Financial-State-Dependent Effects of House Prices on Consumption and Housing Investment*

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Abstract

In this paper, I show that the effects of house prices on consumption and residential investment vary with the financial conditions. I find that consumption is more responsive to house prices under tight financial conditions relative to a loose financial regime whereas the response of residential investment is mixed. To explain this new finding, I employ a life-cycle model that accounts for the financial conditions and quantitatively explore its effects. Younger households, who on average most actively engage in residential investments, show larger consumption responses to house price changes under tighter financial conditions, consistent with the aggregate empirical evidence. I rationalize this outcome by a financial-state-dependent substitution effect between consumption and residential investment due to changes in house prices, which is more pronounced among younger households.

Keywords: House price, Consumption, Residential investment, Mortgage borrowing, Financial friction

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1 Introduction

Housing wealth constitutes a large proportion of households' total wealth in the U.S. Moreover, according to the Survey of Consumer Finance (SCF), almost two-thirds of the households in the U.S. are homeowners. These empirical facts allow one to naturally expect that movements in house prices can significantly affect household wealth, subsequently influencing households' decisions on consumption and investments. Households' choices in turn determine the evolution of aggregate demand and, most importantly, have policy implications during housing market booms and busts.

Relatedly, over 40% of the households in the U.S. have a mortgage, and paying off their debt allows them to acquire home equity over their lifetime. This accumulation also provides households with the opportunity to tap into their home equity for consumption and various housing investments.[1] To utilize the accumulated home equity, households may need to borrow against it. Hence, aggregate financial condition is a plausible determinant that might affect their ability to extract home equity. For instance, an improvement in home equity might be less valuable in changing consumption or engaging in residential investments[2] (such as moving to a bigger home or improving the current home) if financial institutions or lenders are constrained in a way that makes home equity loans unattractive or inaccessible. Therefore, responses of consumption and residential investment to changes in the housing wealth can be tightly connected to the financial state of the economy which has consequences for housing market dynamics.

This paper examines the effect of house prices on consumption and residential investment under tight and loose regimes of aggregate financial conditions. While the effect of house price shocks on consumption and residential investment has been previously explored, I show that these effects are dependent on the state of financial markets. I first estimate the effect of house prices conditional on the financial state and then provide a structural interpretation of the empirical evidence.

In the empirical analysis, using ordinary least squares (OLS), I estimate how consumption and residential investment respond to house price changes—measured at the metropolitan statistical

[1] Boar, Gorea and Midrigan (2022) finds that 15% of the mortgage borrowers who do not move increase their mortgage balance by more than 5% in the 1999 and 2001 waves of the Panel Study of Income Dynamics.

[2] I use residential investment and housing investment interchangeably throughout the paper.

area (MSA) level in the U.S.—conditional on the aggregate financial conditions. The state of the financial sector is measured by the National Financial Condition Index (NFCI) constructed by the Federal Reserve Bank of Chicago. However, as argued by Cloyne et al. (2019), house price is an endogenous outcome and thus results in the OLS estimates being biased. For example, house prices may be driven by income growth or shocks to expected growth, confounding the estimate. To identify the exogenous source of variation in house prices, I use MSA-level variations in housing supply elasticity as an instrument.[3] The intuition for this identification strategy is that MSAs with inelastic supply will experience large swings in house prices in response to a particular housing demand shock, whereas MSAs with elastic supply will have a modest house price change. Exploiting these variations in house prices across MSAs, I then conform to an instrumental variable regression to estimate the effects of house prices on consumption and residential investment.

I find that consumption responds more strongly to house price changes under tight financial conditions across both OLS and IV specifications. The positive consumption response to an increase in house prices has been documented in previous studies. However, the relatively stronger response of consumption under tight financial conditions is opposite to what one may expect. To shed light on this evidence, I argue that the response of residential investment is key to the consumption response. In particular, the response of residential investment to house prices is weaker during adverse financial periods under OLS and stronger under IV however, both the responses are not statistically significant. Although the evidence across specifications is mixed, the response of housing investment suggests that there may be a financial-state-dependent substitution effect between consumption and residential investment to changes in house prices. This is because housing investments entail considerable transaction costs and are generally larger, therefore under tight financial conditions—characterized by high interest rates—households may be reluctant to make housing investments and instead divert the equity gains to raise consumption. A house price increase can, therefore, result in higher consumption relatively more during tight financial periods.

Motivated by this evidence and to rationalize the substitution hypothesis, this paper employs a partial equilibrium (i.e., house prices and interest rates are exogenously given) life-cycle model that builds on Berger et al. (2018) and Zhou (2022). The model explores the effects of house price

[3]This elasticity measure has been introduced by Saiz (2010) using the land topology-based measure in the U.S.

changes on consumption and residential investment and their dependence on financial conditions. Households face uninsurable labor income risk in their earnings, accumulate assets in two forms (liquid savings and housing), borrow using mortgage debt, and make consumption and housing investment choices. These features closely follow Zhou (2022), but different from her model, I assume mortgages have fixed rates instead of adjustable rates, to be consistent with the fact that the majority of the households in the U.S. hold a fixed-rate mortgage. Incorporating these rich heterogeneities in the household sector, the model generates key life-cycle moments that closely match those observed in U.S. household microdata.

I simulate the calibrated model to house price shocks under two financial regimes: tight and loose. These regimes, respectively, are defined as high and low mortgage rates in the model. Contingent on the financial state, the model generates an age-specific response in consumption and residential investments. Specifically, consistent with the aggregate MSA-level empirical estimate, I find that consumption of younger households increases more to a positive house price change in tight financial conditions. On the other hand, consumption is barely responsive for middle-aged and older households and indeed falls for the latter age group under tight financial conditions. The key margin in understanding the heterogeneity in consumption behavior is linked to the response of housing investments across households. Residential investment falls or is unresponsive across all age groups under tight financial conditions. The mechanism generating these responses is an age-specific trade-off between consumption and residential investment to house price changes conditional on the financial state. The intuition is as follows. Households early in their life cycle start at the lower rungs of the housing ladder and accumulate housing wealth over the life cycle. At the same time, younger households are the ones that have low incomes and liquid assets. Therefore, tight financial conditions—characterized by high mortgage rates—refrain younger households from borrowing against their home equity to make residential investments. As a result, they substitute additional housing investments with consumption in response to this gain in their housing wealth. This state-dependent substitution channel is weaker for households in their prime and older stages of their life cycle. This is because middle-aged and older households have accumulated sufficient housing wealth and are closer to their preferred housing size, making them less responsive in residential investments and consumption during tight financial periods.

Overall, the model generates significant heterogeneity in the response of consumption and residential investment. Comparing the household-level responses with the aggregate MSA-level evidence, it is the responses of younger households that are in line with the latter. Given that the empirical evidence does not take into account heterogeneity across age groups, it is unclear whether the responses of middle-aged and older households are at odds with the empirical results. The gap between the aggregate empirical evidence and the model-generated responses of some groups may indicate the possibilities of other quantitatively relevant determinants that could reduce residential investments further and hence increase consumption to house price growth under tight financial conditions.

RELATED LITERATURE. This paper contributes to two strands of the literature.

