perceptions

The approach for modelling house price perceptions is informed by the stylized patterns presented in Section 4, from which the following was concluded: i) households track actual house price changes with through their perceptions, but underreact at a degree of about 34%, ii) households exhibit a degree of 'stickiness' in their perceptions, as both positive and negative house price changes are perceived to be smaller in absolute value than they are, and iii) households extrapolate their perception of current house price or rent changes into the future.

Using these facts, along with the intuition presented in Section 3, I can translate the stylized facts into a number of modelling assumptions. The first fact can be used to calibrate the probability π that a household observes house prices and house price growth in the current period, and or else the probability that its perceptions of the values $\tilde{P}^H_{j,t}$ and $\tilde{\phi}^H_{j,t}$ equal the actual values. The probability of updating house price perceptions π can be transformed into an average n value with which households observe actual house price changes, where $\bar{n} = 1/\pi$ and $\bar{n}$ is the average of the parameter.

Then, using the second and third stylized facts, I assume that a household's perception of current house prices is:

$$\{\tilde{P}^H_{j,t}, \tilde{\phi}^H_{j,t}\} = \mathbb{E}_{t-n}[\{P^H_{j,t}, \phi^H_{j,t}\}|P^H_{j,t-n}, \phi^H_{j,t-n}, \Gamma] = \{(\Gamma\phi^H_{j,t-n})^n \Psi^H_t P^H_{j,t-n}, \phi^H_{j,t-n}\} \tag{10}$$

The above equation indicates that, when owners perceive house prices $P^H_{j,t-n}$ and house price growth $\phi^H_{j,t-n}$ n periods before t, they extrapolate and expect that house prices follow the same annual growth rate as the one they last observed n periods ago.

Similarly for expectations of future house prices, households use their last observed values to determine what they expect prices to be:

$$\{\tilde{P}^H_{j,t+1}, \tilde{\phi}^H_{j,t+1}\} = \mathbb{E}_t[\{P^H_{j,t+1}, \phi^H_{j,t+1}\}|\{P^H_{j,t-n}, \phi^H_{j,t-n}\}, \Gamma] = \{(\Gamma\phi^H_{j,t-n})^{n+1} \Psi^H_t P^H_{j,t-n}, \phi^H_{j,t-n}\} \tag{11}$$

Note that household perceptions of actual growth refers to the component of house price changes driven by factors other than the business cycle. Homeowners are assumed to understand national house price growth Γ and observe house price shocks Ψ^H since they are correlated to changes to their income. This choice is made to reflect the second stylized fact on the deviation of perceptions and realized values with respect to the level of the house price change. If households miss-perceived house price general dynamics that vary along the business cycle, the degree to which they miss the real values should have been at the same level no matter the magnitude of actual house price growth.

In the case of renters, house prices and house price growth are observable through changes in their required rent payments, and therefore their perception of house price changes moves in line with actual house price changes, or in other words $n = 0$ in the above equations. So for their house price perceptions, the perceived match the realized values:

$$\{\tilde{P}^H_{j,t}, \tilde{\phi}^H_{j,t}\} = \{P^H_{j,t}, \phi^H_{j,t}\} \tag{12}$$

and their expectations are formed using up to date information from current period t.

$$\{\tilde{P}^H_{j,t+1}, \tilde{\phi}^H_{j,t+1}\} = \mathbb{E}_t[\{P^H_{j,t+1}, \phi^H_{j,t+1}\}|\{P^H_{j,t}, \phi^H_{j,t}\}, \Gamma] \tag{13}$$

5.6 Housing Wealth and Adjustment Costs

In addition to their liquid wealth, home owners also have housing wealth $H_{i,t}$. The value of a house in period t is the product of the price of one unit of housing $P^H_{j,t}$ in the area j where the home owner lives and the number of housing units $h_{i,t}$ the household owns. The actual value of the house depreciates over time by depreciating factor δ and therefore evolves according to:

$$H_{i,t+1} = (1-\delta)h_{i,t}P^H_{j,t+1} \tag{14}$$

Unlike liquid wealth however, the adjustment of housing wealth is costly, rendering it as illiquid wealth. Specifically, households incur a cost proportional to the size of their housing adjustment, captured by their chosen housing units $h_{i,t}$ and to the market price of housing per unit $P^H_{j,t}$. The total adjustment cost is:

$$\kappa_{i,t} = \tau h_{i,t}P^H_{j,t} \tag{15}$$

where τ is the adjustment cost parameter that reflects the necessary down payment in the case of a house purchase or costs involved in selling the property.

5.7 Debt

Households can increase their consumption by borrowing, but their borrowing capacity criteria differ depending on whether they are owners or renters. Owners can borrow using the value of their house as collateral, whereas renters can borrow up to a proportion of their permanent income.

For owners, the maximum amount they can borrow equals $(1-\theta)$ of the current value of their home before depreciation. Therefore θ is the equity that owners have in their home and this collateral constraint is equivalent to a LTV constraint on homeowner borrowing. The constraint is:

$$-a_{i,t} \leq (1-\theta)h_{i,t}P^H_{j,t} \tag{16}$$

For renters, as they have no collateral to borrow against, their collateral constraint is determined against their permanent income and is chosen to be similar to a DTI constraint that households typically face. The DTI limit is σ, so for renters the borrowing limit is:

$$-a_{i,t} \leq \sigma p_{i,t} P_t \tag{17}$$

In either the owner or renter case, debt adjustment has no additional cost for the household, as long as they meet their LTV and DTI requirements respectively. The interest rate on debt is common for owners and renters, denoted as $r^{\text{borrow}} > 0$ and equals the risk-free rate r plus some spread g^{borrow}. Note that $g^{\text{borrow}} > g^{\text{save}}$, so that $r^{\text{borrow}} > r^{\text{save}} > r$ as would be expected. Because $r^{\text{borrow}} > r$ and the existence of the borrowing constraints, the only case in which it would be optimal for households to borrow is if they have depleted their liquid assets, when the borrowing amount is equal to $-a_{i,t}$.

6 Estimation

This section details the procedure followed for the estimation of the model parameters, and presents the parameter values and how the model predictions fit the data. The model is solved at an annual frequency and the period used to estimate the model is between 2013 to 2019, similarly to the empirical facts in Section 4. The model estimation follows two main steps. The first step involves the estimation or calibration of parameters that can be identified without using the model, which are all parameters that describe house price changes that are independent to the business cycle and the corresponding house price perceptions, as well as institutional characteristics relevant to non-housing consumption, housing and borrowing. These values are determined through a reduced form approach or by using values from the literature. For the second step, all previously determined parameters are inputted in the model to estimate the remaining parameters, which are all preference and transaction cost parameters. The estimation approach followed is the Generalized Method of Moments. The remainder of this section describes the estimation procedure for each group of parameters.

6.1 House Prices and House Price Perceptions Parameters

The house price process is driven by two growth factors: a constant growth factor that summarizes national house price dynamics, Γ^H and ϕ_t^H which summarizes house price variations that are independent to business cycle dynamics. For Γ^H I use the FHFA HPI index at the national level, adjusted for inflation, to calculate an average annual growth of 3.32 %. Similarly to Campbell and Cocco (2007), the value is adjusted downwards by 1% to account for any house price growth that reflects improvements in the quality of housing, giving a Γ^H of 2.32%.

For the growth rate ϕ_t^H pertaining to house price variations that are independent to business cycle dynamics, the process is calibrated to match data on metro-level house price changes, over and above national house price changes. To first isolate this variation in the data, the annual metropolitan-level house price changes for the 2013-2019 period is calculated using FHFA HPI All-Transactions metro-level indices and controlling for inflation. These growth rates are then regressed against the national house price changes. The residual captures the dynamics independent of national house price changes that we are after. These values are discretized to summarize a Markov process with 3 states, where each state represents a decrease in growth, increase in growth, or about the same growth relative to the national average, as shown in Table 2. The transition probabilities are calibrated such that the state can change once every two years on average. With respect to the standard deviation of house prices, over the relatively short period of 2013 to 2019, the value equals 0.71%.

In terms of house price growth perceptions, the parameter required is the probability a household updates their perceptions of house price growth during some period t. This probability can be otherwise expressed as the average % of households whose perceptions of house price growth equal actual house price growth. I calibrate this value based on the first stylized fact in Section 4, where I regress the perceived house price growth values against the actual values. In that section, the value estimated was 34%. Table 2 summarizes all values related to house prices, both actual and perceived.

Parameter	Description	Value
	National House Price Growth	
Γ^H	Mean of Real House Price Growth	2.32%
σ^H	S.D. of Real House Price Growth	0.71%
	House Price Growth Independent of Business Cycle	
$\phi^H_{j,low}$	Low Additional Growth State	-3.53%
$\phi^H_{j,no}$	No Additional Growth State	0.00
$\phi^H_{j,high}$	High Additional Growth State	4.04%
$\text{prob}^H_{j,low}$	Unconditional Low State Probability	24.6%
$\text{prob}^H_{j,no}$	Unconditional No Growth State Probability	57.8%
$\text{prob}^H_{j,high}$	Unconditional High State Probability	17.4%
	House Price Growth Perceptions	
π	% Perceptions Updating Probability	34%

Table 2: Estimated Values of House Price Parameters. *Notes*: The table includes all parameters estimated or calculated without the direct use of the model. These parameters are partial equilibrium inputs in the model and all refer to house prices and house price perceptions.

6.2 Calibrated Parameters

All parameters other than the ones related to house prices, perceptions, preferences and transaction costs are taken from the literature or calibrated to match economic aggregates over the 2013 to 2019 analysis period. Starting with the exogenously set prices in this partial equilibrium model, the risk free interest rate r is set to equal 1%, which is approximately the average of the Federal Funds Effective Rate over the period. For the wage rate w, the value needs to refer to the steady state compensation of one unit of labor, defined as $w = (1-a)K^a$, where K is the steady state capital to labor productivity ratio and a is the capital's share of income. Using values from Carroll et al. (2020), I take 0.36 for the capital's share of income, 48.55 for the steady state capital to labor productivity ratio and hence the steady state wage rate amounts to 2.59.

The parameters of the idiosyncratic income of the households, namely the standard deviation of permanent and transitory idiosyncratic productivity σ_ψ and σ_θ respectively are calibrated again using common values in the literature, as in Li et al. (2016) with values 0.22 and 0.1 respectively. For the standard deviation of the aggregate permanent and transitory productivity, I use values 0.006 and 0.003 respectively. In terms of the housing depreciation rate δ, I use 2.2%, and for the ratio of rent price per housing unit over house price per housing unit $\tilde{R}$, I use 6%, like in Berger et al. (2017). For the borrowing limits for owners and renters, owners can have a maximum LTV of 80% that agrees with the corresponding values in the data for the average household, and renters can borrow up to 5% against their permanent income. Households have a 2% chance of dying in any year and face certain death after living in the model economy for 65 years, which denotes the years over which they earn some form of income.

6.3 Preference and Transaction Cost Parameters

The remaining parameters, which determine household preferences and transaction costs for housing, are estimated using the model and the Generalized Method of Moments. These preference and cost parameters are not directly observable in data, therefore are purposefully estimated using a structural model for their identification. Because this model incorporates household perceptions, as well as accounts for the endogenous household decision of home-ownership, the structural approach leads to the estimation of the true value of parameters that are implied by different moments in the data.

The parameters estimated are the coefficient of relative risk aversion ρ, the elasticity of substitution between non-housing consumption and housing α, the discount factor β, as well as the housing adjustment cost parameter τ. Note that, for the housing adjustment cost, although this value depends on the institutional characteristics of the US housing market, it also captures the psychological cost of households choosing to move houses, or else the unconditional probability of moving, regardless of market prices and rates. That is why it is estimated using the model.

6.3.1 Data Moments

I calculate moments in the data that refer to households' balance sheets, as well as the endogenous decision of housing choice. For the moment calculation, I use data from the Survey of Consumer Finances, as well as from the Current Population Survey for the analysis period of 2013-2019. All dollar values are adjusted for inflation. In terms of variable definitions, household income is the total household wage income, which is normalized by the median wage income in the data, calculated by taking into account the survey weights. The home value of the household is the sum of the value of their primary residence and the value of other residential real estate held, and liquid assets is the total of all types of transactions accounts, directly held pooled investment funds held, directly held stocks, directly held bonds, minus the outstanding balance of any credit cards. The total of all types of transactions accounts is adjusted upwards by 5% to account for any cash. Debt is defined as the total value of debt secured by the primary residence held by household, including mortgages, home equity loans and HELOCs secured by the primary residence. For the moving rate, I use the CPS data, and specifically the survey answers on why households moved residence. I count households who moved because they wanted to own home, not rent, wanted new or better housing or moved for cheaper housing, as a percentage of total households that completed the survey after weighing the values appropriately according to the survey weights. The same procedure for determining the moving rate in the data is followed by Guren et al. (2020). Using this data, the moments calculated are the ratio of liquid assets to income for all households, owners only and renters only, the ratio of debt to income, the ratio of debt to home value, as well as the moving rate across years.

6.3.2 Model Moments

I use model simulations to produce the model counterparts to the data moments, in order to perform the GMM estimation. For the simulation, I create panel of 10,000 households and the model is simulated for 1,000 annual periods. After excluding a burn-in 200 periods, the rest of the panel, now in steady state, is used to calculate the model moments. When each household is born, its initial conditions are set based on the data. The panel is first randomly split into owners and renters, in order to match the actual fractions in the data. For each group, households are classified as belonging to one of the income quantiles in the data specific to renters or owners. The starting housing and liquid assets equal the median value for renters or owners in that income group in the data. For the initial conditions, as well as for the calculation of the data moments delayed below, the top 25% of households along the distribution of liquid assets are dropped, similarly to Gomes and Michaelides (2005). This is done to ensure that the data are representative of the typical US household over the period, because the SCF over-samples wealthy households.

For each period ran, the optimal housing and consumption is determined for each household, so that the necessary moments are calculated. Specifically, income and home value are explicitly defined in the model as $y_{i,t}$ and $H_{i,t}$ respectively. For liquid assets and debt, both are captured using the same variable $a_{i,t}$. As explained in Section 5, it is optimal for households to take on debt only after they have depleted their liquid wealth. Thus, liquid assets are captured through $a_{i,t}$ conditional on it being a positive value and debt is measured through $a_{i,t}$ again, but only when it is negative. The liquid assets/income, home value/debt and home value/income moments are then calculated for each household in each period. For the GMM, I use the quartiles for each of the variables as moments. For the moving rate, I sum the number of households that choose to adjust their housing, so move to a different residence over the total simulated population.

6.3.3 Parameter Identification

It is useful at this point to discuss what is the source of identification for the parameters estimated in the model. Because the parameters I am after affect primarily specific groups of households, separate targeted moments provide the necessary variation for the identification of different parameters.

The model is over-identified, since there are more moments than parameters. The main moment variation is as follows. With respect to the housing adjustment cost τ, the moment that identifies it is the moving rate of households. Since the housing adjustment cost is only incurred when an owner decides to buy or sell housing service units, the average proportion of households in any year that choose to do so varies as τ changes value. For the CRRA parameter, as risk aversion increases, owners increase their precautionary savings and are less reliant on debt, so the debt to home value decreases. For the elasticity of substitution between consumption and housing, necessary moment variation comes from the debt/income ratio. For lower values of the parameter, households gain more utility from their housing and by buying more housing, they can also increase their collateralized debt capacity, resulting in an increase in the level of the debt/income ratio. Finally, with respect to the discount factor β, for higher values of β where households are more patient, and therefore increase their liquid assets. For further discussion on parameter identification, Appendix D provides a complete sensitivity analysis of the model-simulated moments at percentile level to the estimated parameters.

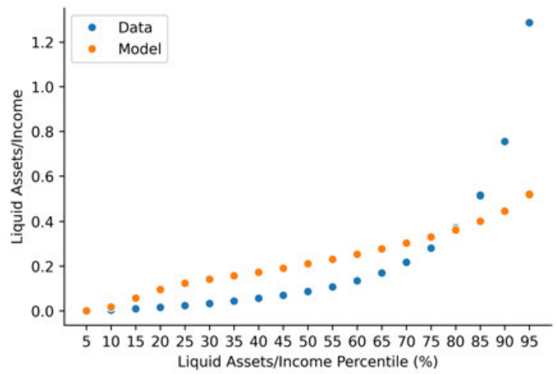
6.4 Estimation Results

Table 3 includes the estimated parameters using the GMM and 4 shows the fit of the model with respect to the data moments described in the previous subsections. Note that the figure plots targeted and untargeted moments, since the quartiles were used to run the estimation. The parameter estimates are largely within expected ranges when comparing to papers in the literature that utilize models of consumption and housing. The CRRA parameter is estimated to be 1.51 and the elasticity of substitution between consumption and housing 0.849. For the elasticity of substitution, this parameter is often assumed to be 1 in the literature, however papers that aim to quantify it make the case that it may be close to unity but not exactly 1.0 (Davis and Ortalo-Magne, 2011). The discount factor is estimated to be 0.92, which agrees with the model frequency and the housing adjustment cost is just over 5%, a value within the ranges assumed in the literature that makes intuitive sense as well: households incur a transaction cost of approximately 5% of the total value of their house.