First, it relates to the large literature studying the effects of house prices on consumption. Campbell and Cocco (2007) and Attanasio et al. (2009) investigate the effects of regional house price changes on household consumption using household surveys in the United Kingdom. However, there have been concerns regarding the causality of these effects as house prices are most likely to be an endogenous outcome. To tackle these issues, several studies, for instance, Mian and Sufi (2011), Mian, Rao and Sufi (2013), Mian and Sufi (2014), Aladangady (2017), Cloyne et al. (2019), Guren et al. (2021), and Zhou (2022) build an instrumental variables strategy to study the impact of house prices on consumption in the U.S. These papers find that the wealth and collateral effects of house prices have a substantial impact on consumption and are significantly heterogeneous across households. Recently, Zhou (2022) documents that residential investment displayed large swings in the Great Recession. Investigating its importance for housing market dynamics, the paper finds that the response of residential investment is more responsive to house price growth than consumption. The empirical analysis in this paper is complementary to previous studies and closely follows Zhou (2022). However, this paper differs by extending Zhou (2022)'s specification to incorporate the state of the aggregate financial conditions in evaluating the responses of consumption and residential investment to changes in house prices.

Second, on the theoretical front, Berger et al. (2018), Kaplan, Mitman and Violante (2020), and Zhou (2022) quantitatively examine the economic consequences of house prices using life-cycle models. These papers find that younger households are the ones whose consumption and housing investment behaviors are impacted significantly. As the marginal propensity to consume (MPC) is relatively higher for these age groups, the wealth and collateral effects of house price changes are substantially more pronounced. My paper is closest to Berger et al. (2018) and Zhou (2022), which analyze the effects of house price changes on households' behavior. Even though I build on their quantitative framework to study the effects of house prices, I further explore how these effects can vary with the state of the financial markets. While the wealth and collateral effects are dominant economic forces for house price changes alone, I argue and quantitatively show that consumption can be more responsive to house prices under tight financial conditions. In this regard, the paper proposes a financial-state-dependent substitution mechanism between consumption and residential investment to changes in house prices that dominate the aforementioned standard channels, especially for younger age groups.

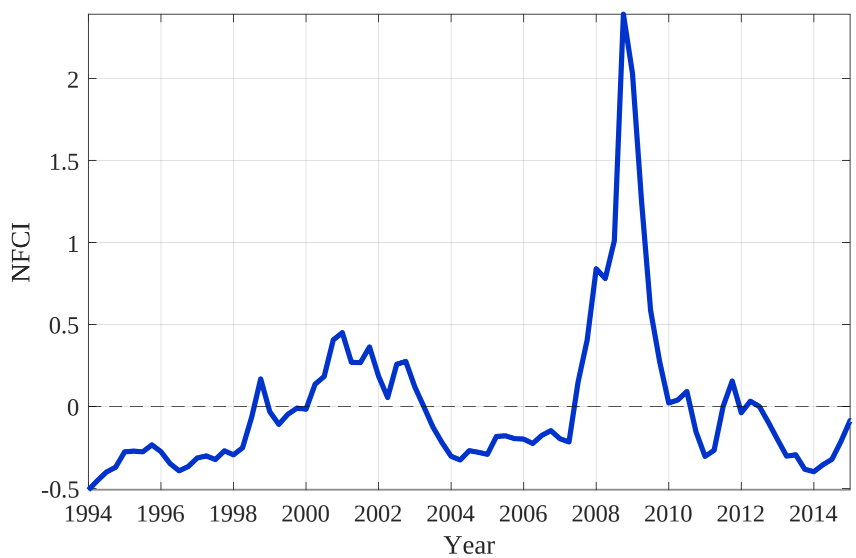
OUTLINE. The rest of the paper is organized as follows. Section 2 outlines the data sources and presents the relationship between consumption/residential investment and house prices across different financial conditions in the U.S. Section 3 estimates the response of consumption and residential investment to house price changes under different financial states of the economy. Motivated by the evidence, Section 4 builds a life-cycle model of households and lays out their optimizing behavior. The calibration and the life-cycle properties of the model are discussed in Section 5. Section 6 discusses the state-dependent household-level responses to house prices. Section 7 explores an alternative calibration to discuss the implications for the baseline results. Lastly, Section 8 concludes.

2 Data and Motivating Facts

This section discusses the data sources and the measurement of key variables used for the empirical analysis in Section 3. I then document two patterns in the data that motivate the paper's subsequent analyses.

Data The data spans on a quarterly basis from 1994(Q1) to 2015(Q4) and is constructed for the U.S. The measure of consumption is at the MSA level. However, as quarterly MSA-level consumption data is not available for the entire time period, following Guren et al. (2021), I use retail employment per capita from the Quarterly Census of Employment and Wages (QCEW) as a measure of consumption. This measure, as shown in Guren et al. (2021), is one of the best proxies for consumption expenditures and matches almost one-for-one both in aggregate and in cities for which the data is available. Residential investment is constructed, following Zhou (2022), using the valuation of building permits required for new single-family housing units.[4] As shown in Zhou (2022), this measure is highly correlated with aggregate-level residential investment. The main index of house price at the MSA level is obtained from Freddie Mac House Price Indices (FMHPI).[5]

Figure 1: National Financial Conditions Index



I follow Adrian, Boyarchenko and Giannone (2019) in using the National Financial Conditions Index (NFCI) constructed by the Federal Reserve Bank of Chicago to capture the aggregate financial condition. The NFCI is a weekly estimate of the financial conditions of the U.S. in money markets, debt and equity markets, and the traditional and shadow banking systems. This index is a weighted average of several measures of financial activity, grouped into a leverage subindex,

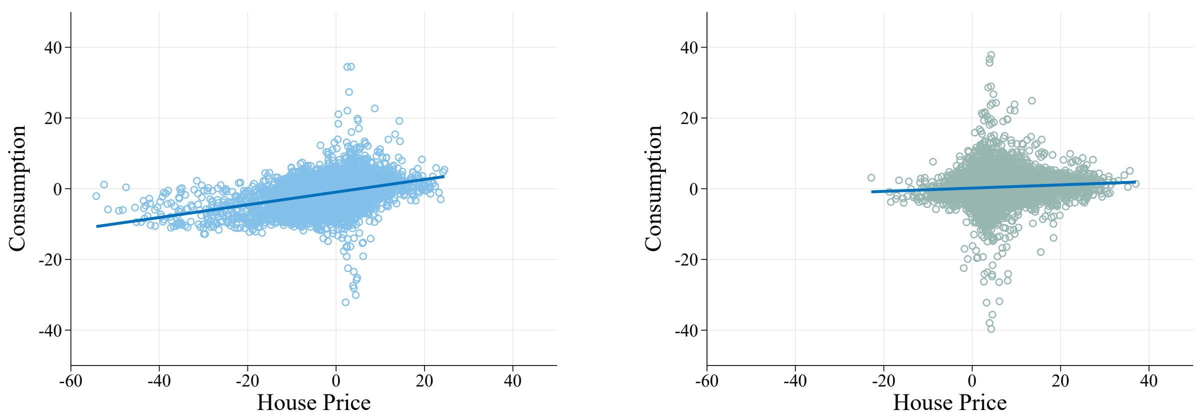
[4]Building permits are used as a proxy for residential investment due to a lack of data at the MSA level. In addition, this measure only represents upsizing to a bigger or better home and not improvements to their existing house.

[5]I also use house price indices from the Federal Housing Finance Agency (FHFA) to validate the robustness of the main results.

a risk subindex, and a credit subindex. The index is a continuous variable. Although the NFCI started in 1971, I only use the sample period between 1994 and 2015, to be consistent with the time period of other variables used in the empirical analysis. As the analysis is at the quarterly frequency, I transform the weekly estimates to quarterly frequency by averaging over the quarter which is then demeaned over the sample period. This implies that a positive value of the index represents a tighter financial condition than the average and a negative value denotes a looser financial condition than the average. Figure 1 above plots the quarterly time series of the index.