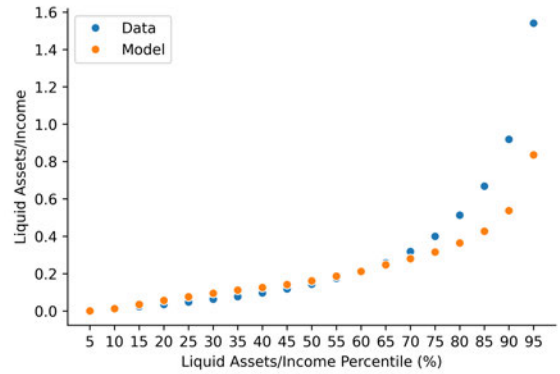
Parameter	Description	Value	s.e.
ρ	CRRA	1.51	0.006
α	Elasticity of Substitution between Consumption and Housing	0.849	0.011
β	Discount Factor	0.92	0.015
τ	Housing Adjustment Cost	0.051	0.0002

Table 3: Estimated Preference and Transaction Cost Parameters. *Notes*: The table includes the parameters estimated within the model, using GMM. Details on the estimation methodology can be found in appendix C. The sensitivity of the model moments to the estimated parameters is detailed in the sensitivity analysis in appendix D.

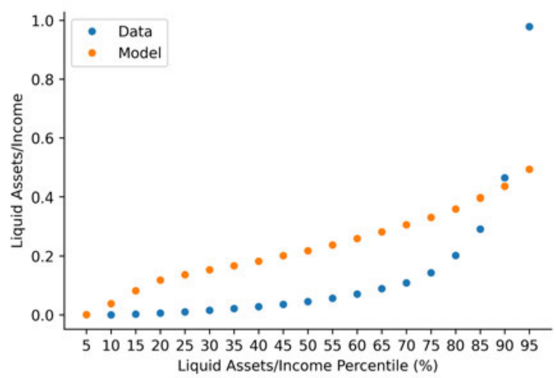
Figure 4 shows the data moments along with the predicted model moments using the estimated parameters. For each moment, the panels show the value at each percentile of the moment. From the figure we can note that the model performs well in replicating the data with respect to the liquid assets/income ratio for all the population, as well as the liquid assets/income ratio for owners specifically and the debt/home value ratio. The liquid assets/income ratio for renters is overstated for lower values of the ratio and understated for higher values of debt/income. This possibly stems from simple debt assumptions for renters, where the borrowing constraint is the same proportion of permanent income for all renters. However this assumption should not bear implications for the housing wealth effect that is the aim of this model, since the overall liquid assets to income and the debt to home value moments are closely matched. In addition to the depicted moments in Figure 4, the moving rate in the data is 3.21% in the data and predicted to be the close values of 2.25% by the estimated model.



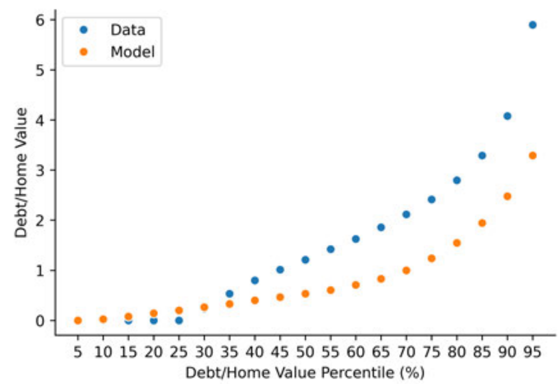
(a) Liquid Assets/Income, All



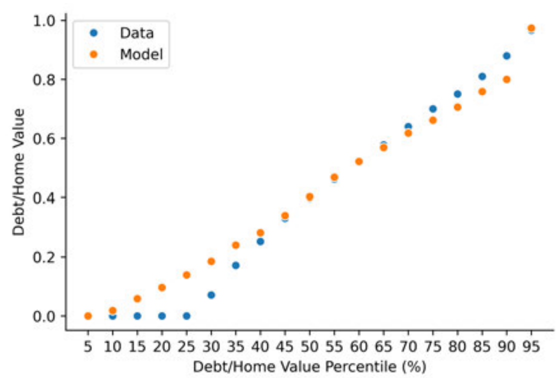
(b) Liquid Assets/Income, Owners



(c) Liquid Assets/Income, Renters



(d) Debt/Income, Owners



(e) Debt/Home Value, Owners

Figure 4: Model Fit of Predicted Moments vs. Data Moments. *Notes*: The graphs in this Figure plot the model moments against the corresponding data moments. For each moment, the predicted or data values are separated in groups of 5 percentiles and the corresponding percentile value of the moment is plotted. Note that the figure plots targeted and untargeted moments, since the quartiles were used to run the stimation.

7 Untargeted Model Moment: The Housing Wealth Effect

In this section, I examine the main untargeted moment predicted by this model: the housing wealth effect, or else the \$ change in non-housing consumption due to a \$ change in house prices. For the corresponding empirical moment, I leverage an empirical setting where house prices changed locally and independently from business cycle variations, due to property investment by institutional investors.

7.1 Housing Wealth Effect and Institutional Investors

Institutional investor ownership of properties in the U.S. has grown over the last years, emerging primarily from the 2008 financial crisis and subsequent foreclosure crisis. Today, institutional investors make up a relatively small percentage of total annual house transactions, but their presence is concentrated in specific areas in the U.S. More generally, the impact of investor property ownership on housing markets and households is currently in focus, both in the news (Waters, 2023), as well as in the U.S. legislative debate (Waters, 2022).

Changes in house prices driven by institutional investors provide a unique environment for studying the housing wealth effect. I focus specifically on the impact of the purchases of 5 large institutional investors that specialize in Single Family Rental properties. The operating model of this type of investors is a fitting environment for my context, since they buy properties to rent them out and they invest significantly in the renovation of houses after purchase. Hence any house price appreciation observed is not only because of market forces, but is a result of the improvement of the hedonic value of the homes.

In this setting, I am able to compare house price changes in areas with institutional property investment to areas without, over the same period and the same macroeconomic conditions, and examine the response of non-housing consumption to these house price changes. Therefore, to collect the required empirical evidence, it is necessary to: a) quantify the change in local house prices caused by institutional investors, and b) quantify the change in non-housing consumption of owners and renters because of this house price change.

To first determine the causal effect of institutional investors on house prices, it is tempting to simply regress the change in institutional investor property ownership in each area against the corresponding local house price change. However, as Lambie-Hanson et al. (2019) point out, the OLS approach would lead to the miss-estimation of the effect, because the choice of investors about where to buy or sell properties is endogenous and depends on local income levels, unemployment rates and recent house price growth, among other factors.

In order to isolate the causal effect of institutional property investors on local house prices, I follow an Instrumental Variable approach, where the change in the number of properties owned by institutional investors is instrumented using mortgage credit shocks. Because investors do not require mortgage credit to finance their purchases, a shock to mortgage credit will only impact household demand for house purchases. Due to this, in a market where investors are absent, a mortgage credit shock would impact house prices, since it leads to an increase or decrease of houses. However, in a market with institutional investors, a change in mortgage credit will impact household demand, but investor property demand will remain unaffected and investors will be able to absorb the change in property demand by households. This mechanism has been reviewed in detail by the literature, with Greenwald and Guren (2021) examining how investors dampen the house price changes resulting from credit shocks. In my setting therefore, mortgage credit shocks provide a change in institutional investor property purchases that is not decided by the investors themselves, but that is a consequence of a change in the demand of the other home buyer in the market, the household. In appendix E I follow an additional identification approach to confirm the causal effect of institutional investors on house prices, using a series of their mergers as event studies.

7.2 House Price Growth Driven by Institutional Investors

To create mortgage credit shocks, I follow an approach akin to the one used by Lambie-Hanson et al. (2019), with an important differentiation. In order to identify shocks to mortgage credit, I use the liquidity position of banks. This decision is based on the fact that there is work in the literature that shows that when a bank has an increase in its liquidity position, it increases the number of originations of illiquid loans, namely mortgages (Loutskina (2011) and Loutskina and Strahan (2009)). Here bank liquidity is defined as the sum of Held to Maturity and Available for Sale securities over the bank's total assets, as reported in the Federal Reserve's Report of Condition and Income. Therefore, by using the change in bank liquidity at the national level, I use a shift-share approach for local variation, based on the branches of different banks in each location.

Starting by the year-on-year mortgage loan origination growth by county $\Delta L_{b,c,t}$, this can be decomposed in within and between county components:

$$\Delta L_{b,c,t} = S_{b,t} + D_{c,t} + \epsilon_{b,c,t} \tag{18}$$

where $S_{b,t}$ are bank-year fixed effects and $D_{c,t}$ are county-year fixed effects. For this regression, I use weights based on the market share of each bank, implied by the number of its local branches:

$$b_{b,c,t} = \frac{L_{b,c,t}}{\Sigma_{b\in B_{c,t}} L_{b,c,t}} \tag{19}$$

The part of the mortgage supply shift due to changes in bank liquidity only is isolated using the following regression:

$$\hat{S}_{b,t} = \beta \text{Liquidity}_{b,t} + \eta_b + \lambda_t + v_{b,t} \tag{20}$$

The bank liquidity driven shift is then:

$$\tilde{S}_{b,t} = \hat{\beta} \text{Liquidity}_{b,t} \tag{21}$$

To take these values from county to metropolitan level:

$$\tilde{S}_{j,t} = \frac{b_{b,j,t-1}}{\Sigma_{b\in B_{j,t-1}} b_{b,j,t-1}} \tilde{S}_{b,t} \tag{22}$$

$$\hat{D}_{j,t} = \frac{b_{b,j,t-1}}{\Sigma_{b\in B_{j,t-1}} b_{j,J,t-1}} \hat{D}_{c,t} \tag{23}$$

Finally, to remove any remaining local demand effects from the Liquidity variable, while using metro-level population weights:

$$\tilde{S}_{j,t} = \gamma \hat{D}_{j,t} + \eta_j + \lambda_t + \epsilon_{j,t} \tag{24}$$

The residual $\epsilon_{j,t}$ of the above equation gives the mortgage credit supply shocks

Having created the mortgage credit supply shocks, so the instrument for the IV, the expression for the first stage is:

$$\Delta \text{Inv Prop}_{j,t} = \gamma_0 + \gamma_1 \text{Mtg Cred Shk}_{j,t} + \gamma_2 Z_{j,t-1} + \xi_{j,t} + \eta_j + \nu_{j,t} \tag{25}$$

where $\text{Mtg Cred Shk}_{j,t}$ are the mortgage credit shocks in metro area j in period t and $Z_{j,t-1}$ are local controls including lagged real house price growth, lagged population growth and lagged unemployment. $\xi_{j,t}$ are state-year fixed effects and η_j are metro fixed effects. For the data on invetsor property purchases, I extract property portfolio data from the 10-K submissions of the 5 institutional investors I focus on. In the 10-K's, REITs like these investors have to disclose information on the properties they own by metropolitan area. This data includes the number of properties that I use for my analysis. The results of this regression are shown in Table 4 and Figure 5 presents the relationship between the instrument and the instrumental variable, after regressing the two against all controls and fixed effects included in the IV analysis.

	Δ Investor Properties (000s)
Mortgage Credit Shock	-0.216***
	(0.030)
Investor Presence	-0.002
	(0.283)
Lagged Real HPI Growth	0.469
	(0.572)
Lagged Population Growth	-0.089
	(0.217)
Lagged Unemployment	0.903
	(3.582)
Metro FE	Yes
State x Year FE	Yes
Kleibergen-Paap rk LM statistic	0.000
Anderson-Rubin Wald test	0.010
Stock-Wright LM S statistic	0.010
N	1852

Table 4: First Stage Results of Instrumental Variable Analysis. *Notes*: The table presents the results of the first stage of the IV analysis for determining the effect of SFR institutional investor property purchases on local house prices. The specification includes metropolitan area fixed effects and state-year fixed effects. The standard errors are robust standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

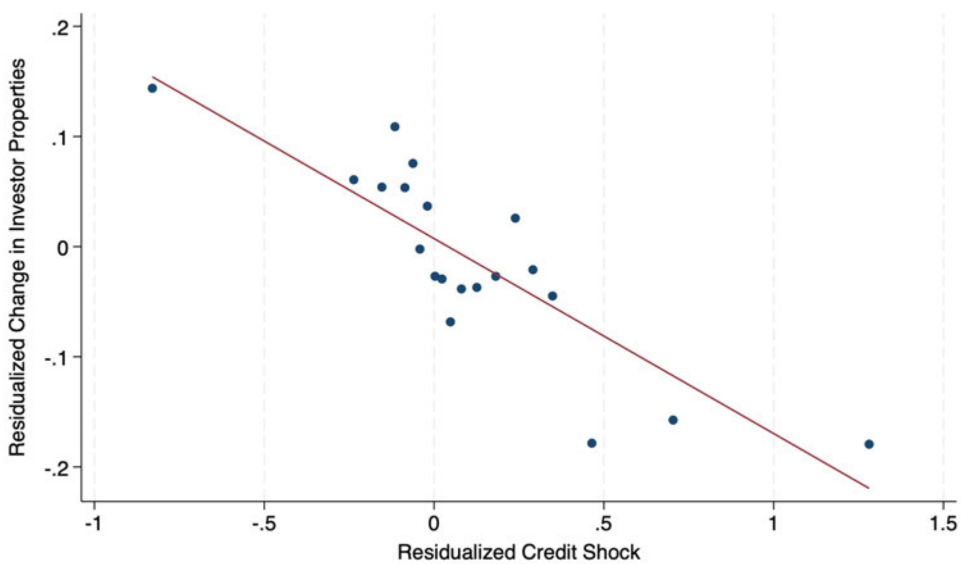


Figure 5: First Stage Regression for Instrumental Variable Analysis of Institutional Investor Effect on House Prices. *Notes*: The figure plots the residualized change in investor properties over a year against the mortgage credit shock. The regressions to arrive to the residuals include all variables and fixed effects used in the IV, so the values are regressed against investor presence, lagged real HPI growth, lagged population growth and lagged unemployment. Metropolitan area fixed effects and state-year fixed effects are also included.

The estimate shows that there is a statistically and economically significant relationship between mortgage credit supply shocks and the number of properties institutional investors buy or sell over a year in a particular metropolitan area. Note that the relationship is negative, as would be anticipated: if there is a negative mortgage shock, household demand for houses will decrease and investors will absorb this decrease. The table also quotes some relevant statistics revealing the validity of the instrument.

Having validated the first stage of the IV, the second stage is used to pin down the causal effect of investors on house prices, as well as to investigate whether there is an effect on households' perceived value of their homes in areas where actual house prices are possibly affected. The corresponding expressions are:

$$\Delta p^H_{j,t} = \beta_0 + \beta_1 \Delta \text{Inv } \hat{\text{P}}\text{rop}_{j,t} + \beta_2 Z_{j,t-1} + \xi_{j,t} + \eta_j + \epsilon_{j,t} \quad (26)$$

$$\Delta \tilde{p}^H_{j,t} = \beta_0 + \beta_1 \Delta \text{Inv } \hat{\text{P}}\text{rop}_{j,t} + \beta_2 Z_{j,t-1} + \xi_{j,t} + \eta_j + \epsilon_{j,t} \quad (27)$$

where $\Delta p^H_{j,t}$ is the real house price growth in metro area j in year t and $\Delta \tilde{p}^H_{j,t}$ is the perceived real house price growth. $\Delta \text{Inv } \hat{\text{P}}\text{rop}_{j,t}$ is the predicted change in institutional investor properties from the first stage of the Instrumental Variable analysis, and $Z_{j,t-1}$, $\xi_{j,t}$ and η_j are local controls, state-year fixed effects and metropolitan area fixed effects as before. The effect on actual house price growth is included in Table 5 and the effect for perceived house price growth is included in Table 6. The tables also quote the estimates of running the second stage regressions as OLS specifications.