Motivating Facts I now document the relationship between consumption/residential investment and house prices conditional on the financial state of the U.S. economy. As mentioned above, I define two financial states: A tight financial state is when the value of the NFCI is positive, and a loose financial state is when it is negative.

Figure 2: Consumption and House Prices across Financial Conditions

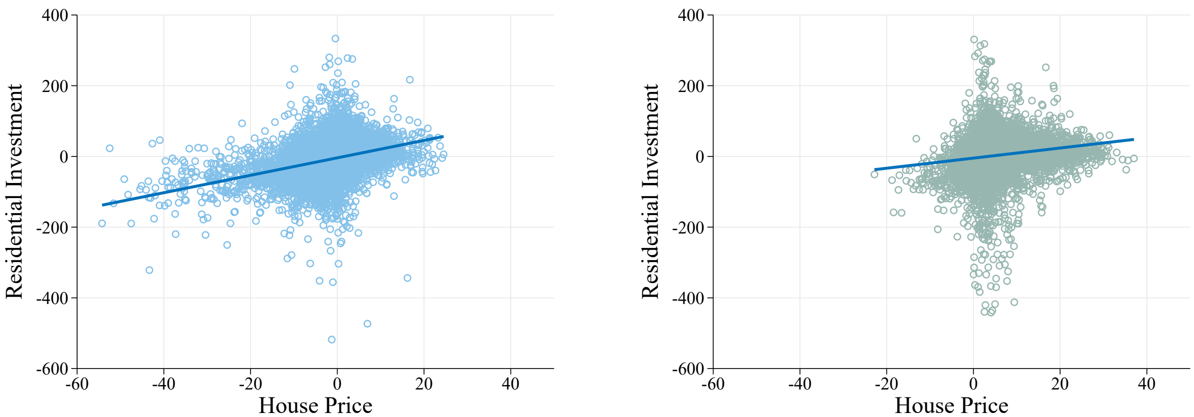


(a) Tight Financial Conditions (b) Loose Financial Conditions

Notes: The figure plots the log annual changes in consumption (vertical axis) versus log annual changes in house prices (horizontal axis) for each MSA and quarters when NFCI is positive (i.e., under tight financial conditions, Panel (a)) or negative (i.e., under loose financial conditions, Panel (b)) during the time period of 1994(Q1)-2015(Q4). The straight lines are a linear fit of the observations. Values of consumption changes that were higher than 40% are excluded for the sake of comparison. There was one such observation under tight financial conditions.

Figure 2 plots, for each MSA, the log annual changes of consumption against the log annual changes in house price separately for periods when financial conditions are tight (Panel (a)) and loose (Panel (b)), respectively. Figure 3 shows the same for log annual changes in residential investment (Panel (a) for tight and (Panel (b) for loose financial conditions). The straight lines are a linear fit of the observations.

Figure 3: Residential Investment and House Prices across Financial Conditions



(a) Tight Financial Conditions

(b) Loose Financial Conditions

Notes: The figure plots the log annual changes in residential investment (vertical axis) versus log annual changes in house prices (horizontal axis) for each MSA and quarters when NFCI is positive (i.e., under tight financial conditions, Panel (a)) or negative (i.e., under loose financial conditions, Panel (b)) during the time period of 1994(Q1)-2015(Q4). The straight lines are a linear fit of the observations. Values of residential investment changes that were higher than 400% are excluded for the sake of comparison. There were four such observations under loose financial conditions.

The figure shows that both consumption and residential investment depict a positive relationship with house prices across both financial states. However, these trends reveal a striking pattern: The relationship is relatively stronger under tight financial markets. At the same time, these plots demonstrate simple correlations, and therefore, the financial-state-dependent relationship between the variables does not necessarily imply a causal effect of house prices on consumption and residential investment. Several potential factors could be affecting these variables both across MSAs and over time and thus the relationship reported could be a manifestation of those factors. Nevertheless, the suggestive evidence of a stronger response under tight financial conditions serves as a motivation for further verifying the causality of these relationships.

3 Empirical Analysis

Given the suggestive empirical patterns in the previous section, this section lays out the econometric method to estimate the response of consumption and residential investment to house prices and shows how it varies with the financial state of the economy.

Methodology The empirical strategy follows Zhou (2022) but extends the specification to take into account the financial state in estimating the responses of consumption and residential investment to house prices:

$$\Delta x_{i,t} = \alpha_t + \gamma_i + \beta_1 \Delta hp_{i,t} + \beta_2 \Delta hp_{i,t} \times nfi_t + \beta_3 Z_{i,t} + \epsilon_{i,t}, \tag{1}$$

where $\Delta x_{i,t}$ represents the log annual change in a quarter (t) relative to the same quarter of the previous year of consumption (C) or residential investment (RI) expenditures in MSA i. Δhp is the log annual change in house prices. nfi is the annual average of the financial index from quarter t to the same quarter of the previous year where, as previously, a positive value indicates tight financial conditions compared to the average and loose otherwise. The index is annualized because the overall change in the financial conditions during the year (quarter to quarter) is relevant for the change in the variable of interest x (consumption and residential investment). α_t and γ_i capture time and MSA-level fixed effects, respectively. The effect of house price when the financial index takes the average value is estimated by β_1. The parameter of interest for the current analysis is β_2 which reflects the difference in the effect of house prices on consumption or residential investment between tight and loose financial states of the economy. Finally, $Z_{i,t}$ denotes controls which are described below.

It is evident and largely discussed in the literature that using OLS to estimate equation (1) is likely to suffer from omitted variable bias problems. For instance, the house price growth may be correlated with the error term through changes in current or future expectations of income. In order to control for these confounding effects, I instrument for house price growth by exploiting variations in housing supply elasticity across MSAs constructed by Saiz (2010). As a nationwide housing boom prevails, MSAs with inelastic housing supplies will tend to have a higher house price growth than MSAs with relatively elastic housing supply. However, Davidoff (2016) raised concerns that areas with lower Saiz housing supply elasticity are more exposed to business cycle fluctuations due to their inherent characteristics such as industrial composition and differential exposure to risk premia. To address these issues, following Zhou (2022) and Guren et al. (2021), I include an extensive set of controls in $Z_{i,t}$: (i) the differential sensitivity of MSA-level retail employment to regional retail employment, (ii) the differential sensitivity of MSA-level retail employment to 30-year mortgage rates and to the Gilchrist and Zakrajšek (2012) measure of excess bond premia and (iii) two-digit standard industry classification (SIC) industry shares.[6] As the analysis in this paper uses both OLS and IV as a method of estimation, I include these same sets of controls to be consistent across specifications.

Since house prices are suspected to be endogenous, the interaction term with the financial index will most likely be endogenous as well. Therefore, I also interact with the predicted house price from the first-stage regression with the financial index. It is important to note that the aggregate financial index is assumed to be exogenous at the MSA level. The parameters are estimated by a two-stage least square (2SLS) estimator. The first-stage regression is as follows:

$$\Delta hp_{i,t} = \alpha_t + \gamma_i + \sigma_1 \Delta nhp_t \times Saiz_i + \sigma_2 Z_{i,t} + v_{i,t}, \tag{2}$$

where Δnhp_t is the log change in the national house price and $Saiz_i$ is the housing supply elasticity.