	OLS	IV
Δ Investor Properties (000s)	0.001	0.013**
	(0.001)	(0.005)
Investor Presence	0.000	0.011
	(.)	(0.011)
Lagged Real HPI Growth	-0.203***	-0.210***
	(0.025)	(0.022)
Lagged Population Growth	-0.016*	-0.016**
	(0.009)	(0.008)
Lagged Unemployment	-0.647***	-0.649***
	(0.156)	(0.135)
Metro FE	Yes	Yes
State x Year FE	Yes	Yes
Adj. R^2	0.617	0.580
N	1822.000	1852.000

Table 5: Effect of Institutional Investor Property Purchases on House Prices, OLS and Second Stage Results of Instrumental Variable Analysis. *Notes*: The table presents the effect of the property purchases of institutional investors on house prices. The relationship is examined through two specifications: a OLS regression and an IV, for which this table shows the results of the second stage. The OLS and the IV include metropolitan area fixed effects and state-year fixed effects. The standard errors are robust standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

From Table 5 note that, in both the OLS and IV specification, investors' property purchases have a statistically significant impact on local house price growth, but this impact becomes economically significant as well after implementing the second stage of the Instrumental Variable analysis. Based on these results, if institutional investors purchase 1,000 properties in a metropolitan area over the course of a year, house price growth in the area is 1% higher compared to metropolitan areas where investors did not buy properties.

	OLS	IV
Δ Investor Properties (000s)	0.001	-0.004
	(0.002)	(0.010)
Investor Presence	0.000	-0.001
	(.)	(0.023)
Lagged Real HPI Growth	0.281***	0.289***
	(0.056)	(0.051)
Lagged Population Growth	0.006	0.006
	(0.030)	(0.025)
Lagged Unemployment	0.626*	0.648**
	(0.354)	(0.304)
Metro FE	Yes	Yes
State x Year FE	Yes	Yes
Adj. R^2	0.139	0.129
N	2159.000	2195.000

Table 6: Effect of Institutional Investor Property Purchases on House Prices, Perceptions. *Notes*: The table presents the effect of the property purchases of institutional investors on house price perceptions of households. The relationship is examined through two specifications, similarly to the approach followed to examine the effect on actual house prices: a OLS regression and an IV, for which this table shows the results of the second stage. The OLS and the IV include metropolitan area fixed effects and state-year fixed effects. The standard errors are robust standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

From Table 6 which shows the equivalent results, but for the perception of house prices by local households that own a house, it is observed that the result is very different. There seems to be no economically or statistically effect of institutional investors on what households perceive the value of their house to be.

7.3 Housing Wealth Effect: Empirical Estimate

After quantifying the change in house price growth caused by institutional investors in the previous section, it is possible to now empirically estimate the change in consumption resulting from this house price change. Therefore, for the housing wealth effect, the following regression is run:

$$\Delta c_{i,t} = \alpha_0 + \alpha_1 \hat{\Delta p}^H_{j,t} \times \text{owner}_{i,t} + \alpha_2 X_{i,t} + \eta_j + \xi_{J,t} + \epsilon_{i,j,t} \tag{28}$$

where $\Delta \hat{p}^H_{j,t}$ is the impact of institutional investors on metropolitan-level house prices and $X_{i,t}$ are household and local controls. In terms of fixed effects, η_j are fixed effects for Scantrack markets, the Nielsen-defined geographical unit that is equivalent to metropolitan areas in a market context and $\xi_{J,t}$ are state-year fixed effects. Importantly, I interact $\Delta \hat{p}^H_{j,t}$ with a dummy indicating whether a household owns their home, in order to have separate estimates for the housing wealth effect to owners and renters in a pooled regression. To isolate renters from owners in the Nielsen data, I use the same assumptions as Stroebel and Vavra (2019). Table 7 presents the results.

	(1)	(2)	(3)
Δp^H	-0.206**	-0.190**	-0.195**
	(0.068)	(0.068)	(0.061)
Δp^H x Owner	0.054	0.056	0.055
	(0.043)	(0.045)	(0.043)
Household Controls	Yes	Yes	Yes
Local Controls	Yes	No	Yes
Industry Controls	No	Yes	Yes
SMM FE	Yes	Yes	Yes
State x Year FE	Yes	Yes	Yes
Adj. R^2	0.010	0.010	0.010
N	170479	170483	170479

Table 7: Effect of House Price Change by Institutional Investors on Household Consumption. *Notes*: The table shows the results of estimating equation 28, where $\Delta \hat{p}^H = \beta_1 \Delta \text{Inv Prop}$, as estimated using the IV earlier in the analysis. The specification is run using different sets of controls, including household controls, local controls, industry controls. All regressions include state-year fixed effects and Scantrack market (defined by Kilts-Nielsen in the household consumption data) fixed effects. Errors are clustered at the Scantrack market and year levels. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$

As shown in Table 7, although the consumption effect for owners is positive as would be expected, it is statistically insignificant at the 10% level, possibly reflecting the previous empirical finding on household perceptions, where owners do not appear to understand the impact institutional investors have on the household's own housing wealth through the increase in house prices that they bring about. On the contrary, the effect for renters is statistically significant at the 5% level, negative and larger in magnitude, as well as robust to including local controls with the local lagged real house price growth, lagged population growth and lagged unemployment rate, and to including local industry composition controls, so the employment share of construction, manufacturing, retail trade, and finance/real estate/insurance (FIRE) sectors. I calculate these controls using Census Bureau Patterns data. The sign is in accords to economic intuition: as house prices increase, renters who are future home owners need to increase their saving rate in order to be able to afford their now more expensive future house and therefore are forced to decrease their consumption.

7.4 Housing Wealth Effect: Model Estimate

The estimates discussed above provide empirical facts on the owners' and renters' housing wealth effect out of a house price changes that is independent to the business cycle, which this paper's model should be able to replicate, conditional on the fact that is it correctly specified. Therefore, I use the model to predict the empirically estimated values for owners and renters, after a positive house price change. The size of the shock is ∼1%, which was the house price change caused by institutional investors per 1,000 properties purchased in a year, as shown in Table 5. In the model, I use the simulated panel of households used for calculating the model moments in Section 6, which represent a representative sample of US households living in the steady state of the economy. I predict a counterfactual consumption for each household by only shocking house prices and calculate the elasticity, using the common definition of:

$$\eta_{i,t} = \frac{d\ln c_{i,t}}{d\ln H_{i,t}} \frac{H_{i,t}}{c_{i,t}} \tag{29}$$

where $d\ln c_{i,t}$ is the log change in consumption between the baseline scenario and the counterfactual for household i in period t, $c_{i,t}$ is the baseline consumption level, $d\ln H_{i,t}$ is the log change in housing wealth between the baseline scenario and the counterfactual for owners and the log change in house prices between the baseline scenario and the counterfactual for renters respectively and $H_{i,t}$ is the initial housing wealth for owners and the initial house price level for renters. The model predicts a 0 response to the house price change for owners, since households do not perceive the house price changes, as seen in Table 6, which also matches the empirical moment in Table 7. For renters, the model predicts an average elasticity of -0.1766, which is very close to its empirical counterpart of -0.195.

8 The Housing Wealth Effect Along the Cross-Section

Having estimated the model and established that it is able to replicate moments in the data, this section focuses on the housing wealth effect for owners and renters, given their perceptions of house price changes. The housing wealth effect is quantified with respect to the Marginal Propensity to Consume out of Housing Wealth (MPCH) for owners and out of house prices for renters. The definition of the MPCH is the \$ change in consumption a year after a house price shock over the \$ change in housing wealth or house price respectively.

As has been discussed earlier in the paper, the model is able to quantify the housing wealth effect by taking into account perceptions of house prices and by considering house price changes that are independent to business cycle house price variations and the correlated changes in household income or other wealth. Therefore, in this section, I will use the model to determine the housing wealth effect and how it varies along the cross-section of households.

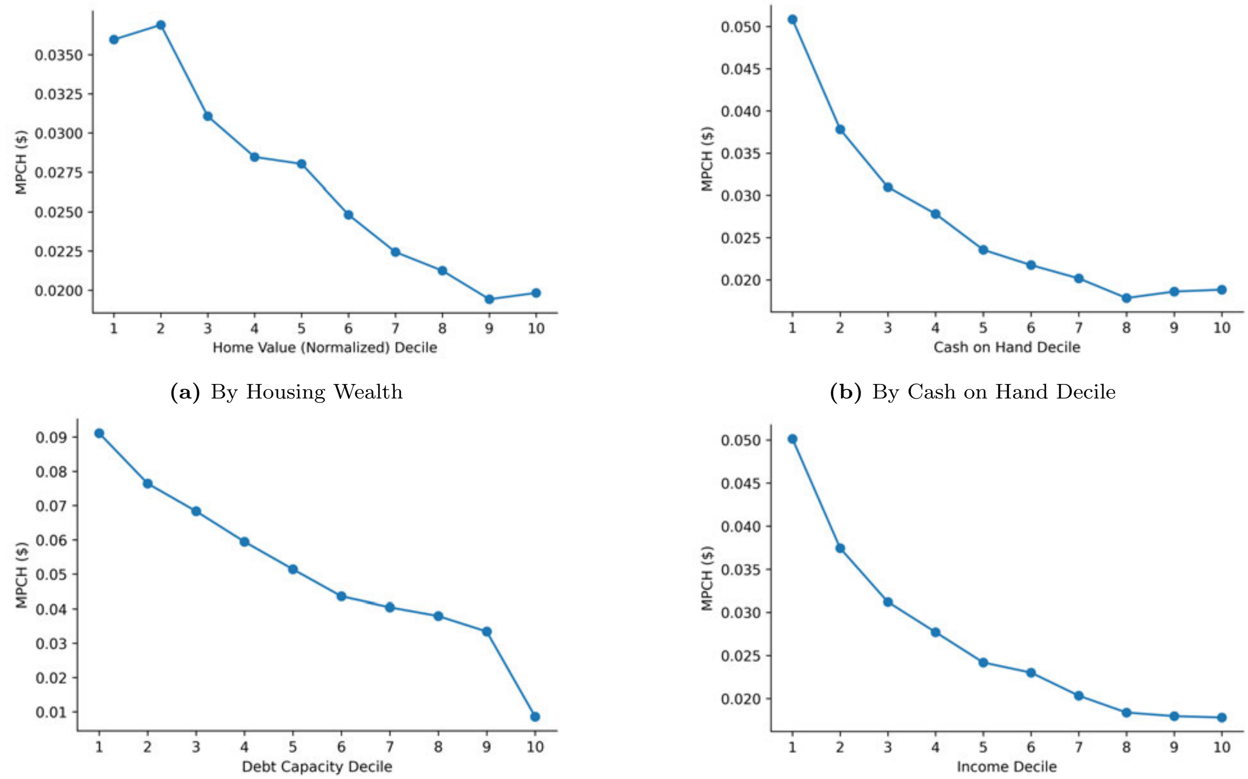
8.1 Predicting Average MPCH Values by Household Group

In order to show how the MPCH varies along the cross-section of households, I use the baseline simulation of the model with the estimated parameters in Section 6 and group the simulated panels with respect to their characteristics. Specifically, I group households by home value over housing units decile, cash on hand decile, debt capacity and income decile, while considering owners and renters separately. Each of these dimensions are chosen to proxy for a different type of financial constraint a household can face, which would drive its reaction to a change in home values.

For each group of households, the average value of MPCH is plotted in dollar terms in Figure 6 for owners and Figure 7 for renters. For the calculation of the MPCH, I shock house prices by 10%. The average MPCH of households across groups is calculated as 2.7 cents out of a $1 increase for owners and -2.6 cents out of a $1 increase for renters.

8.1.1 MPCH for Owners

Starting from the findings for owners and the average MPCH values along the normalized housing values, we observe that the response to a change in housing wealth is largest for households who live at the cheapest available houses, with values at 3.5 cents to a $1 change. Since owners' collateral constraints are defined with respect to their housing value, the households at the lower end of the housing distribution will be the ones facing the largest collateral constraints. As a result, they are very sensitive to an appreciation of house prices and react the most to the applied shock. Moving on to Panel (b) in Figure 6, the households with the least amount of cash on hand, or else the households with the least liquidity are the ones with the highest values of MPCH. These households are the most liquidity constrained, and hence are the ones are most responsive to the home value shock, with a MPCH of 5 cents as opposed to households with high liquidity, whose MPCH is just under 2 cents.



(a) By Housing Wealth

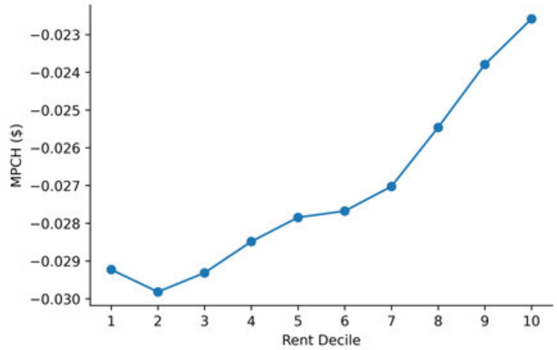
(b) By Cash on Hand Decile

(c) By Debt Capacity Decile

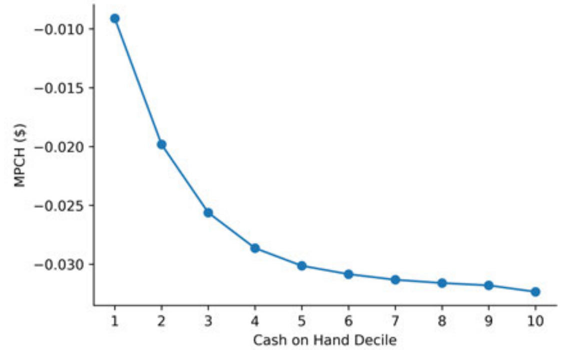
(d) By Income Decile

Figure 6: The Housing Wealth Effect along the Cross-Section of Homeowners. *Notes*: The figure plots the MPCH in dollar terms along the cross-section of owners with respect to different characteristics. For the estimated values, I use the baseline simulation of the model with the parameters in Section 6 and group the simulated panels with respect to their characteristics. Specifically, I group households by home value over housing units decile, cash on hand decile, debt capacity and income decile.

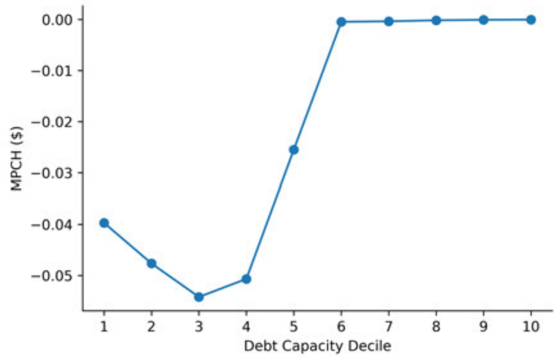
Panel (c) shows the average values of MPCH along different levels of debt capacity available to households. In this case, the MPCH values are highest for the households with the least available debt to them. The value for the lowest debt capacity decile is relatively quite high at 9 cents for a $1 increase in housing wealth. Since these owners have the lowest levels of debt capacity, I can associate them with owners who face the most credit constraints and as a consequence are the most sensitive to an appreciation in their home value which will relax their borrowing constraints. Finally for owners, Panel (d) shows the housing wealth effect along the income distribution. As expected, poorer households are more sensitive to a change in housing wealth, since they are the ones most likely to be liquidity constrained based on the model setup. The MPCH magnitudes are very close to the profile of MPCH with respect to cash on hand as expected, because the inflow of a household's liquid assets is its income after consumption.



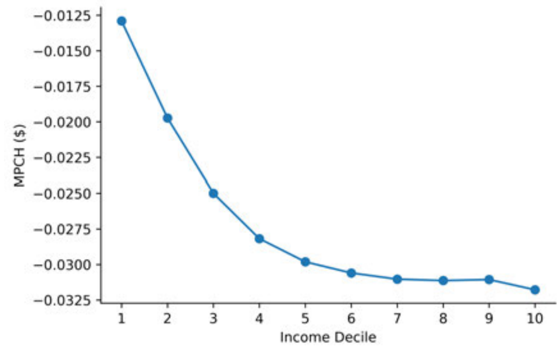
(a) By Housing Wealth



(b) By Cash on Hand Decile



(c) By Debt Capacity Decile



(d) By Income Decile

Figure 7: The Housing Wealth Effect along the Cross-Section of Renters. *Notes*: The figure plots the MPCH in dollar terms along the cross-section of renters with respect to different characteristics. For the estimated values, I use the baseline simulation of the model with the parameters in Section 6 and group the simulated panels with respect to their characteristics. Specifically, I group households by home value over housing units decile, cash on hand decile, debt capacity and income decile.