The second stage is then given by:

$$\Delta x_{i,t} = \alpha_t + \gamma_i + \beta_1 \widehat{\Delta hp_{i,t}} + \beta_2 \widehat{\Delta hp_{i,t}} \times nfi_t + \beta_3 Z_{i,t} + \epsilon_{i,t}. \tag{3}$$

The predicted MSA-level house price change from equation (2) is denoted by $\widehat{\Delta hp_{i,t}}$.

Results Although the OLS estimates are likely to be biased due to endogeneity concerns, I provide the results from OLS to compare with the instrumental variable (IV) estimates. The estimates from both specifications are shown in Table 1. To prevent the effect of outliers in the IV estimation, the interaction term in the first stage regression (2) is winsorized at the top and bottom 1%. The

[6] As in Zhou (2022), the sensitivity measures of MSA-level retail employment is obtained by estimating a regression of log annual changes in retail employment on regional retail employment for (i) and on 30-year mortgage rates and excess bond premium for (ii). In these estimations, the coefficients are allowed to vary across MSAs—which captures the differential sensitivity of retail employment in a given MSA to regional retail employment—and the product of this estimated coefficient along with the aggregate variable is used as a control implying that the estimate is orthogonal to the cyclical differences across MSAs. The same is applied in constructing the sensitivity to excess bond premium.

first row shows the response of consumption and residential investment to house prices when the financial index takes a value of 0.

Table 1: Effect of House Price and its Variation with Financial Conditions

	OLS		IV	
	(1)	(2)	(3)	(4)
	Consumption	Residential Investment	Consumption	Residential Investment
House Prices	0.09***	1.20***	0.10***	0.58***
	(0.01)	(0.13)	(0.02)	(0.23)
House Prices × Financial Tightness	0.03***	-0.15	0.12***	0.54
	(0.01)	(0.15)	(0.04)	(0.51)
MSA Fixed Effects	✓	✓	✓	✓
Quarter Fixed Effects	✓	✓	✓	✓
R-squared	0.30	0.22	0.34	0.22
Observations	17,475	17,475	17,475	17,475

Notes: ***,**,* indicates that the estimates are significant at a 1%, 5%, 10% level. The numbers in the parenthesis are the standard errors and are clustered at the MSA level. The interaction term in the first stage regression (2) is winsorized at the top and bottom 1%. The standard errors are bootstrapped in the IV estimation. All the estimates are in percentage. The sample used in the analysis comprises 216 MSAs.

In terms of magnitude, when the financial index takes a value of 0, consumption increases by 0.09%, and residential investment increases by 1.20%, to a 1% increase in house price under OLS. The IV estimate for consumption (column (3)) in the first row is similar to the OLS but is slightly more responsive (0.10% vs, 0.09%). This is aligned with previous studies that show the consumption response tends to be larger with the Saiz instrument. On the other hand, it has also been documented that residential investment is less responsive to the instrument (0.58% vs. 1.20%).

Table 2 reports the first-stage results. The coefficient on the interaction term in equation (2) is negative and is consistent with the intuition for the identification strategy of the IV. In other words, the negative sign on the coefficient means that the size of the increase in house prices to a national housing boom will be smaller in MSAs with a relatively more elastic housing supply. Finally, the F-statistic indicates that the instrument does not suffer from a weak IV problem.

Table 2: First-Stage Regression

	House Prices
Saiz Elasticity × National HP	-0.24***
	(0.03)
MSA Fixed Effects	✓
Quarter Fixed Effects	✓
F-statistic	76.13
Observations	17,475

Notes: ***,**,* indicates that the estimates are significant at a 1%, 5%, 10% level. The numbers in the parenthesis are the standard errors which are clustered at the MSA level.

The key parameter of interest is β_2 in equations (1) and (3). Specifically, the aim is to verify if consumption and residential investment have a state-dependent response to house price fluctuations. Table 1, under both specifications, shows that consumption demonstrates a stronger response to a house price change in tight financial conditions with the difference being statistically significant across financial states. On the other hand, the effect on residential investment is mixed: Under OLS residential investment seems to be less responsive while under IV it turns out to be more responsive to house prices when financial conditions are tight.

Comparing these responses to the empirical patterns documented in Section 2 confirms that consumption indeed responds more strongly to house price changes during tight financial conditions. However, for residential investment, the patterns in Figure 3 do not appear to be robust in the empirical analysis where it seems to differ under OLS and IV (see columns (2) and (4) of Table 1).

Table 3: Aggregate Effect of Financial Tightness on Consumption (C) and Residential Investment (RI)

	OLS					IV				
	-2 std.	-1 std.	0	+1 std.	+2 std.	-2 std.	-1 std.	0	+1 std.	+2 std.
C	0.06	0.07	0.09	0.10	0.12	-0.01	0.04	0.10	0.16	0.21
RI	1.34	1.27	1.20	1.13	1.05	0.06	0.32	0.58	0.84	1.10

Notes: The numbers are constructed as follows: $\beta_1 + \beta_2 \times n(\sigma_{nfi})$, where n is the number of standard deviations from the mean. The standard deviation of the index is 0.48.

In order to assess the magnitude of the results, Table 3 above reports the response of consumption and housing investment to house price changes with varying levels of the financial index. The estimates in Table 3 show that the consumption response depicts an upward-sloping curve as the financial index increases, whereas residential investment decreases under OLS and increases under IV. Quantitatively, these effects are substantially large: For instance, under OLS, the marginal effect of housing wealth on consumption increases by 33% $\left(\frac{0.12-0.09}{0.09} \times 100\right)$ when the financial index increases by two standard deviations from the average, while the corresponding effect is even stronger under IV—it increases by more than 100% $\left(\frac{0.21-0.10}{0.10} \times 100\right)$.

In summary, the response of consumption under tight financial conditions is opposite to what one may expect. This is because, despite an improvement in their housing wealth, tight financial conditions can impact households' ability to extract funds from financial institutions, resulting in lower consumption and residential investment response. To shed light on the, perhaps, counterintuitive empirical evidence presented in Table 1, I argue that the response of residential investment can play an important role in determining the response of consumption. In particular, a financial-state-dependent substitution effect between consumption and residential investment prevails in response to house prices. Specifically, as residential investments entail considerable transaction costs and exhibit lumpiness, households may be reluctant to engage in housing investments and instead divert the equity gains to raise consumption under stringent financial conditions. Thus, a house price increase during tight financial periods can lead to higher consumption at the expense of reducing housing investments. In the rest of the paper, I explore this hypothesis as a potential mechanism, using a structural model, to interpret the empirical evidence.

4 Model

Motivated by the empirical evidence, I employ a partial equilibrium model of homeowners to study the role of financial states on the effect of house prices on consumption and residential investment. Specifically, following Berger et al. (2018) and Zhou (2022), I build a quantitative life-cycle model that captures rich heterogeneity in the household sector. Households live for a finite number of periods, are subject to idiosyncratic labor income shocks, derive utility from consumption and housing, save using a short-term liquid asset and housing, and borrow using long-term mortgage debt. Unlike Zhou (2022), the mortgage debt follows a fixed-rate contract which dominates the mortgage market in the U.S.[7] More importantly, this property has significant implications for their interest payments and their decision to refinance when mortgage rates fluctuate. Therefore, the mortgage rate is fixed unless the household decides to refinance their loan. The balance of the loan is amortized over the remaining life of the household. Households who borrow against their home by taking on a mortgage pay a fixed monetary mortgage origination cost. Households invest in different types of housing which also entails a fixed cost. Finally, the partial equilibrium structure implies that interest rates and house prices are exogenously given.

4.1 Setup

Preferences Households live for J periods. The expected lifetime utility of a household of generation t and age 0 is

$$\mathbb{E}_t\left[\sum_{j=0}^{J-1}\beta^j u\left(c_{j,t+j},h_{j,t+j}\right)+\beta^J\Phi\left(w_{J,t+J}\right)\right],$$

where c and h denotes consumption and housing, respectively. $\Phi(.)$ is the bequest utility function and $w_{J,t+J}$ represents terminal wealth comprised of liquid assets and the home equity in the last period of life. Households work for the first J_y periods and move into the retirement phase for the remaining $J-J_y$ years.

Income Households face uninsured idiosyncratic labor income shocks during their working periods. They receive income as follows:

$$\log(y_{j,t})=\chi_j+z_{j,t}.$$

χ_j is the deterministic income that is invariant across households of identical age and $z_{j,t}$ is the idiosyncratic component. The idiosyncratic component evolves according to an AR(1) process:

$$z_{j,t}=(1-\rho_z)\bar{z}+\rho_z z_{j-1,t-1}+\epsilon_{j,t},$$

where $\bar{z}$ is the unconditional mean and ρ_z denotes the persistence. The innovations, $\epsilon_{j,t}$, are drawn from a standard normal distribution with volatility σ_z. Households, when in their retirement phase, receive a fixed payment that is a fraction of the income they earn in the final year of their working phase.

[7]According to the National Mortgage Database, almost 95% of the mortgages are fixed-rate mortgages.

Liquid Savings Households can save in one-period risk-free liquid assets (a) at an interest rate r^a. A liquidity constraint is imposed as $a_{j+1} \geq 0$.

Housing Housing investments can take three forms: upsizing (i.e., moving to a larger or better home), downsizing (i.e., moving to a smaller home), and minor improvements (for instance, activities like renovating the current home). Homeowners are subject to a transaction cost if they change their housing investments. The fixed cost ($\mathbf{F}$) of making a housing investment is characterized as:

$$\mathbf{F} = \mathbb{I}\{h' \geq (1 + \underline{h}^U)h\}f^U + \mathbb{I}\{h' < (1 - \delta)h\}f^D.$$

The fixed cost is measured as a fraction of home value, so in the event of an upsizing (first component), households pay f^U if their upgrading home size is higher than a certain threshold, where $1 + \underline{h}^U$ is the threshold of the new home size with respect to their home size in the previous period. Hence, in sum households must pay $f^U ph'$, where p is the price of the new home. If the household decides to increase housing investment that is below the upsizing threshold (i.e., minor improvements of their current home) or decides not to alter its housing size then no transaction cost is incurred. Finally, the second component indicates a transaction cost (f^D) for downgrading the home size without any threshold requirement as this is simply moving to a smaller home relative to their home size—net of depreciation—in the previous period. The housing depreciation rate is denoted by δ.

Mortgage Debt Households can borrow against the value of their home using mortgages at a fixed rate of r^b and pay a proportional transaction cost of $f^b b'$—where f^b is the fixed cost of refinancing and b' is the new mortgage balance—when entering a new loan or if they decide to refinance an existing mortgage. In both these cases, households are subject to a collateral constraint that is defined as the minimum equity requirement:

$$0 \leq b' \leq \frac{(1-\theta)(1-\delta)}{1+\tilde{r}^b} ph,$$

where the minimum down-payment ratio is denoted by θ. The constraint reflects that the new mortgage must be lower than a certain fraction of the home value. This fraction intuitively means that the total amount of new borrowing—at the new mortgage rate ($\tilde{r}^b$)—should be lower than the undepreciated current value of the home net of the down-payment amount.

As in Wong (2021), mortgage debt is amortized over the life cycle of the borrowing household. The amortization is computed by setting a fixed payment every period and a full repayment at the end of the term. Formally, one with a principal amount b and the current mortgage rate of r^b for a contract term T, the amortization schedule is as follows:

$$M(b, r^b, T) = \frac{r^b b}{1 - (1 + r^b)^{-T}}.$$

The loan balance evolves as follows:

$$b' = b(1 + r^b) - M.$$

Finally, the mortgage rate paid on the loan, r^b, remains fixed over the life of the loan unless it is refinanced. In the event of refinancing, the mortgage rate faced by a household is set to the new market rate ($\tilde{r}^b$):

$$r^b = r^b \times (1 - refi) + \tilde{r}^b \times (refi),$$

where $refi$ is an indicator that takes a value of one if the household refinances and zero if not.

4.2 Recursive Formulation

The state variables of a household are age (j), home size (h), mortgage (b), liquid assets (a), income (y), and their existing mortgage rate (r^b). I denote these state variables in a vector: $s = (j, h, b, a, y, r^b)$. The aggregate states (S) are house prices (p) and the current market mortgage rate ($\tilde{r}^b$).

In each period, households choose whether to (i) refinance and upgrade ($V^{R,U}$), (ii) refinance and downgrade ($V^{R,D}$), (iii) refinance but does not alter their home size or decides to upgrade but less than the upsizing threshold ($V^{R,\varnothing}$), (iv) not refinance and upgrade ($V^{NR,U}$), (v) not refinance and downgrade ($V^{NR,D}$), or (vi) not refinance and does not alter their home size or decides to upgrade but less than the upsizing threshold ($V^{NR,\varnothing}$). The value function can be written as follows:

$$V(s; S) = \max\left\{ V^{R,U}(s; S), V^{R,D}(s; S), V^{R,\varnothing}(s; S), V^{NR,U}(s; S), V^{NR,D}(s; S), V^{NR,\varnothing}(s; S) \right\}.$$

If the household decides to upgrade the home conditional on refinancing, then it solves the value function:

$$V_j^{R,U}(s;S) = \max_{h',b',a',c} u(c,h) + \beta \mathbb{E}_j\Big(V_{j+1}(s';S')\Big),$$

subject to the budget constraint

$$c + a' + p[h' - h(1-\delta)] = y + (1+r^a)a + b' - (1+r^b)b - f^b b' - f^U ph',$$

and the upgrading threshold, collateral, liquidity constraints, and the new mortgage rate, respectively:

$$h' \geq (1+\underline{h}^U)h,$$

$$0 \leq b' \leq \frac{(1-\theta)(1-\delta)}{1+\tilde{r}^b} ph,$$

$$a' \geq 0,$$

$$r'^b = \tilde{r}^b.$$

If the household decides not to refinance an existing mortgage and upgrade, it solves:

$$V_j^{NR,U}(s;S) = \max_{h',a',c} u(c,h) + \beta \mathbb{E}_j\Big(V_{j+1}(s';S')\Big),$$

subject to the upsizing threshold, budget constraint, liquidity constraint, and the mortgage rate, respectively:

$$h' \geq (1+\underline{h}^U)h,$$

$$c + a' + p[h' - h(1-\delta)] = y + (1+r^a)a - M - f^U ph',$$

$$a' \geq 0,$$

$$r'^b = r^b.$$

The balance on the mortgage is

$$b' = (1+r^b)b - M,$$

where the mortgage payment, M, follows the amortization schedule mentioned above.

The problem for households who decide to downgrade conditional on refinancing or not is identical to the upgrading problem with the corresponding fixed cost for downsizing, f^D. Finally, the optimization problem for households who decide not to alter their home size or engage in minor improvements less than the threshold, conditional on refinancing, is similar but without being subject to a fixed cost.

5 Calibration and Life-Cycle Properties

In this section, I first discuss the calibration of the model and then report the life-cycle properties of the model.