8.1.2 MPCH for Renters

Next I consider the predicted MPCH values for renters in Figure 7. For renters, a change in house prices requires households who aim to buy a house in the future to increase their savings to be able to afford to pay the higher down payment. Although both these effects result in negative MPCH values, the relative magnitudes will vary along different household dimensions, based on which households are most likely to be short the housing asset, or most likely to be putting money aside in order to buy a house.

Panel (a) of the Figure shows the MPCH values for households paying different rent prices. The largest response to the house price increase is by households with cheaper rents. The driver of the MPCH profile along this dimenison is the fact that the households who pay lower rents are also the ones who have less income or decreasing income in time. These households will face the largest liquidity constraints and therefore will be the most responsive to changes in rents. Panel (b) plots the marginal propensities to consume with respect to the cash on hand level of renters. Here the largest response is by households with higher levels of cash and therefore liquid savings. These households are the renters who are accumulating liquid wealth in order to purchase a home. Therefore, they decrease their consumption in order to increase their savings to be able to afford the appreciated down payment cost. Furthermore, as house prices and rents increase, the incentive to own a house, from which households gain more utility than renting, increases so more households who are richer in cash will want to save to buy a home.

Moving on to Panel (d), this figure shows the model predicted MPCH by renter debt capacity. As was the case for owners, renters with lower levels of debt capacity are the ones facing the highest credit constraints. Therefore, after an increase in required savings to buy a house in the future, the credit constrained renters will not be able to increase their borrowing, so will have to decrease their consumption. Note that for households who have access to debt, the increase in required savings can be covered by taking on more debt, so there is no need to decrease consumption as their consumption will be financed through the additional debt they take on. Finally, Panel (d) shows the MPCH with respect to renter income. Similarly to what was the case for the MPCH profile with respect to cash on hand, renters with higher income are more likley to be the savers for future home ownership, therefore will have to decrease their consumption to put aside a larger portion of their income in to their savings account.

For renters it should be noted that the MPCH values predicted are overall higher than what is considered by some papers in the literature, where renters have a negligible response to changes in house prices (Aladangady (2017), Graham and Makridis (2023)). This difference stems mainly from the assumptions taken by these papers, where it is assumed that renters have the option of buying a smaller home when prices increase, hence decreasing their housing consumption instead of their non-durable consumption (Berger et al., 2017). Furthermore, the literature often assumes a one-to-one substitution elasticity between non-housing and housing consumption (Campbell and Cocco, 2007). In this paper, the estimated parameter of the elasticity of substitution between consumption and housing is under 1, with the model moments being sensitive to a change in the parameter value, as is illustrated in appendix D. In addition to this, renters can only rent houses that provide a single unit of housing consumption out of which they gain utility. This leads to the first house of new owners likely being the lowest priced house available. The latter assumption in the model is purposefully chosen to approximate realistic conditions for renters entering the housing markets. These two factors result in households having limited flexibility to substitute away from non-housing consumption when looking to buy their first home and driving up the housing wealth effect.

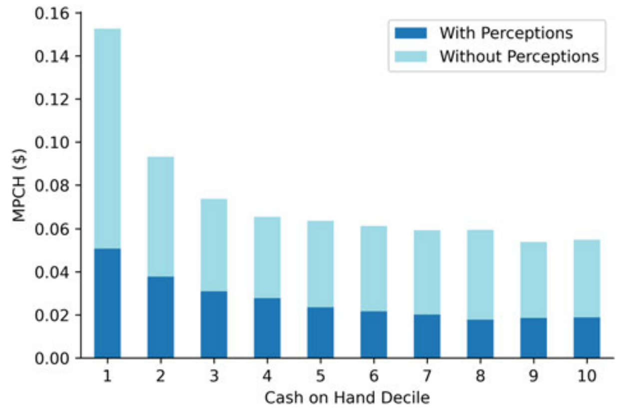
9 Effect of Perceptions on MPCH

After discussing the baseline predictions of the model for the MPCH of households based on their characteristics, I now move on to decompose the impact of perceptions on the responsiveness of household consumption to changes in housing wealth and house prices. I start by re-solving and re-simulating the model in the counterfactual case where owners have full information on house price changes, or in other words in the case that the updating probability of household perceptions is equal to 1. In this counterfactual, renters have the same response to house prices as before, but now all owners perceive the house price shock occurring and consume based on what is optimally best for them to do. The difference between the baseline model prediction and the counterfactual prediction with full information quantifies the effect of perceptions on the housing wealth effect and emphasizes the significance of the novel elements included in this paper's model.

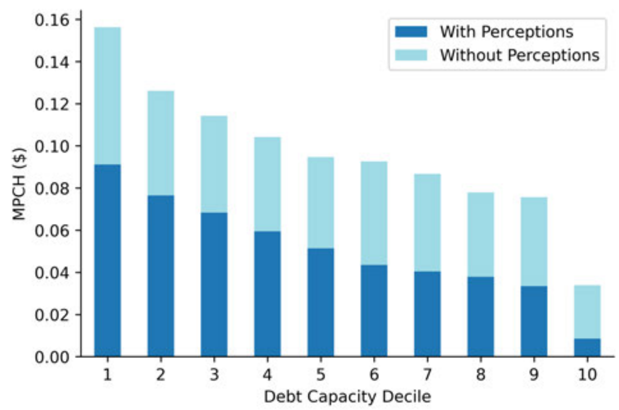
Figure 8 shows the results of the counterfactual model run, along with the baseline results discussed in the previous section. Note that only the results for owners are included, since renters have full perception of house price changes in either of the two scenarios considered here. The difference between the two simulations quantify the effect of perceptions for different households. As was done earlier, households are grouped based on their characteristics in deciles of cash on hand, debt capacity and income and the corresponding average MPCH value by decile in plotted.

Starting from Panel (a), when ignoring perceptions the MPCH is largest for the households with the least cash. The profile along the cash distribution mirrors the one of the baseline prediction, but when perceptions are not taken into account, the cash poor households are predicted to respond much more to housing wealth changes than the rest, with the average MPCH at the lowest decile being 16 cents out of a 1 $ change in housing wealth. Another way to interpret this is that the households that are most impacted due to them not fully perceiving house price changes are the households at the lower end of the cash distribution. This is in accords to the interpretation of the baseline result in the previous section, where it was explained that the households at the lower end of the cash distribution are the ones with the least liquidity and thus the most likely to face liquidity constraints. As a result, they are the ones that stand to gain the most from a home value appreciation when they perceive it. Similar observations can be drawn when focusing on Panel (c) and the MPCH values along the income distribution. Along this distribution, households with the lowest income values have an average marginal propensity to consume after a positive 10% shock to housing wealth of 12 cents to the dollar. The profile of MPCH values with respect to income mirrors that of the profile with respect to cash as expected. Panel (b) of the figure shows the counterfactual and baseline prediction for the MPCH with respect to household debt capacity. In this case as well, the largest increase in MPCH between the simulation including perceptions and the simulation with full information is for the households at the lower end of the debt capacity distribution. Households in these deciles are the ones most likely to be debt constrained and are the ones who are most sensitive to a change in home value.

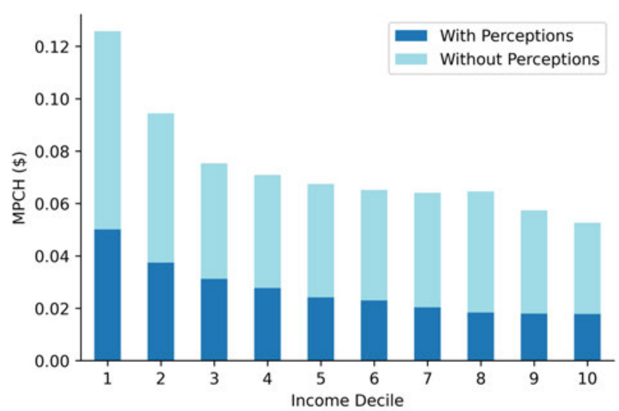
Because the counterfactual simulation is for a model that does not account for household house price perceptions, it is relevant at this point to compare the MPCH predicted by the current model to the values found in other papers. Considering marginal propensities to consume out of housing wealth, average estimates of MPCH range between 1 and 9 cents out of a dollar change in house prices and housing wealth, although the definition of consumption does vary among papers (Carroll et al. (2011), Mian et al. (2013), Aladangady (2017), Paiella and Pistaferri (2017), Guren et al. (2020), Disney et al. (2010), Graham and Makridis (2023)). My average value for owners of 2.7 cents is at the lower end of these estimates, as is to be expected given that perceptions dampen the average effect of a house price change in a population of households. Interestingly, the average predicted MPCH in full information counterfactual is at the mid-to-higher end of estimates in the literature, at 5.9 cents for a $1 increase in housing wealth.



(a) By Cash on Hand Decile



(b) By Debt Capacity Decile



(c) By Income Decile

Figure 8: Effect of House Price Perceptions on MPCH. *Notes*: The figure shows the average MPCH along different household cross-sections, for the baseline model and for the 'Without Perceptions' counterfactual. I re-solving and re-simulating the model in the counterfactual case where owners have full information, or when the updating probability of household perceptions is equal to 1.

10 Experiment: Monetary Policy Tightening

In this section, the model is applied to examine the consumption effects of a monetary policy change. Specifically, I investigate the consumption changes that result from a positive monetary policy shock, or else the consumption response of households to monetary policy tightening. The model developed in this paper can be used to examine the impact of a monetary policy shock on household consumption, and therefore the transmission of monetary policy through the house price channel along with other channels, because of its inclusion of house price changes that are independent of the business cycle. Furthermore, as is discussed largely in the central banking communication literature[6], the role of perceptions of house price changes by households is critical in quantifying monetary policy transmission.

It is important to begin by noting that a monetary policy shock will impact a number of aggregate state variables and is as a result transmitted through a number of channels to households. In a partial equilibrium setting like the one specified in this paper, the main channels will be the interest rate channel and the asset price channel. With respect to the interest rate channel, an increase in policy rates will result in increases in deposit rates and lending rates. These increases will have a direct impact on household liquid wealth and liability payments and therefore will affect households' consumption. With respect to the asset price channel, in the context of the model presented in this paper, a positive monetary policy shock will lead to a decrease in house prices.

In order to consider how monetary policy tightening impacts household consumption, I proceed in two steps. First, the effects of a policy rate increase on the aggregate state variables, so on interest rates and house prices, must be estimated. This is done by using local projections of monetary policy shocks on the variables of interest. Second, the consumption response to these changes in aggregate state variables is predicted using the estimated model. I decompose the effect of the house price change caused by monetary policy tightening on consumption, and show the importance of perceptions in policy transmission for each of the relevant transmission channels separately. I then focus on the house price channel and show how the size of the monetary policy shock interacts with the probability of updating perceptions to impact the transmission of monetary policy, as well as the role of local house price change heterogeneity after a policy shock on the change in consumption. I further the analysis by considering monetary policy transmission efficiency in the cross-section of households.

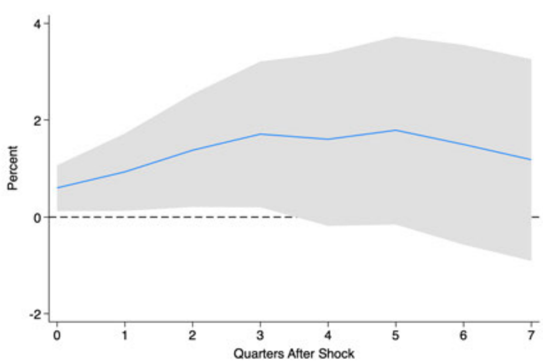
[6] See Woodford (2005), Kryvtsov and Petersen (2021) and Ehrmann and Wabitsch (2022) as examples.

10.1 Effect on Aggregate State Variables

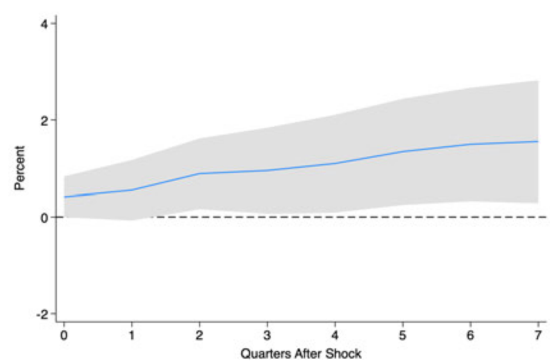
10.1.1 Interest Rates on Saving Accounts and Debt

First, I quantify the impact of a monetary policy shock on interest rates. With respect to interest rates, a central determinant of the magnitude of their change after a monetary policy shock is the institutional characteristics of the economy, such as the degree of competitions between banks. For lower levels of banking competition, the adaptation of banking rates to changes in the policy rate will be slower, with the borrowing rate likely increasing faster than the saving rate. Other likely factors that may impact the effect of monetary policy on lending and saving rates may be the available alternative funding sources to households, which would have similar impact to an increase in banking competition, as well as the depth of capital markets, with more integrated capital markets increasing the responsiveness of banks to policy rates.

The effect of monetary policy tightening on metropolitan-level house prices is determined by following the approach introduced by Jordà (2005) and using local projections of monetary policy shocks on interest rates. For the monetary policy shocks, I leverage the time series extension of quarterly Romer and Romer shocks (Romer and Romer, 2004) by Wieland and Yang (2020). For the deposit rate, I use the certificate of deposit yankee early 3 month rate in dollar terms. For the lending rate, I use the commercial bank interest rate on credit card plans for all accounts, from the Board of Governors of the Federal Reserve System's G.19 release on consumer credit. I estimate a local projection for each variable using lags for 4 quarters of data. The resulting projections for are depicted in Figure 9.



(a) Interest Rate on Saving Accounts



(b) Interest Rate on Debt

Figure 9: Local Projection of Interest Rates after a Monetary Policy Shock. *Notes*: The figure shows the local projection of the deposit and lending rate after a monetary policy shock of 1%. For the monetary policy shocks, I leverage the time series extension of quarterly Romer and Romer shocks (Romer and Romer, 2004) by Wieland and Yang (2020). For the deposit rate, I use the certificate of deposit yankee early 3 month rate in dollar terms and for the lending rate, I use the commercial bank interest rate on credit card plans for all accounts, from the Board of Governors of the Federal Reserve System's G.19 release on consumer credit.

From the figure note that both the deposit and the lending rate increases with a positive monetary policy shock, but the increase is temporarily statistically significant in the case of the deposit rate as opposed to the rate on debt.

10.1.2 House Prices

With respect to house prices, an increase in policy rates translates to an increase in mortgage rates, which therefore increases the effective cost of a house for a household that requires credit to make a home purchase. Home sellers react to these changes by decreasing their properties' listing prices. Although it has been understood that house prices respond much slower than asset prices to changes in monetary policy, Case and Shiller (1989) and Gorea et al. (2022) have shown in recent work that an unexpected, one standard deviation increase in policy rates results in a house price decrease of 0.2–0.3 percent two weeks later.

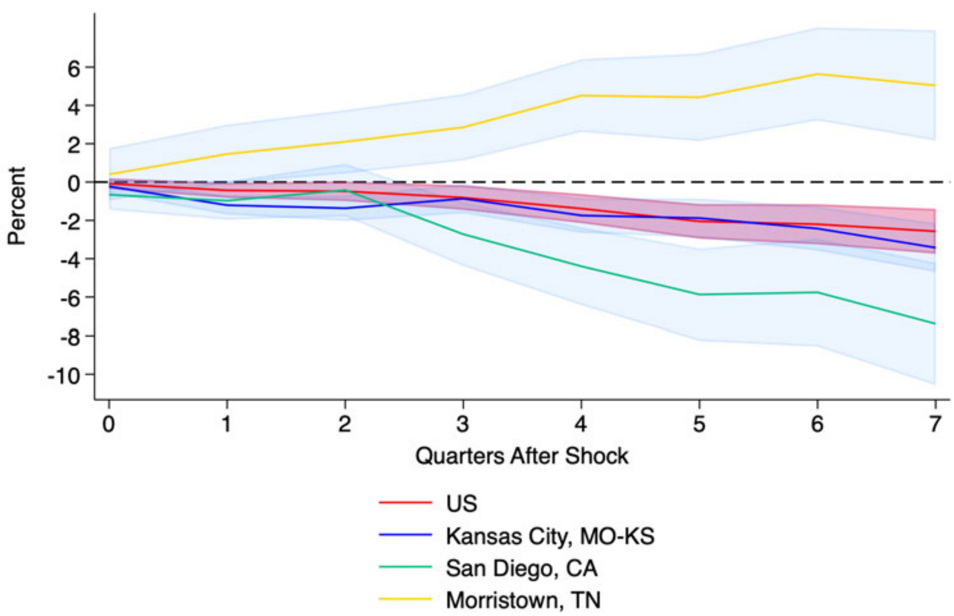


Figure 10: Local Projection of House Prices after a Monetary Policy Shock. *Notes*: The figure shows the local projection of metropolitan-level house prices after a monetary policy shock of 1%. For the monetary policy shocks, I use the time series extension of quarterly Romer and Romer shocks by Wieland and Yang (2020) and for the local house prices I use the quarterly FHFA metropolitan house prices HPI index. For each metropolitan area, I estimate a separate local projection.