5.1 Parameterization

Table 4 summarizes the parameter values used to calibrate the model. A period in the model is one year. Households start their life at age 26 and work for $J_y = 40$ years. They retire at the age of 65 and their life terminates at the age of 85. The initial holdings of housing, mortgage balance, and liquid assets are set to match the distribution of households with ages 21 to 25 in the Panel Study of Income Dynamics (PSID).

The utility function is generalized as a constant relative risk aversion (CRRA) utility where non-housing consumption and housing are aggregated through Cobb-Douglas preferences following Berger et al. (2018):

$$u(c_{j,t}, h_{j,t}) = \left(\frac{c_{j,t}^{\alpha} h_{j,t}^{1-\alpha}}{1-\sigma} \right)^{1-\sigma},$$

where σ—the relative risk aversion parameter—is set to 2, that generates an inter-temporal elasticity of substitution of 0.5. Following Zhou (2022), I set α, the expenditure share of consumption in total spending, to 0.81 to match the housing expenditure share of total household spending in PSID.

The bequest utility function takes the CRRA form as in Berger et al. (2018) as well:

$$\Phi(w_{J,t+J}) = \eta \left(\frac{w_{J,t+J}}{1-\sigma} \right)^{1-\sigma}.$$

The bequest parameter, η, is calibrated to match the borrowing patterns of households during their retirement phase. A lower η implies that impatient households finance consumption by extracting their home equity. This leads to higher rates of equity extraction towards the end of their life that is inconsistent with the rates observed in PSID. Hence, I set the value of η to 6 to generate constant borrowing behavior during retirement. As in Zhou (2022), I set β—the discount factor—to 0.93 to match the wealth-to-income ratio across the entire distribution of age.

Table 4: Parameter Values

Parameter	Description	Value	Source/Target
J_y	Working phase	40	PSID
$J - J_y$	Retirement phase	20	PSID
σ	Relative risk aversion	2	Standard
α	Consumption expenditure share	0.81	Zhou (2022)
η	Bequest parameter	6	Borrowing of retirees
β	Discount factor	0.93	Zhou (2022)
ψ_1	Slope parameter of age in deterministic income	0.067	Zhou (2022)
ψ_2	Slope parameter of age-squared in deterministic income	-0.0007	Zhou (2022)
ρ_z	Persistence of idiosyncratic income	0.9	Zhou (2022)
σ_z	Std. deviation of idiosyncratic income	0.18	Zhou (2022)
ν	Retirement income replacement rate	0.6	Zhou (2022)
δ	Housing depreciation rate	0.023	Berger et al. (2018)
θ	Downpayment ratio	0.2	Standard
f^b	Refinancing cost	0.02	Federal Reserve guide
f^U	Upsizing transaction cost	0.015	Zhou (2022)
h^U	Threshold of upsizing	0.07	PSID
f^D	Downsizing transaction cost	0.03	PSID

I follow Zhou (2022) in exogenously setting the persistence parameter, ρ_z, at 0.90 and the standard deviation of income shocks, σ_z, at 0.18 to match the annual persistence and standard deviation of residual earnings in the PSID data. I discretized the process with five states using the method outlined in Tauchen (1986). The deterministic age-specific income (χ) is chosen to fit a quadratic regression of annual earnings in PSID as in Zhou (2022). The resulting estimated coefficients on age (ψ_1) and age-squared (ψ_2) are 0.067 and -0.0007, respectively. Households in their retirement phase receive a fraction, ν, of their income in the final period of their working phase. This fraction is set to 0.6 following Zhou (2022).

The depreciation rate of housing is chosen to be 2.3% following Berger et al. (2018). The minimum mortgage down payment ratio, θ, is set to 20% as is conventionally required for home buyers in the U.S. The mortgage refinancing cost, f^b is set to 2% according to the Federal Reserve Board's mortgage refinancing guide for consumers.

The fixed costs associated with an upsizing of their housing stock, f^U, is set to 0.015 as in Zhou (2022). The threshold size (h^U) in the model determines the fraction of households who engage in upsizing and improvements. Therefore, I set h^U to 7% to match the annual frequency of upsizing and improvements in the PSID data which is 12%. The downsizing fixed cost (f^D) is set to 3% to match the corresponding annual rate in PSID.

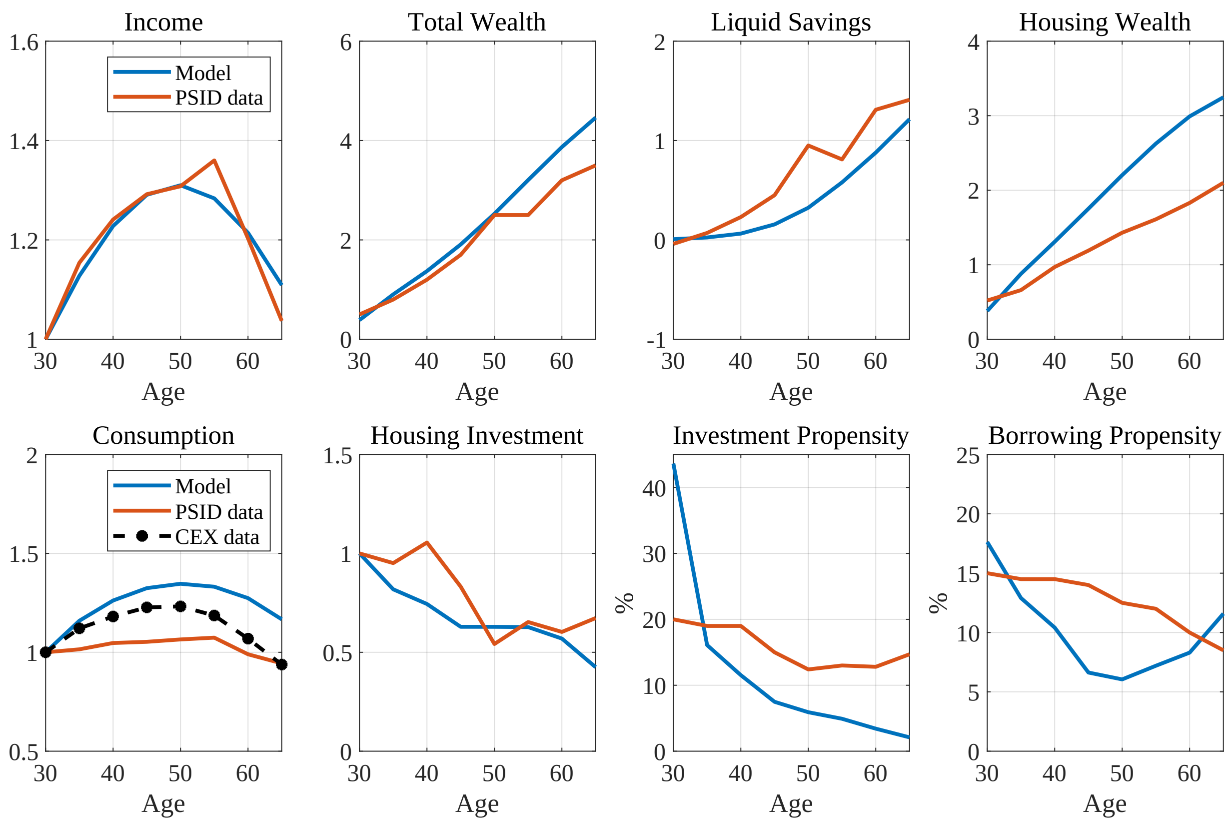
In steady state, house prices (p) and mortgage rates ($\tilde{r}^b$) are set to 1 and 4%, respectively. Liquid asset return (r^a) is set to 1%. The mortgage rate is constructed from the 30-year fixed rate mortgage net of inflation and the liquid asset return is the average of the real 1-year treasury rate during the period 1994 to 2015 in the U.S.