The effect of monetary policy tightening on metropolitan-level house prices is determined by following once again Jordà (2005) and using local projections of monetary policy shocks on local house prices. For the monetary policy shocks, I again leverage the time series extension of quarterly Romer and Romer shocks by Wieland and Yang (2020) and for the local house prices I use the quarterly FHFA metropolitan house prices HPI index. For each metropolitan area, I estimate a separate local projection using lags for 4 quarters of data. The resulting projection for 3 examples of metropolitan areas, as well as for the national house price level changes, are depicted in Figure 10.

The purpose of this plot is to show the heterogeneity in response of metropolitan-level house prices to a monetary policy shock. The examples shown are of two extreme cases with respect to the national price changes, as well as of an example where metropolitan house prices tracked the national changes closely. Specifically, Morristown, TN and San Diego, CA represent the extremes, with the decrease in house prices in San Diego being much larger in magnitude than the national average, with an eventual decrease after 2 years of approximately 8% as opposed to the 2% change in US house prices. On the contrary, house prices in Morristown, TN have an estimated statistically significant positive change after an increase in interest rates. The metropolitan area of Kansas City, MO-KS is an example of an area where the predicted house price changes are almost identical to the country average.

10.2 Effect on Consumption

After determining how to map a monetary policy shock to changes in interest rates and house prices, I use the model to predict the consumption response of households under the counterfactual scenario of monetary policy tightening. The main aims are to understand i) the impact of house price perceptions on the transmission of monetary policy, and ii) the channels through which monetary policy is transmitted by households given their house price perceptions.

10.2.1 Channels of Monetary Policy Transmission

As mentioned earlier in the section, the relevant transmission channels are the interest rate channel and the asset price, specifically house price channel. I decompose the interest rate channel in a savings and a debt channel, in order to separate the impact of an increase in the deposit rate from that of an increase in the lending rate. I define the savings channel as the following:

$$\text{Savings Channel} = c(a, H, y; r^{\text{save}} + \Delta r^{\text{save}}, r^{\text{borrow}}, P^H) - c(a, H, y; r^{\text{save}}, r^{\text{borrow}}, P^H) \quad (30)$$

where Δr^{save} is the change in the deposit rate after a monetary policy shock, estimated by local projection in the previous section. Equivalently for the debt channel, or the effect of the change in the lending rate:

$$\text{Debt Channel} = c(a, H, y; r^{\text{save}}, r^{\text{borrow}} + \Delta r^{\text{borrow}}, P^H) - c(a, H, y; r^{\text{save}}, r^{\text{borrow}}, P^H) \quad (31)$$

For the impact of the change in house price, so the house price channel:

$$\text{House Price Channel} = c(a, H, y; r^{\text{save}}, r^{\text{borrow}}, P^H + \Delta P^H) - c(a, H, y; r^{\text{save}}, r^{\text{borrow}}, P^H) \quad (32)$$

where ΔP^H is the change in house prices resulting from the monetary policy shock, again as estimated using local projection in the previous subsection of the paper.

10.2.2 Monetary Policy Transmission Channels Decomposition and Perceptions

To first determine the impact of house price perceptions on the transmission of monetary policy, I run counterfactual simulations of the model using different values for the perception updating probability and estimate the average consumption change driven by each of the previously defined channels of transmission, so the savings, debt and house price channels. The average change in consumption by perception updating probability value is plotted in Figure 11, with Panel a) depicting the results for owners and b) for renters. Note that the values are expressed as percentage changes, where the denominator is the consumption level before the shock.

In Panel a) we observe that for increasing values of the updating probability, so when information rigidities are lower, the savings channel becomes monotonically less determinant to the consumption response out of a policy shock. On the contrary, the debt and house price channels become more prominent, with the debt channel being the main driver of the consumption response when the probability that a household perceived the policy shock is high. Because the rate shock is the same for all values of the updating probability, the difference in the interest rate transmission channels is driven by the wealth distribution of households in economies with different levels of information rigidities. When more households update their perceptions of house prices more often, more households are likely to observe house price growth changes and adjust their home ownership. Since adjusting the illiquid housing asset is costly, owners run down their savings by more than if they perceived less house price growth changes. Similarly for the debt channel, households that perceive house price growth changes more often will be able to take advantage of changes in their collateral with higher frequency. Since in this model's economy house prices are growing overall in time by growth factor Γ^H, this implies that at higher updating probability values, collateralized debt levels will also be higher. Note that these results are sensitive to the probability of switching between Markov states of house price growth independent to the business cycle, as was defined in Section 5. If the house price growth rate changes less often, the incentive to adjust housing will be lower no matter the probability of perception updating. With respect to the house price channel, the interpretation of this result is straightforward: after a negative shock to house prices, when the updating probability is higher more households will observe this house price change and will adjust their consumption accordingly, making the house price channel more prominent. As is expected, renters consumption response remains largely constant when varying the perception probability. This parameter does not affect renters directly because their perceptions of house prices agree with realizations.

10.2.3 House Price Channel, Policy Shocks and Updating Probability

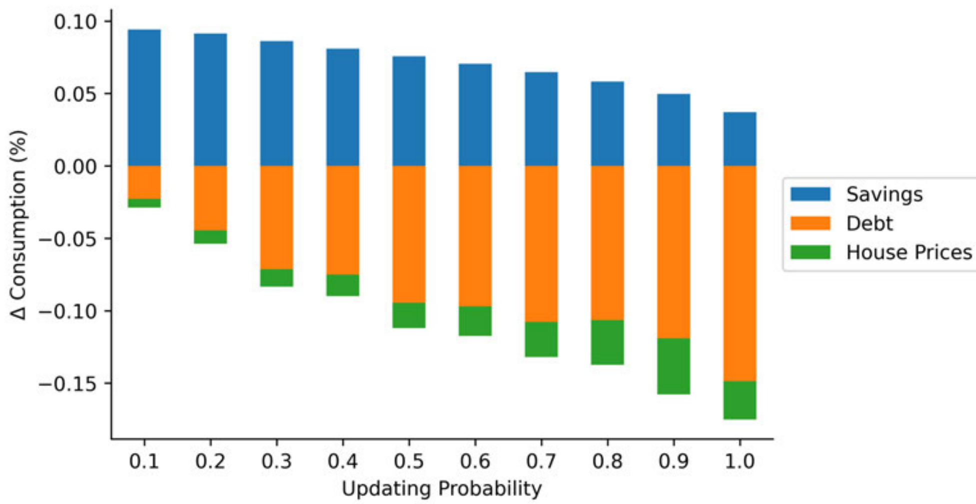
Next, I focus on the house price channel and how its transmission to consumption depends on the interaction of the size of the monetary policy shock and the probability of perception updating. I simulate the model under different sizes of shocks to the policy rate and for different levels of perception updating probability.

Figure 12 plots the size of the shock against the consumption response because of the house price channel, for 3 values of the updating probability: 10%, 50% and 100%. We observe that for owners in Panel a) the consumption response increases in magnitude with the updating probability. This finding is as expected, since when more households are well informed, monetary policy is more efficiently transmitted. Note however that the gain in transmission efficiency between an updating probability of 10% and 50% is much larger than that between 50% and 100% at all levels of the policy shock, revealing a nonlinear relationship between the updating probability and the house price channel transmission. A positive relationship also exists between the magnitude of the consumption response and the size of the monetary policy shock. For renters there is no variation in response by updating probability, so I plot only one level of the perception parameter to present complete results.

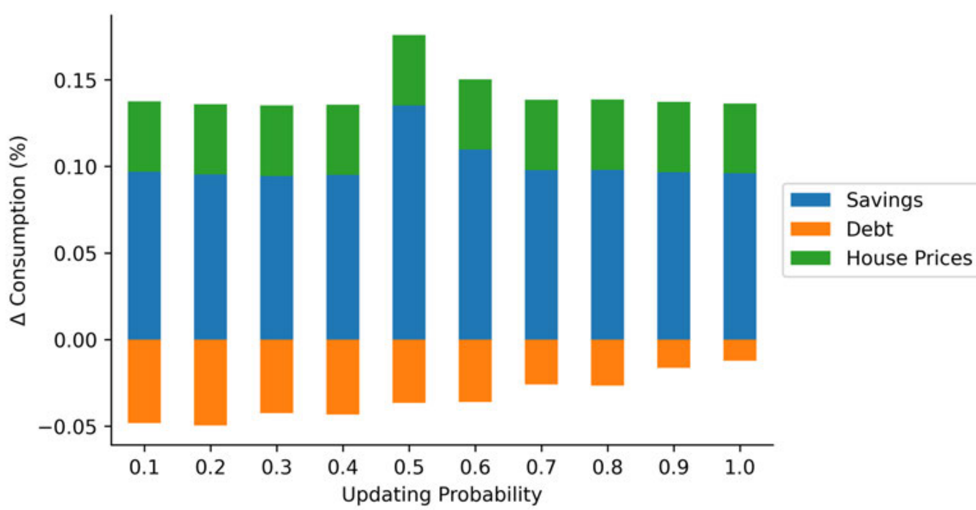
10.2.4 House Price Channel, Policy Shocks and House Price Changes

In Subsection 10.1.2, I highlighted that the same policy shock leads to a heterogeneous response in house price changes across different metropolitan areas in the US. This finding motivates the following application, where I consider how this house price heterogeneity interacts with the size of the policy shock and impacts monetary policy transmission through the house price channel.

In Figure 13 I plot the average change in consumption due to house prices by local house



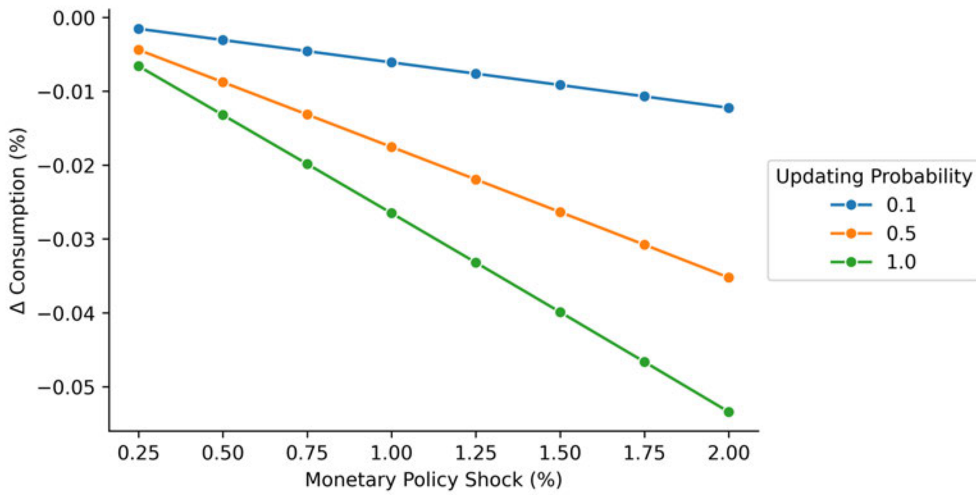
(a) Decomposition for owners



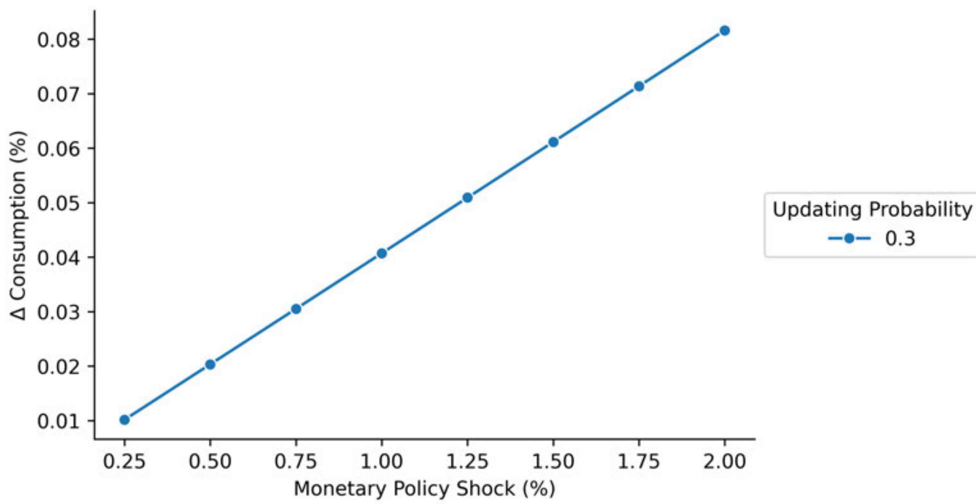
(b) Decomposition for renters

Figure 11: Monetary Policy Transmission Channels Decomposition and Perceptions. *Notes*: The figure shows the average consumption change driven by each of three channels, the savings, debt and house price channel. I run counterfactual simulations of the model using different values for the perception updating probability and estimate the average consumption change driven by each of the channels. Results are shown separately for owners and renters. The change in consumption is expressed as a percentage change, where the denominator is the consumption level before the shock.

price change, for different magnitudes of shocks. House prices are presented in terms of deciles, where the distribution is centered at approximately 0 house price change and values in decile 5 or higher are positive in sign. In the Figure, Panel a) shows the results for owners and b) for renters. Note that for renters, the consumption effect is symmetric for positive and negative local house price changes, with consumption increasing for negative house price changes and decreasing for the reverse. The size of the consumption change is reflected between decreases and increases of house prices.



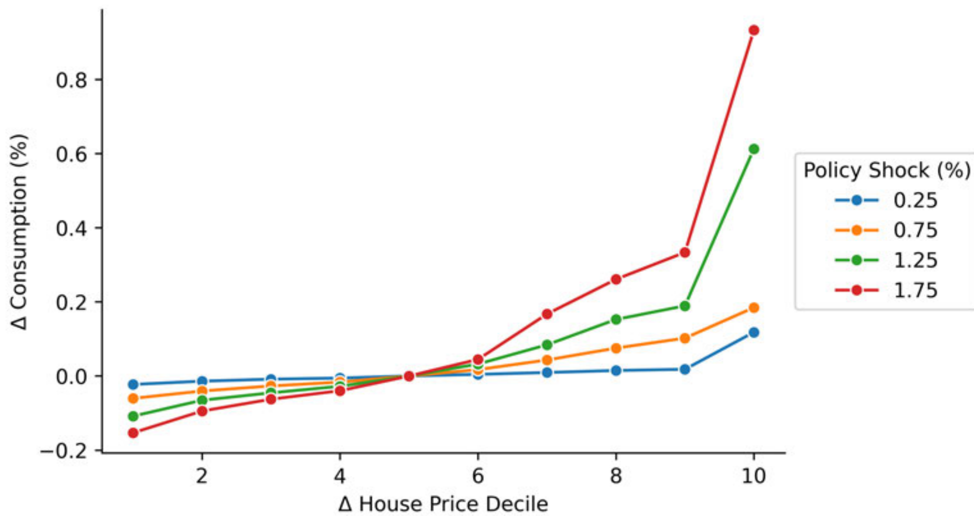
(a) Change in Consumption for Owners



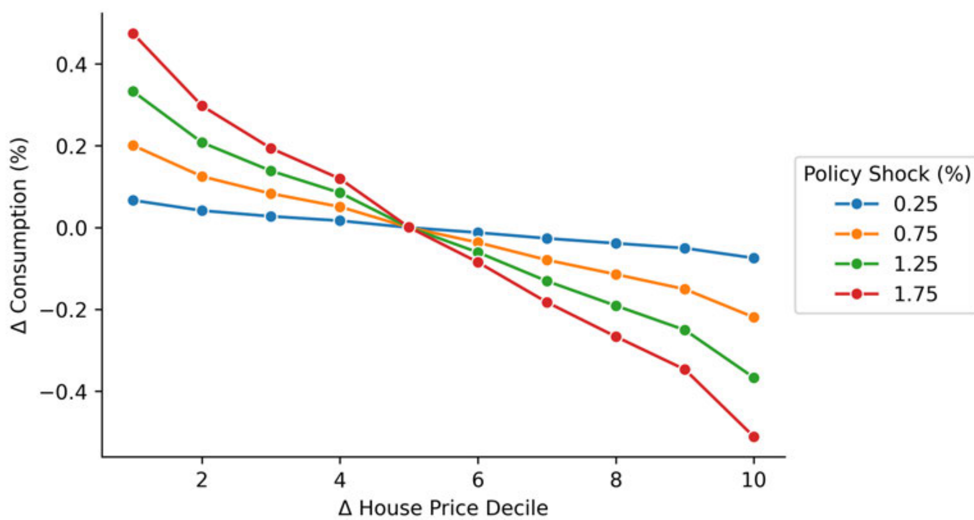
(b) Change in Consumption for Renters

Figure 12: Change in Consumption due to House Prices by Updating Probability and Shock Magnitude
Notes: The plots show the average chane in consumption due to the house price channel, with respect to the size of the shock, for 3 values of the updating probability: 10%, 50% and 100%.