5.2 Life-Cycle Properties

Figure 4 shows the life-cycle profiles of the model compared to PSID and to the Consumer Expenditure Survey (CEX) data additionally for consumption. The model does a good job of closely matching the age profiles of income, total wealth, liquid assets, hump-shaped consumption, and housing investment. Although there are some noticeable gaps between the model-generated profiles and the empirical patterns for housing wealth, investment propensity, and the probability of increasing mortgage debt (borrowing propensity), the changes with age are, however, qualitatively similar.

The model's ability to capture how housing investment varies with other household decisions, in particular with borrowing decisions, over the life cycle plays a vital role in determining the trade-off between consumption and residential investment to aggregate disturbances. Specifically, the model exhibits three main properties. First, households increasing their mortgage borrowing are more likely to increase housing investments. Second, the share of expenditure in housing investments, relative to consumption share, increases with more borrowings. Finally, the marginal propensity to invest (MPI) out of a one-dollar increase in debt is around 40 cents. These features are consistent with the empirical patterns documented in Zhou (2022). Furthermore, these relations are quantitatively larger for younger households. As a result, such heterogeneity in their investment decisions across the age distribution will naturally lead to different implications for their responses to aggregate shocks.

Figure 4: Life-cycle Profiles



Notes: This figure compares the life-cycle profiles of the simulated data and the household survey in the U.S. The horizontal axis represents five-year age bins starting from age 25. The variables in the top panel are constructed relative to the income of the youngest age bin (25-30) which is normalized to 1. In the bottom panel, consumption and housing investment are shown relative to the corresponding expenditures of the youngest age group. The PSID and CEX data are for the years 1994-2015.

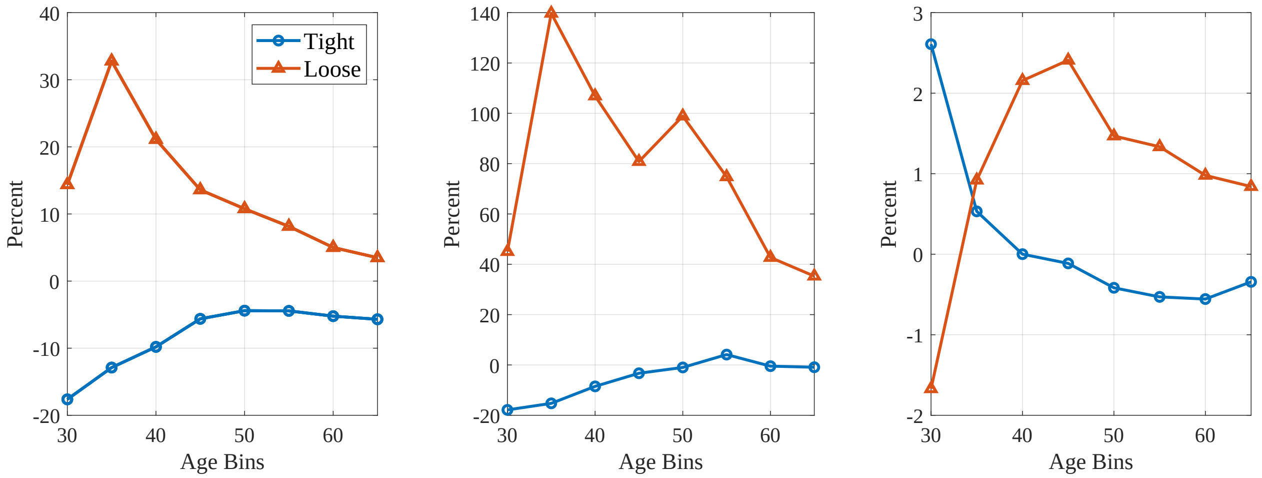
6 State-Dependent Effects of House Prices

This section discusses the results of the main experiment on the calibrated model to understand the state-dependent effects of house prices on consumption and residential investment presented in Section 3. To this end, I first solve the steady state of the model where the values of house prices and interest rates (mortgage and liquid assets) are set to their steady state values. The model then simulates a one-time permanent increase in house price and a concurrent change in the state of the financial condition. The financial condition (e.g., tight or loose) in the model is determined by the value of the current mortgage rate that households face if they refinance. The mortgage rate under a loose and a tight regime respectively is set to $(\tilde{r}^{b,Loose}; \tilde{r}^{b,Tight}) = (2.80\%, 5.29\%)$. These rates are constructed in three steps. First, the NFCI is ranked from low (loose) to high (tight) during the period 1994(Q1) to 2015(Q4). In the next step, I sort the mortgage rates according to the corresponding rank of the NFCI obtained in the previous step. Finally, the sorted NFCI is then divided into terciles, and the mortgage rates are computed as the average of the corresponding first and third terciles of the NFCI. Thus, the permanent house price increase is simultaneously subject to a permanent change in the mortgage rate ($\tilde{r}^{b,Loose}$ or $\tilde{r}^{b,Tight}$). I compute the responses of consumption and residential investment to house prices of each age group under each financial state and compare them to the responses in the steady state.

Heterogeneous Impact Responses Figure 5 plots the impact responses—relative to the steady state—of household borrowing, residential investment, and consumption over different age groups to a 1% permanent house price increase under both the tight (circle) and loose (triangle) financial states. I now describe them in turn.

The model generates significant heterogeneity across age groups in households' behavior toward house prices and how that varies between financial regimes. A house price increase during a tight financial regime leads to a lower likelihood of borrowing with respect to the steady state and the magnitude of the change varies across age groups as shown in the first panel (Panel (a)) of Figure 5. Similarly, the response of residential investments (Panel (b)) falls relatively more for younger households and is mostly non-responsive later in the life cycle. In contrast, the third panel (Panel (c)) shows that the pattern of consumption response over age is substantially different. Specifically, the model generates an increase in consumption for younger households under tight financial conditions, and more importantly, the increase is larger than that under loose financial conditions, which is opposite to what one may expect. On the other hand, middle and older households reduce their consumption during tight financial periods.

Figure 5: Household Behavior to House Price Changes: Tight vs. Loose Financial Conditions



(a) Borrowing Propensity (b) Housing Improvement (c) Consumption

Notes: The vertical axis is measured as the percentage change from the steady-state responses. The horizontal axis shows five-year age bins starting from age 26.

Analyzing the responses in a loose financial state, the model predicts that borrowing increases across all age groups—with relatively larger responses for younger households—to higher house prices. A similar pattern prevails for residential investment. In contrast, consumption does not exhibit a similar response across households. The model predicts that younger households reduce consumption whereas, middle-aged and older households increase consumption to a positive change in house prices in a loose financial state.

Mechanism I now describe the mechanism that generates the model's impact responses. To set the stage for understanding the state-dependent results, I briefly discuss the economic intuition behind the impacts of house price changes on consumption and residential investment when the financial regime is in normal times. Intuitively, an increase in house price generates a positive wealth effect and additionally relaxes collateral constraints. Both these channels lead to higher household borrowing, residential investment, and consumption. These responses are significantly stronger for younger households relative to middle-aged and older households as shown quantitatively in Berger et al. (2018) and Zhou (2022). Now, if the house price increase occurs during a time when financial conditions are tight such that the mortgage rates are higher, these economic forces will most likely be weaker. However, the impact responses for younger households in Figure 5 show the opposite for consumption. The reason behind this outcome—described more below—is that the response of residential investment to house prices under each financial state significantly characterizes the corresponding age-specific consumption behavior.