Interestingly, this symmetry in consumption response between increases and decreases in house price does not hold for owners. In Panel a) we observe that the house price channel results in a decrease in consumption for negative house price changes and an increase for positive house price changes as would be expected for owners, but the magnitude of the consumption change for positive house price changes is much larger than that of negative house price changes.



(a) Change in Consumption for Owners



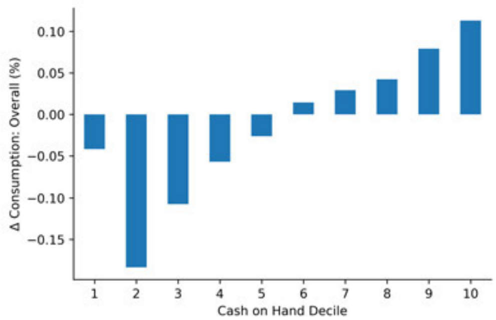
(b) Change in Consumption for Renters

Figure 13: Change in Consumption due to House Prices by Local House Price Change and Shock Magnitude
Notes: The figure shows the average change in consumption due to house prices by local house price change, for different magnitudes of shocks. House prices are presented in terms of deciles, where the distribution is centered at approximately 0 house price change and values in decile 5 or higher are positive in sign. The change in consumption is expressed as a percentage change, where the denominator is the consumption level before the shock.

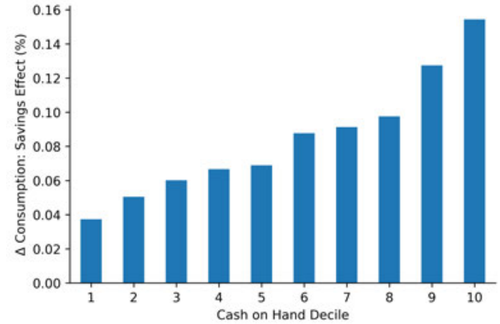
10.2.5 Monetary Policy Transmission Along the Cross-Section

The remainder of this section examines the transmission of monetary policy along the cross-section of households, given the level of house price perceptions used in the baseline model specification. Each of the transmission channels, the savings, debt and house price channel, are decomposed from the total consumption response to a monetary policy shock, in order to focus on which of the three drives the consumption response to policy shocks.

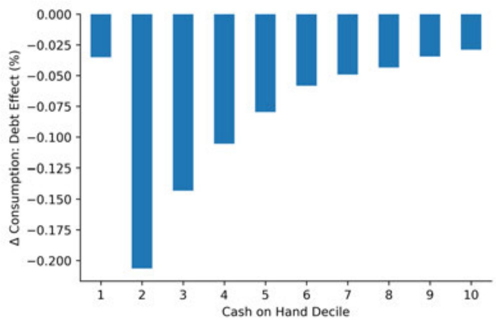
Staring with owners, Figure 14 depicts the overall consumption response to the policy shock in Panel a), the consumption change resulting from the savings channel in Panel b), the corresponding values for the debt channel in Panel c) and the house price channel in Panel d). Each of these figures are average % changes in consumption by cash on hand decile, taking the ratio of the dollar change in consumption due to each channel over the initial level of consumption. This measure means that in order to interpret the results, we need to take into account both the elasticity of consumption to the aggregate variable change, as well as the initial level of the variable along each x dimansion. We observe that the sign of the overall consumption change varies by the cash on hand level of a household. Specifically, owners with less cash are mostly affected by the change in the lending interest rate that results from monetary policy tightening. Moving along the cash distribution, the gain in savings becomes the dominating channel, turning the overall consumption response positive for households with high liquidity. This is intuitive since cash poor owners will rely more on their collateralized debt, having higher debt positions and therefore will decrease their consumption by more after changes to the rate that pertains to it. On the contrary, households with more cash will have higher levels of liquid wealth and therefore will gain more from the increase in the deposit rate. Note that, because owners' debt capacity is driven by their collateral position, when isolating the effect of monetary policy tightening on the savings account, any effect of debt constraints is removed. In Panel (c), the effect of debt on the consumption change decreases with increasing cash on hand as expected. The exception to this is households with very low levels of cash on hand. These households are the ones who will tend to have the smallest houses in the distribution, and therefore the least amount of collateralized debt. The house price effect is similar across the cash distribution, although slightly more negative for lower-cash households, feeding further into their overall consumption decrease.



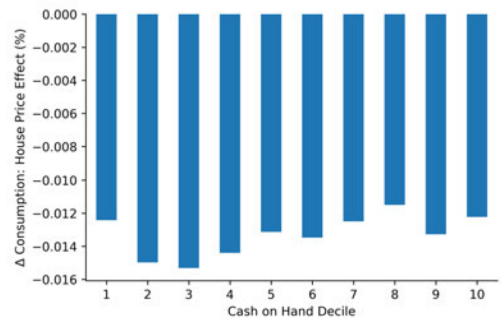
(a) Overall Consumption Change



(b) Savings Effect



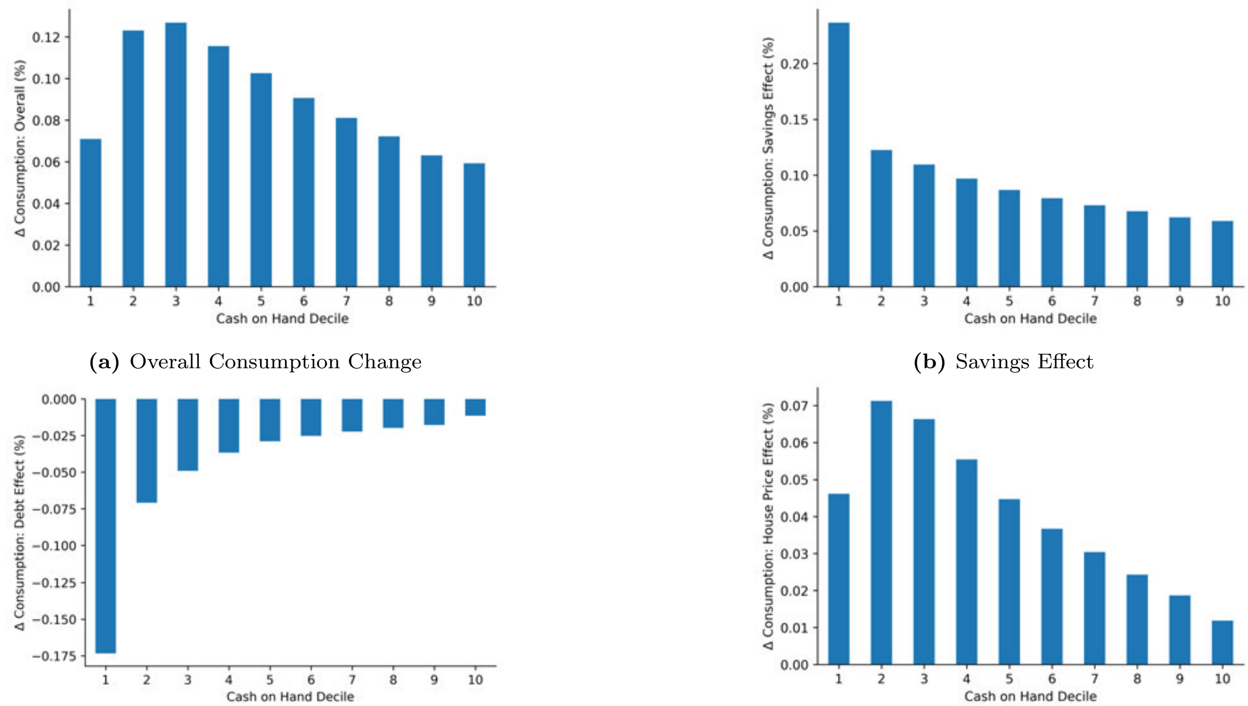
(c) Debt Effect



(d) House Price Effect

Figure 14: Monetary Policy Transmission by Effect, Owners *Notes*: The figure shows the transmission of monetary policy along the cross-section of owners, for the baseline level of house price perceptions probability. Each of the transmission channels, the savings, debt and house price channel, are decomposed from the total consumption response to a monetary policy shock, in order to focus on which of the three drives the consumption response to policy shocks.

Figure 15 provides the results for renters, where Panel a) depicts the overall consumption response to the policy shock, Panel b) the consumption change resulting from the savings channel, Panel c) the corresponding values for the debt channel and Panel d) the house price channel. The effects decrease monotonically for renters along the cash distribution. Interestingly, with respect to the debt effect, the response is largest for the households at the lowest decile of available cash. This is because all renters are able to borrow against their income, therefore the households who will be most affected by debt becoming more expensive will the most cash poor renters. Note that, opposite to owners, an overall decrease in house prices results in an increase in consumption for renters with any amount of cash available. This results from the fact that a decrease in house prices means that required down payments to purchase a home also decrease. So for renters who want to own in the future, consumption can increase since they can save less of their income in each period.



(a) Overall Consumption Change

(b) Savings Effect

(c) Debt Effect

(d) House Price Effect

Figure 15: Monetary Policy Transmission by Effect, Renters *Notes*: The figure shows the transmission of monetary policy along the cross-section of renters, for the baseline level of house price perceptions probability. Each of the transmission channels, the savings, debt and house price channel, are decomposed from the total consumption response to a monetary policy shock, in order to focus on which of the three drives the consumption response to policy shocks.

11 Conclusion

In this paper, I estimate the housing wealth effect by incorporating households' house price perceptions in a structural model of consumption and housing with endogenous home ownership choice. The novel feature in my model is the inclusion of house price perceptions. Renters' perception of house prices and house price changes track the actual values exactly, whereas owners perceive only house price changes that co-move with the aggregate component of their income, but perceive house price changes that are independent to the business cycle only occasionally.

I find that, on average, households' marginal propensity to consume out of housing is 2.7 cents over a year out of a 1 dollar increase in housing wealth for owners and -2.6 cents over a year out of a 1 dollar increase in house prices for renters. By decomposing the effect of house price perceptions, I show that the MPCH for owners with full information would be approximately twice as high as the predicted value of the baseline model. Along the cross-section of households, the MPCH is largest for owners who face the highest liquidity and debt constraints, as well as for renters who are most likely to want to purchase a home.

My model provides an ideal framework for examining the efficiency of monetary policy transmission and the impact that household house price perceptions has on it. I show that the consumption response of owners resulting from the house price channel increases in magnitude with the updating probability. Furthermore, for increasing values of the perceptions updating probability, the savings channel becomes less determinant to the consumption response out of a policy shock and the debt and house price channels become more prominent, with the debt channel being the main driver of the consumption response when the probability that a household perceived the policy shock is high. These differences are mainly driven by the steady state wealth distribution of households in economies with different levels of information rigidities. Focusing on the house price channel, I show that the efficiency of monetary policy transmission increases with increasing probability of perceiving house price changes. Furthermore, I look into the impact monetary policy transmission in the cross-section of households and find significant heterogeneity in both the overall effect of the monetary policy tightening event I simulate, but along the different transmission channels as well.

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A Data

Many different data sources are used for the analysis, below is an outline of the main datasets.

A.1 American Community Survey

For all data on perceptions, I use the American Community Survey. The survey contains information about a wide variety of topics, including house prices. For the analysis in this paper, I utilize the data related to home values, where the survey asks for the respondent's estimate of how much their owned property would sell for if it were for sale at the time of the questionnaire. Thus, the responses are used to examine households' perceptions of the price of their own house. This information is available at an annual frequency at the metropolitan level.

A.2 NielsenIQ Homescan Consumer Panel

The NielsenIQ Homescan Consumer Panel is a longitudinal panel of U.S. households, that includes data on their purchases. Specifically, the products covered are all Nielsen-IQ tracked categories of food and non-food items across all retail outlets. The purchase data is weekly and includes bar code-level information of products purchased, such as the prices, quantities and whether the product was part of a promotion among other characteristics. In addition to purchases, demographic characteristics and geographic variables are annually updated for each household, such as the household income, size, type of residence and the location the household lives in.

A.3 Zillow House Price Data

For data on house prices, I use the Zillow home value index, which is a measure of the typical home value by metropolitan area. Specifically, it is an estimate of the typical value for homes in the 35th to 65th percentile range in the area.

A.4 Federal Housing Finance Agency

The Federal Housing Finance Agency HPI is derived using all house transactions, so both sales prices and appraisal data, providing home values as driven both by improvements in house quality as well as local market dynamics.

A.5 Survey of Consumer Finances

The Survey of Consumer Finances, is a triennial cross-sectional survey of U.S. families. The data include information on families' balance sheets and therefore used for calculating the empirical moments used in the estimation of the model parameters, as outlined in Section 6.

A.6 New York Fed Survey of Consumer Expectations

The Survey of Consumer Expectations is a monthly survey of a rotating panel of households, that includes information on consumers' expectations and financial decisions on many topics, including housing. I use data for owners and renters for the one of the stylized patterns discussed in Section 4. For owners, I use the available information on respondents' expectation about house prices in their zip code one year and five years in the future. For renters, I use data on their expected rent in one and five years in the future.

A.7 County Business Patterns

I use the County Business Patterns (CBP), provided by the Census Buerau. The CBP is an annual series on county-level economic data by industry, including information on number of establishments, which I leverage for the industry controls used in the regressions in Section 7.

A.8 10-K Reports of Institutional Investors

For the empirical analysis of the impact of investors on house prices, I extract data from the 10-k Reports of Institutional Investors. The SFR institutional investors used in this analysis are classified as Real Estate Investment Trusts and therefore are required to disclose information about their property portfolio. Due to this requirement, I can extract data on the number of properties owned by metropolitan area from the SFR investors' 10-K submissions.

A.9 Federal Reserve's Report of Condition and Income and FDIC Branch Data

I also incorporate Federal Reserve's Report of Condition and Income and FDIC Branch Data. The Federal Reserve's Report of Condition and Income, along with FDIC branch data, is used for collecting data on local banks in different metropolitan areas. This information is used in creating the instrument for the IV analysis.

A.10 Home Mortgage Disclosure Act (HMDA) Data

I include The Home Mortgage Disclosure Act Loan Application Register Data for the mortgage loan volume originated by different financial institutions, as used in the Instrumental Variable analysis in Section 7.

B Household Problem

This appendix describes in detail the problem faced by the household in each period. As mentioned in Section 5, households face a discrete-continuous choice of housing and consumption. With respect to housing, households choose between keeping the ownership of their current house, moving to a smaller/larger house, or renting:

$$v(\mathbf{s}) = \{v^{keep}(\mathbf{s}), v^{adjust}(\mathbf{s}), v^{rent}(\mathbf{s})\} \tag{33}$$

Each of the continuation value functions are defined below:

$$v^{keep}(\mathbf{s}) = \max_{c,h} u(c,h) + \beta\mathbb{E}[v(\mathbf{s}')] \tag{34}$$

$$v^{adjust}(\mathbf{s}) = \max_{c,h} u(c,h) + \beta\mathbb{E}[v(\mathbf{s}')] \tag{35}$$

$$v^{rent}(\mathbf{s}) = \max_{c} u(c,h) + \beta\mathbb{E}[v(\mathbf{s}')] \tag{36}$$

where $\mathbf{s} \equiv (m_{i,t}, p_{i,t}, P_t, \tilde{P}^H_{j,t}, \tilde{\phi}^H_{j,t}, H_{i,t})$. When a household adjusts their ownership, either buying or selling housing units $h_{i,t}$, they incur an adjustment cost equal to $\tau h_{i,t} P^H_{j,t}$, where τ is the adjustment cost parameter.

B.1 Owner Problem

Using the dynamics defined in Section 5, the owner's problem can be summarized by the following:

$$
\begin{aligned}
v^{\text{keep}}(m_{i,t}, p_{i,t}, P_t, \tilde{P}^H_{j,t}, \tilde{\phi}^H_{j,t}, H_{i,t}) = \\
\max_{c_{i,t}, h_{i,t}} \{u(c_{i,t}, h_{i,t}) + \beta \mathbb{E}_t[(1 - d_{i,t}) v(m_{i,t+1}, p_{i,t+1}, P_{t+1}, \tilde{P}^H_{j,t+1}, \tilde{\phi}^H_{j,t+1}, H_{i,t+1})]\}
\end{aligned}
$$

subject to:

$$
\begin{aligned}
a_{i,t} &= m_{i,t} - c_{i,t} \text{ where } -a_{i,t} \leq (1-\theta) H_{i,t} \\
y_{i,t+1} &= w \theta_{i,t+1} p_{i,t+1} \Theta_{t+1} P_{t+1} \\
p_{i,t+1} &= p_{i,t} \psi_{i,t+1} \\
P_{t+1} &= \Gamma P_t \Psi_{t+1} \\
H_{i,t+1} &= (1-\delta) h_{i,t} P^H_{j,t+1} \\
P^H_{j,t+1} &= \Gamma^H \phi^H_{j,t+1} P^H_{j,t} \Psi^H_{t+1} \\
\{\tilde{P}^H_{j,t}, \tilde{\phi}^H_{j,t}\} &= \mathbb{E}_{t-n}[\{P^H_{j,t}, \phi^H_{j,t}\} | \{P^H_{j,t-n}, \phi^H_{j,t-n}\}] = \{(\phi^H_{j,t-n})^n P^H_{j,t-n}, \phi^H_{j,t-n}\} \\
m_{i,t+1} &= y_{i,t+1} + (1 - \delta + r) a_{i,t}
\end{aligned}
$$

B.2 Renter Problem

Likewise for renters, the household's problem can be summarized by the following:

$$
\begin{aligned}
v^{\text{rent}}(m_{i,t}, p_{i,t}, P_t, P^H_t, \Phi^H_t, 0) = \\
\max_{c_{i,t}} \{u(c_{i,t}, \bar{h}) + \beta \mathbb{E}_t[(1 - d_{i,t}) v(m_{i,t+1}, p_{i,t+1}, P_{t+1}, P^H_{t+1}, \Phi^H_{t+1}, 0)]\}
\end{aligned}
$$

subject to:

$$
\begin{aligned}
a_{i,t} &= m_{i,t} - c_{i,t} - R^H_{j,t+1} \text{ where } -a_{i,t} \leq \sigma p_{i,t} P_t \\
y_{i,t+1} &= w \theta_{i,t+1} p_{i,t+1} \Theta_{t+1} P_{t+1} \\
p_{i,t+1} &= p_{i,t} \psi_{i,t+1} \\
P_{t+1} &= \Gamma P_t \Psi_{t+1} \\
P^H_{j,t+1} &= \Gamma^H \phi^H_{j,t+1} P^H_{j,t} \Psi^H_{t+1} \\
R^H_{j,t+1} &= \bar{R} \bar{h} P^H_{j,t+1} \\
m_{i,t+1} &= y_{i,t+1} + (1 - \delta + r) a_{i,t}
\end{aligned}
$$

C Estimation Methodology

For ease of notation, let the vector of parameters $\rho, \alpha, \beta, \tau$ to be estimated be defined as $\boldsymbol{\theta}_1$. All the rest of the parameters, either calibrated from values in the literature, estimated in partial equilibrium and outside of the model or chosen to match empirical data over the period of the analysis are defined as $\boldsymbol{\theta}_2$. The Generalized Method of Moments (GMM) is used, as formalized by (Hansen, 1982), because it works well with larger samples, nonlinear models and allows for us to remain relatively agnostic with respect to the exact distributional properties of all elements in the model.

C.1 The GMM Estimation

The vector $\boldsymbol{g}(\cdot)$ is defined as the distance of the data moments from their corresponding model moments. Using GMM, the vector of parameters are estimated by choosing parameters that minimize the distance between the chosen set of data moments from their model moment equivalents. Therefore, the GMM estimator minimizes the form:

$$\boldsymbol{Q}_T(\boldsymbol{\theta}_1) = \left[N^{-1}\sum_{t=1}^{N}\mathbf{g}(\boldsymbol{\theta}_1, \boldsymbol{\theta}_2)\right]' \hat{\boldsymbol{\Xi}} \left[N^{-1}\sum_{t=1}^{N}\mathbf{g}(\boldsymbol{\theta}_1, \boldsymbol{\theta}_2)\right] \tag{37}$$

where $\boldsymbol{\Xi}$ is the weighting matrix, a positive definite matrix and N is the number of data observations.

The literature recommends many different ways to choose the optimal weighting matrix. In order to take the most conservative approach, I use the identity matrix. In this case the identity matrix is preferable because all empirical moments, bar one, are calculated using the same data source, the SCF and the problem is well conditioned and well defined.

C.2 Variance of Estimated Parameters

For the standard errors of the estimates parameters, or the estimated variance-covariance matrix $\hat{\Sigma}$ of the estimated parameter vector $\boldsymbol{\theta}_1$ is a $K \times K$ matrix, where K is the number of parameters. The model is overidentified as the number of moments R exceed the number of parameters $K < R$.

The GMM variance-covariance matrix is derived from the first derivative of the vector $\boldsymbol{g}(\cdot)$ with respect to each parameter of $\rho, \alpha, \beta, \tau$.

To calculate the derivatives, I define the Jacobian matrix $d(x|\theta)$, a $R \times K$ matrix of derivatives of the $R \times 1$ distance vector $\boldsymbol{g}(\cdot)$.

$$d(x|\theta) \equiv \begin{bmatrix} \frac{\partial g_1(x|\theta)}{\partial \rho} & \frac{\partial g_1(x|\theta)}{\partial \alpha} & \frac{\partial g_1(x|\theta)}{\partial \beta} & \frac{\partial g_1(x|\theta)}{\partial \tau} \\ \frac{\partial g_2(x|\theta)}{\partial \rho} & \frac{\partial g_2(x|\theta)}{\partial \alpha} & \frac{\partial g_2(x|\theta)}{\partial \beta} & \frac{\partial g_2(x|\theta)}{\partial \tau} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial g_R(x|\theta)}{\partial \rho} & \frac{\partial g_R(x|\theta)}{\partial \alpha} & \frac{\partial g_R(x|\theta)}{\partial \beta} & \frac{\partial g_R(x|\theta)}{\partial \tau} \end{bmatrix} \tag{38}$$

The estimates produced from the GMM for the parameters $\boldsymbol{\theta}_1$ are asymptotically normal. Define $\boldsymbol{\theta}_0$ as the true value of the parameters, then according to the distribution of the estimates, the following holds:

$$\text{plim}_{N\to\infty}\sqrt{N}\left(\boldsymbol{\theta}_1 - \boldsymbol{\theta}_0\right) \sim \text{N}\left(0, \left[d(x|\theta)^T \boldsymbol{\Xi} d(x|\theta)\right]^{-1}\right) \tag{39}$$

where $\boldsymbol{\Xi}$ is the weighting matrix used in the estimation procedure from the GMM criterion function and N is the number of data observations. Since I am using panel data, N equals the number of unique households in the dataset. Therefore, the GMM estimator for the variance-covariance matrix $\hat{\Sigma}_{GMM}$ that gives the standard errors of the estimated parameters is the below:

$$\hat{\Sigma}_{GMM} = \frac{1}{N}\left[d(x|\theta)^T \boldsymbol{\Xi} d(x|\theta)\right]^{-1} \tag{40}$$

For the calculation of $\hat{\Sigma}_{GMM}$, I use the applied mathematical equivalent of the above expressions, by leveraging the finite difference method. So for each derivative, the finite difference method would give:

$$f'(x_0) = \lim_{h\to 0} \frac{f(x_0+h) - f(x_0)}{h} \tag{41}$$

The centered second-order numerical approximation of the derivative of a function as shown above is then:

$$f'(x_0) \approx \frac{f(x_0+h) - f(x_0-h)}{2h} \tag{42}$$

D Sensitivity Analysis

D.1 Coefficient of Relative Risk Aversion

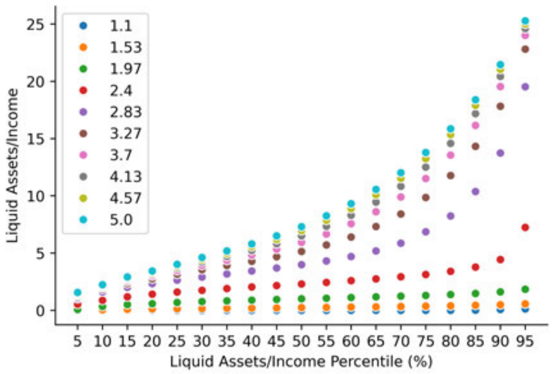
The CRRA ρ appears in the model in the utility function:

$$u(c_{i,t}, h_{i,t}) = \frac{1}{1-\rho}(c_{i,t}^{\alpha} h_{i,t}^{1-\alpha})^{1-\rho}$$

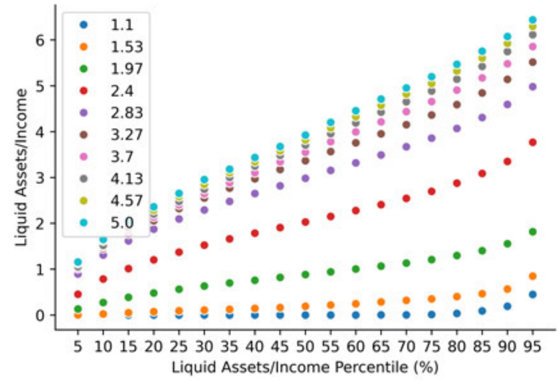
- ρ: coefficient of relative risk aversion
- α: elasticity of substitution between non-housing consumption and housing

Sensitivity prediction:

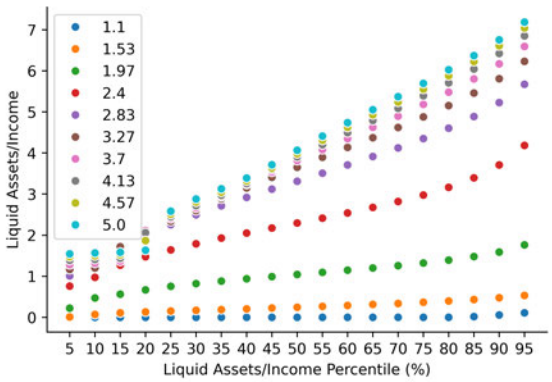
- Liquid Assets/Income, Owners: as risk aversion increases, households increase their precautionary savings, or else their liquid assets
- Liquid Assets/Income, Renters: same as for owners
- Debt/Income, Owners: as risk aversion increases, owners increase their precautionary savings and are less reliant on debt
- Debt/Home Value, Owners: similarly to debt/income, as risk aversion increases, owners increase their precautionary savings and are less reliant on debt
- Moving rate: as risk aversion increases and households increase their savings, they are more flexible to move houses. Moving rate values corresponding to the parameter values shown in the Figure below: 0.017, 0.024, 0.048, 0.114, 0.342, 0.441, 0.485, 0.506, 0.522, 0.534



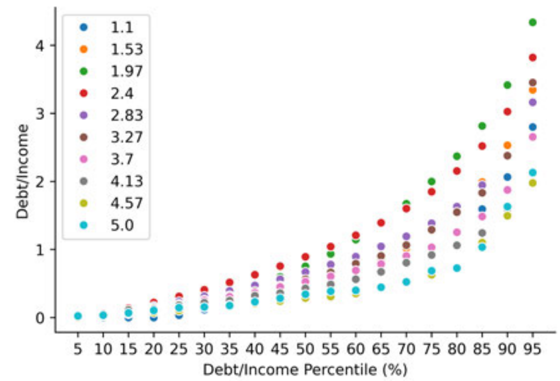
(a) Liquid Assets/Income, All



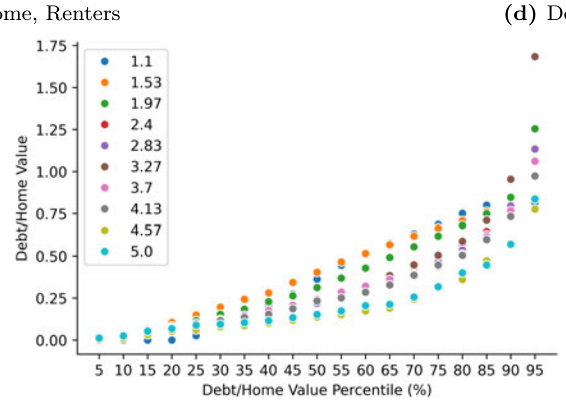
(b) Liquid Assets/Income, Owners



(c) Liquid Assets/Income, Renters



(d) Debt/Income, Owners



(e) Debt/Home Value, Owners

Figure 16: Sensitivity Analysis for the Coefficient of Relative Risk Aversion

D.2 Consumption-Housing Elasticity

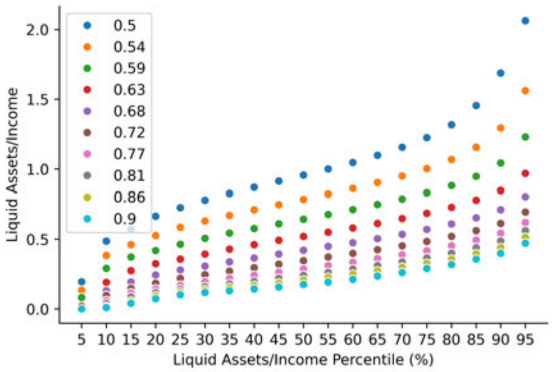
The Consumption-Housing Elasticity α appears in the model in the utility function:

$$u(c_{i,t}, h_{i,t}) = \frac{1}{1-\rho}(c_{i,t}^{\alpha} h_{i,t}^{1-\alpha})^{1-\rho}$$

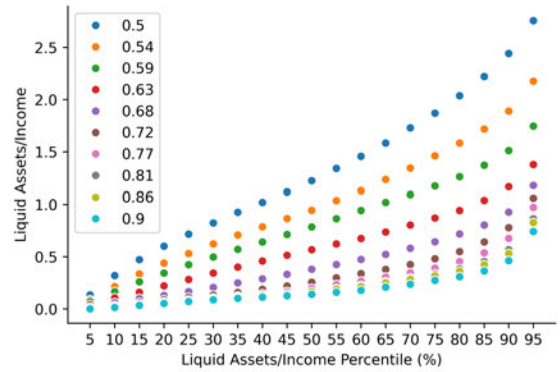
- ρ: coefficient of relative risk aversion
- α: elasticity of substitution between non-housing consumption and housing

Sensitivity prediction:

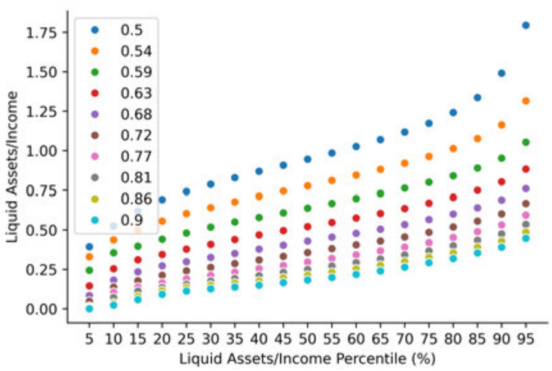
- Liquid Assets/Income, Owners: as the elasticity increases, households gain less utility from housing, so are more likely to own smaller houses, therefore can borrow less. They consume more, so their liquid assets fall
- Liquid Assets/Income, Renters: as the elasticity increases, renters are less motivated to buy a house so their savings that would have been used to purchase a house remain in their account
- Debt/Income, Owners: No effect
- Debt/Home Value, Owners: as the elasticity increases, households gain less utility from housing, so are more likely to own smaller houses, so debt and home value decreases
- Moving rate: the effect is not clearly predetermined, as it depends on the distribution of renters and owners. Moving rate values corresponding to the parameter values shown in the Figure below: 0.014, 0.019, 0.019, 0.019, 0.018, 0.017, 0.02, 0.023, 0.022, 0.022