Households earlier in their life cycle have two features that demonstrate their response: (i) lower income and liquid assets and (ii) these households are also the ones at the lower rungs of the housing ladder and have barely accumulated housing equity. In addition, as documented by Zhou (2022), residential investments are larger and entail considerable transaction costs. As a result, high-interest rate periods make younger households reluctant to engage in housing investments and instead shift the gains in home equity to raise consumption. Thus, both borrowing and residential investment fall whereas, consumption increases. Following this logic, younger households decrease consumption and increase residential investment to house prices in a loose financial market as depicted in Figure 5.

On the other hand, the consumption response of middle-aged and older households to higher house prices in a tight financial regime is significantly muted and indeed decreases for the latter group relative to the steady state (i.e., in normal times). In addition, both residential investment and borrowing propensity are unresponsive and fall during the tight financial regime. This is because these households have accumulated sufficient home equity and are closer to their preferred home size which makes them less willing to further invest in their home. This in turn results in consumption being non-responsive as well. Both middle-aged and older households are still motivated to make larger residential investments and increase consumption to house price increase under loose financial conditions although, their responses are relatively smaller in magnitude compared to their younger counterparts.

Overall, the model generates significant heterogeneity in the response of consumption and residential investment to house prices across age groups and between aggregate financial states. The model generates a financial-state-dependent substitution effect between consumption and residential investment for younger households. This mechanism for younger households provides support for the aggregate MSA-level evidence in Section 3. At the same time, the empirical evidence does not take into account heterogeneity across age groups. Thus, it is unclear whether the responses of middle-aged and older households are at odds with the empirical results. In the next section, I explore other potential features of the model—guided by previous empirical studies—that may bring the response of middle-aged and older households in the model closer to the aggregate empirical evidence.

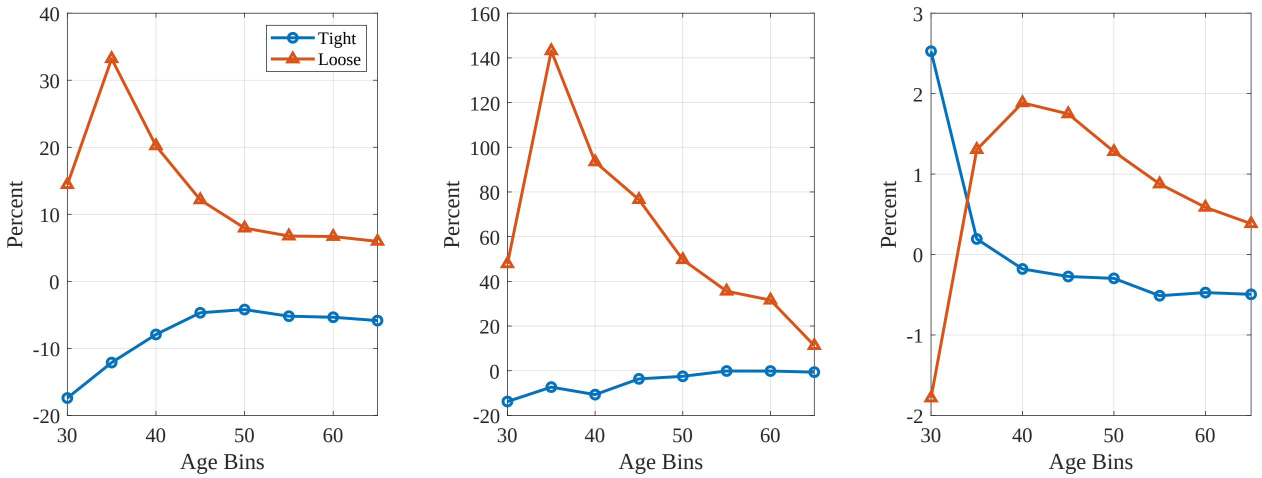
7 Discussion

The results shown in the previous section establish that the responses of middle-aged and older households differ from the aggregate empirical evidence. This suggests the possibilities of other quantitatively relevant determinants that can raise consumption to increases in house prices during tight financial periods. This section examines the preferences of older households, in the light of previous empirical literature, and how it affects their consumption responses.

The model in Section 4 assumes identical risk preferences regarding consumption and bequests. However, recent studies based on survey data in the U.S. document that older households have a lower risk aversion over bequests than their own consumption (see Lockwood, 2018 and Ameriks et al., 2020).[8] Incorporating a lower risk aversion for bequests relative to their own consumption in theory implies that households are more willing to accept changes in the former than in the latter. As a result, when subject to shocks, consumption should respond less especially for middle and older households. In the context of the current analysis, if we allow for a lower risk aversion over bequests, an increase in house prices will generate a more muted response for consumption and residential investment. This may bring the consumption response patterns of older households from the model closer to the empirical findings. In the model, this change is implemented by lowering the risk aversion in the bequest utility function from 2 to 1 with everything else kept the same. As in the baseline, the model is solved for the steady state with this change and then subjected to a permanent house price shock under two financial regimes. Figure 6 below displays the results.

[8]Both these papers model find bequests to be luxury goods as opposed to normal goods in the present paper. This effectively means a lower risk aversion over bequests.

Figure 6: Lower Risk Aversion for Bequest



(a) Borrowing Propensity (b) Housing Improvement (c) Consumption

Notes: The vertical axis is measured as the percentage change from the steady-state responses. The horizontal axis shows five-year age bins starting from age 26.

The qualitative results are similar to those in Figure 5. However, for older households, the gap in the responses across financial regimes is closer. The response of consumption is smaller under both regimes for older households. A similar muted response emerges for borrowings and housing improvement as well. Therefore, a lower risk aversion of bequests quantitatively reduces the gap between the responses of older age groups and the aggregate empirical estimate. At the same time, the gap is not fully closed. This suggests that there might be additional factors that can affect the response of middle-aged and older households which the current model does not capture. The appropriate modeling of those factors, as shown in this section, may quantitatively contribute to explaining the empirical evidence.

8 Conclusion

This paper shows that the effect of house prices on households' consumption and residential investment is dependent on the aggregate financial condition: Consumption responds more to changes in house prices under tight financial conditions while the evidence on residential investment response differs across empirical specifications. I rationalize this aggregate evidence using a quantitative life-cycle model that features rich household heterogeneity and explore the mechanism behind this new finding.

I find that the model's consumption response of younger households is consistent with the aggregate empirical evidence whereas middle-aged and older households respond less to house price changes in tight financial markets. On the other hand, residential investment responds more in loose financial markets which is consistent across all age groups but with varying magnitude. This paper shows that the response of residential investment is crucial for how consumption responds across various age groups. In particular, I find a financial-state-dependent substitution effect between consumption and residential investment to house price changes. This channel reflects that periods of adverse financial conditions are inappropriate for housing investments even if households experience improvements in their housing wealth. Instead, it is beneficial for certain households to raise consumption and postpone their housing investments. This effect turns out to be relatively pronounced for younger households as the majority of them are at lower rungs of the property ladder and find it expensive to build their home equity during periods of high borrowing rates. On the contrary, middle-aged and older households have accumulated sufficient home equity and wealth which makes them mostly unresponsive under tight financial conditions.

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