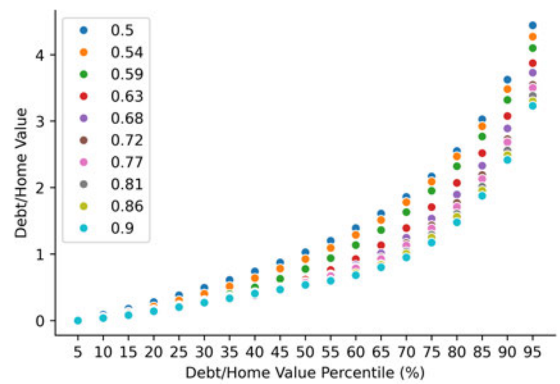
(a) Liquid Assets/Income, All



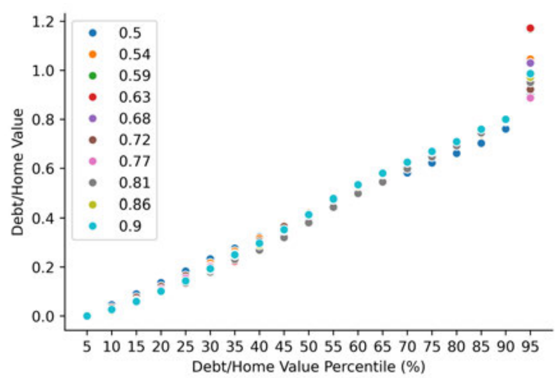
(b) Liquid Assets/Income, Owners



(c) Liquid Assets/Income, Renters



(d) Debt/Income, Owners



(e) Debt/Home Value, Owners

Figure 17: Sensitivity Analysis for the Consumption-Housing Elasticity

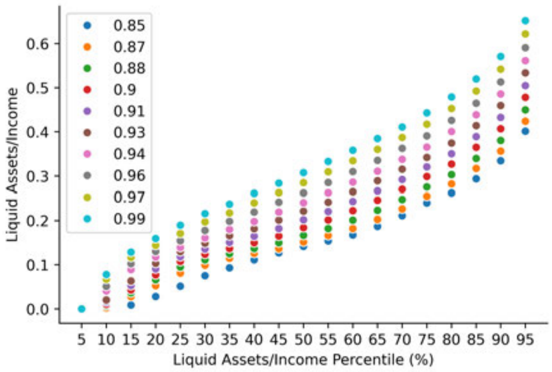
D.3 Discount Factor

The Discount Factor β appears in the model when discounting future cash flows. For example:

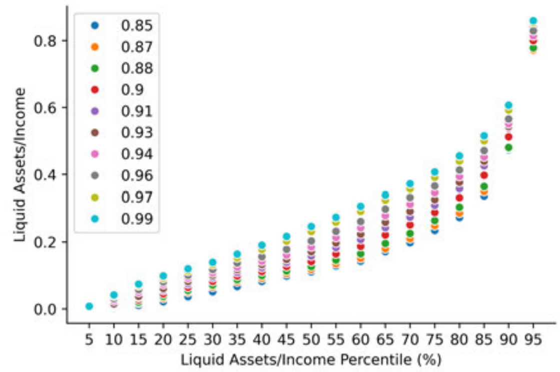
$$v^{\text{keep}}(m_{i,t}, p_{i,t}, P_t, \tilde{P}^H_{j,t}, \tilde{\phi}^H_{j,t}, H_{i,t}) = \max_{c_{i,t}, h_{i,t}} \{u(c_{i,t}, h_{i,t}) + \beta \mathbb{E}_t[(1 - d_{i,t}) v(m_{i,t+1}, p_{i,t+1}, P_{t+1}, \tilde{P}^H_{j,t+1}, \tilde{\phi}^H_{j,t+1}, H_{i,t+1})]\}$$

Sensitivity prediction:

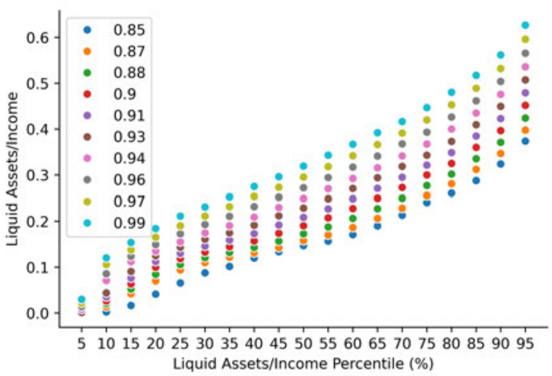
- Liquid Assets/Income, Owners: as the discount factor increases, households become more patient and therefore increase their liquid assets
- Liquid Assets/Income, Renters: same as for owners
- Debt/Income, Owners: no effect since debt is short term debt
- Debt/Home Value, Owners: no effect since debt is short term debt
- Moving rate: as the discount factor increases, households become more patient and therefore homewonership increases, so more renters will choose to become owners, increasing the moving rate. Moving rate values corresponding to the parameter values shown in the Figure below: 0.021, 0.022, 0.022, 0.022, 0.022, 0.022, 0.022, 0.023, 0.023, 0.024



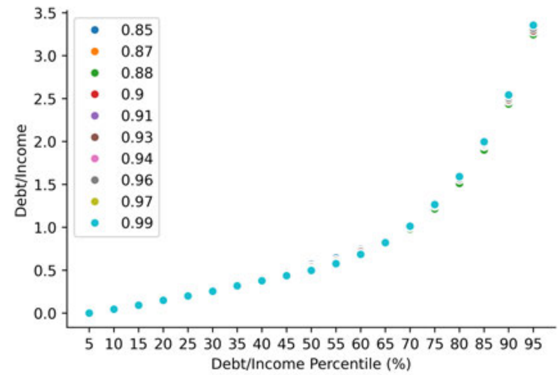
(a) Liquid Assets/Income, All



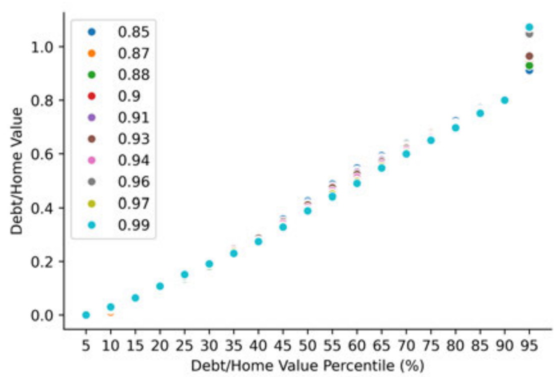
(b) Liquid Assets/Income, Owners



(c) Liquid Assets/Income, Renters



(d) Debt/Income, Owners



(e) Debt/Home Value, Owners

Figure 18: Sensitivity Analysis for the Discount Factor

D.4 Housing Adjustment Cost

The Adjustment Cost τ appears in the model after an owner buys a new house or sells their house:

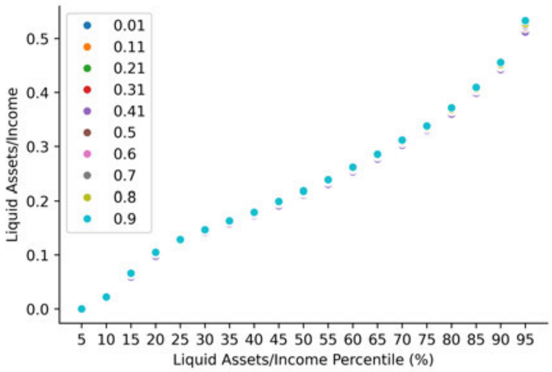
$$\kappa_{i,t} = \tau h_{i,t} P^H_{j,t}$$

$h_{i,t}$: housing service units

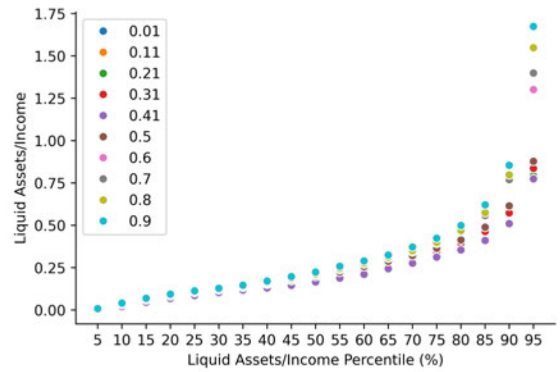
$P^H_{j,t}$: house price in area j

Sensitivity prediction:

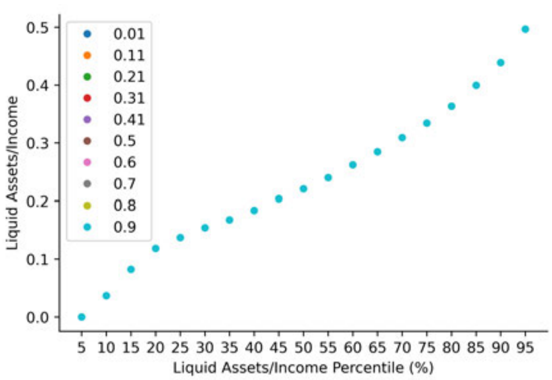
- Liquid Assets/Income, Owners: as the adjustment cost increases, households need to save more to be able to make the required payments for buying a new house or selling the current one
- Liquid Assets/Income, Renters: no effect
- Debt/Income, Owners: as the adjustment cost increases, owners borrow more to be able to make the required payments for buying a new house or selling the current one
- Debt/Home Value, Owners: as the adjustment cost increases, owners borrow more to be able to make the required payments for buying a new house or selling the current one. However, the total adjustment cost is proportional to the home value, so the variation should be limited
- Moving rate: as the adjustment cost increases, owners are less likely to move homes. Moving rate values corresponding to the parameter values shown in the Figure below: 0.019, 0.017, 0.021, 0.007, 0.008, 0.007, 0.003, 0.003, 0.003, 0.002



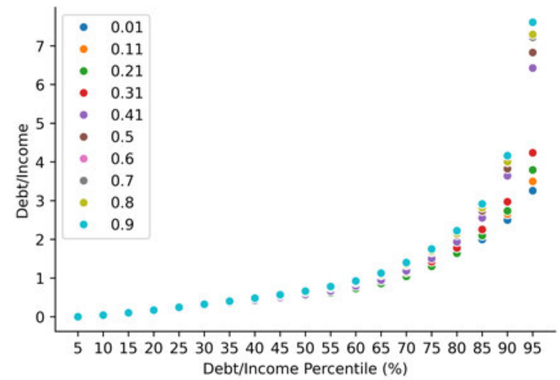
(a) Liquid Assets/Income, All



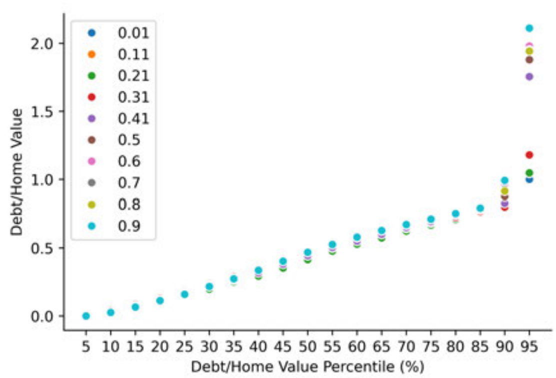
(b) Liquid Assets/Income, Owners



(c) Liquid Assets/Income, Renters



(d) Debt/Income, Owners



(e) Debt/Home Value, Owners

Figure 19: Sensitivity Analysis for Housing Adjustment Cost

E Further Evidence on House Prices and Institutional Investors

To complement the results presented in section 7 for the effect of SFR Institutional Investors, and particularly their effect on house prices, I examine another identification approach for isolating their impact on house prices. While these investors emerged after the Global Financial Crisis, they expanded quickly in later years, between 2015 and 2017, when some large SFR investors merged with their institutional rivals. Such mergers between institutional investors lead to a shift in the scale and market share of the merged firm in different neighborhoods.

Recent papers in the literature have studied these mergers of institutional Single-Family Rental investors, using them as an exogenous change in local investor market share (Gurun et al. (2022), Garriga et al. (Forthcoming), LaPoint (2023)). The merger of institutional SFR investors provides an appropriate setting to examine the direct causal effects on house prices.

For the bellow results, I use replication data derived from ZTRAX. Zillow's Transaction and Assessment Database (ZTRAX) is a real estate database including transactions, property characteristics, geographic information and prior valuation for ∼150 million parcels in the US. Although I currently do not have direct access to the ZTRAX database, I use the replication data from Gurun et al. (2022), which includes the number of properties owned by Acquirer and Target firms in the three mergers of Institutional Single-Family Rental Investors that I use in my analysis.

The mergers I will focus on include: i) the merger of American Homes 4 Rent with American Residential Properties, announced on December 2015 and completed by February 2016, ii) the merger of Starwood Waypoint Residential Trust with Colony American Homes, announced on September 2015 and completed by January 2016, and iii) the merger of Invitation Homes with Starwood Waypoint Homes, announced on August 2017 and completed by November 2017. In the analysis that follows, the time between announcement and completion of each merger is not included in the estimation, therefore the results for the effects after the merger refer to a significant period after each merger was first announced, which should be considered in the interpretation of the results.

Since the aim is to isolate the effects of these mergers, the areas that will be used in the analysis will be all locations where, in each merger, the target firm and/or the acquirer firm own properties. Specifically, local areas are classified as 'Treated' if both the acquirer and the target own properties in the area and 'Control' if either the target or the acquirer are present. Through this specification, the 'Treated' areas are the only ones who should be subject to the impact of the merger and are compared to other areas where, although the investors already own properties, will not be directly impacted by the merger. This setup allows for any selection concern to be taken into account and isolated from the exogenous impact of the merger to the local areas it affects.

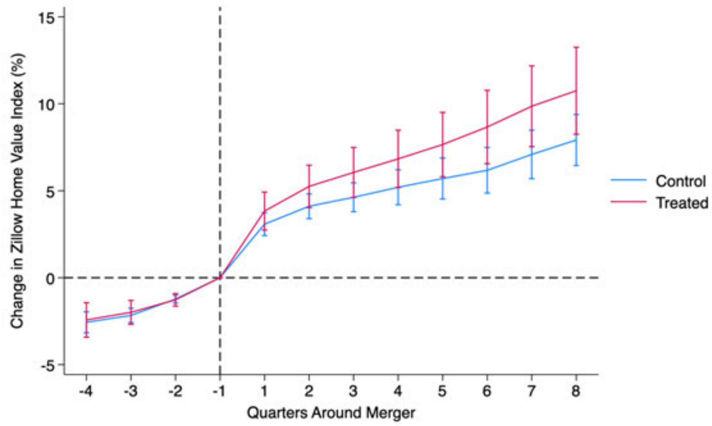
I use a difference-in-difference specification, and the availability of quarterly house prices allows for an analysis in changes in home prices by quarters around the merger:

$$\ln\left(\text{ZHVI}\right)_{m,j,t} = \beta_0 + \sum_{\tau=-4}^{8} \beta_{1,\tau} w_{m,j,t,\tau} \times \text{Treat}_{m,j} + \beta_2 \text{Treat}_{m,j} + \tag{43}$$

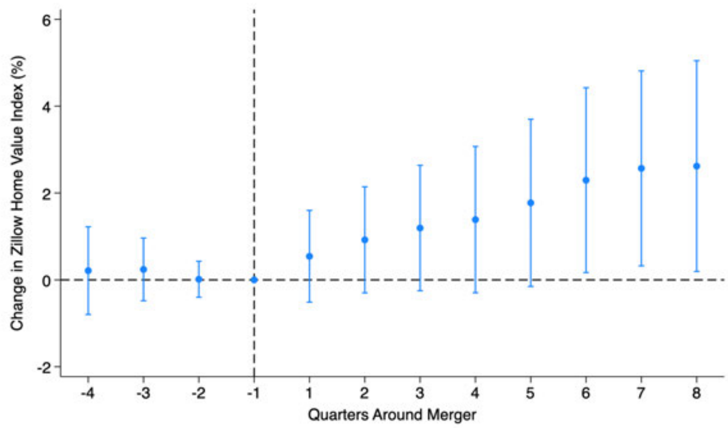
$$\sum_{\tau=-4}^{8} \beta_{3,\tau} w_{m,j,t,\tau} + \gamma_{c,t} + \theta_j + \epsilon_{m,j,t} \tag{44}$$

where j is the zip code, t is the quarterly time period and $w_{m,j,t,\tau}$ is the τ quarterly window. I use fixed effects, at the county-quarter and zip code level. Standard errors are also clustered at the zip code level.

Figure 20 shows the results, where panel (a) depicts the specification run only for 'Control' or 'Treated' households, so with Post = 0 and Post = 1 respectively and panel (b) depicts the coefficients corresponding to the $w_{m,j,t,\tau} \times \text{Treat}_{m,j}$ terms of the equation. Note that, although home prices where moving in step before the merger, home values increase by more after the merger for 'Treated' zip codes, with this difference becoming statistically significant from the 6th quarter after the merger onwards.



(a) Treated vs. Control Zip Codes



(b) Treated - Control Zip Codes

Figure 20: % Average Change in Home Values Before and After the Merges. *Notes*: The figures plot the estimated coefficients from the diff-in-diff specification. The top plots the results of running the specification on control or treated areas separately and the bottom panel depicts the diff-in-diff coefficients. Fixed effects, at the county-quarter and zip code level are included. Standard errors are also clustered at the zip code level.