Financial-state-dependent Effects of House Prices on Consumption and Housing Investment*

Mamoon Kader†

May 27, 2024

Abstract

This paper shows that the effects of house prices on consumption and residential investment vary with changes in financial conditions. I find that consumption is more responsive to house prices when financial conditions tighten whereas residential investment is less responsive. To explain this new finding, I employ a life-cycle model that accounts for the financial conditions and quantitatively explore its effects. I demonstrate that middle-aged and older households show larger consumption responses to house price changes when financial conditions tighten, consistent with the aggregate empirical evidence. I rationalize this outcome by a financial-state-dependent substitution effect between consumption and residential investment facing changes in house prices.

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

---

*I am very grateful to Minjoon Lee for his guidance, support, and feedback. I thank my committee members, Hashmat Khan, Raúl Razo-García, and Jonathan Créchet for their excellent suggestions and advice. I thank Dana Galizia and Gaëlle Simrad-Duplain for their extensive discussions and valuable suggestions. For helpful comments, I furthermore thank Till Gross, Matt Webb, Konstantinos Metaxoglou, and Shirleen Manzur, as well as seminar participants at Carleton University.

†Carleton University; *E-mail:* mamoonkader@cmail.carleton.ca

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 lead 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 allows households 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 for their ability to extract home equity. For instance, an improvement in home equity might be less valuable in increasing 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 conditions of the economy which in turn has consequences for housing market dynamics.

This paper examines the effect of house prices on consumption and residential investment under tightening and loosening of aggregate financial conditions. While the effect of house price shocks on consumption and residential investment has been previously explored, I demonstrate that these effects are dependent on changes in financial conditions. I first estimate the effect of house prices by taking into account the changes in the financial conditions and then provide a structural interpretation of the empirical evidence.

In the empirical analysis, I estimate how consumption and residential investment respond to house price changes—measured at the metropolitan statistical area (MSA) level in the U.S.—contingent

[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.

on the aggregate financial conditions. I assume changes in the average 30-year fixed-rate real mortgage rates reflect changes in aggregate financial conditions. This is because mortgage rates are one of the most important financial indicators relevant to households' decisions related to housing prices. However, as argued by Cloyne et al. (2019), house price is an endogenous outcome. 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 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 when financial condition tightens. The positive consumption response to an increase in house prices has been documented in previous studies. However, the relatively stronger response of consumption under tighter 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, I document that residential investment indeed responds less to house prices during stringent financial conditions. This 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 lumpy, therefore under tightening of financial conditions—characterized by higher mortgage 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 when financial condition tightens.

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 changes on consumption and residential investment and their dependence on financial conditions.

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

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. Together, these features closely follow Zhou (2022), which I enrich with two crucial elements. First, 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. Second, I assume the current market mortgage rates evolve stochastically over time. Incorporating these features and the rich heterogeneities in the household sector, the model generates key life-cycle moments that closely match those observed in U.S. household microdata.

I then simulate the calibrated model to house price shocks under two changes: tightening and loosening the financial conditions. These regimes, respectively, are defined as high and low mortgage rates relative to a medium state in the model. The model generates an age-specific response in consumption and residential investments that depend on the financial condition. Specifically, I find that the consumption of middle-aged and older households, consistent with the MSA-level empirical estimate, increases more to a positive house price change when financial conditions have tightened. On the other hand, consumption decreases for younger households when financial conditions tighten. The key margin in understanding the heterogeneity in consumption behavior is linked to the response of housing investments and the heterogeneous propensity to borrow across households. In particular, residential investment increases less or is unresponsive to a house price increase across all age groups during tighter financial conditions. The mechanism generating these responses is an age-specific trade-off between consumption and residential investment to house price changes that depend on changes in financial conditions. The intuition behind these age-specific responses is as follows. Younger households start at the housing ladder's lower rungs and accumulate wealth over the life cycle. At the same time, these households are the ones that have low incomes and liquid assets and have a higher mortgage balance to be paid off. Thus, tightening of financial conditions—characterized by higher mortgage rates—refrains younger households from borrowing further against their improved home equity resulting in a decrease in consumption and a muted increase in residential investments. On the other hand, middle-aged and older households—consistent with the empirical evidence—increase consumption more by substituting away from residential investment when financial conditions tighten. This is because these households have accumulated sufficient housing wealth and are closer to their preferred housing size, thus inducing them to be less responsive in making further residential investments and instead incentivizing them to shift most of their home equity gains to raise consumption when financial conditions tighten. I show that this financial-state-dependent substitution between consumption and residential investment is present for both middle-aged and older households although it is relatively stronger for the former group as they have a higher propensity to borrow compared to the latter age group.

Overall, the model generates significant heterogeneity in the consumption and residential investment response. Comparing the household-level responses with the aggregate MSA-level evidence, the responses of middle-aged and older age groups align with the empirics. Given that the empirical evidence does not consider heterogeneity across age groups, it is unclear whether the responses of younger households are at odds with the empirical results. However, as the model generates the empirically consistent consumption response for most households along the age distribution, the financial-state-dependent mechanism highlighted in the paper provides a plausible rationale for this new empirical evidence.

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 larger 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 changes in 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 middle-aged and older age groups and in contrast to the previous finding that the unconditional effect of house prices are the strongest for younger households.

OUTLINE. The rest of the paper is organized as follows. Section 2 outlines the data sources and presents the unconditional correlation between consumption/residential investment and house prices across different financial conditions in the U.S. Section 3 further examines the causality of the relationship using an IV approach. 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 and the policy implications. Lastly, Section 7 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 from 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 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 MSA-level house price index is obtained from Freddie Mac House Price Indices (FMHPI).[5]

Given the focus of the current paper on households, mortgage rates are one of the most important measures of financial indicators for the key decisions considered in this paper. Thus, I use the quarterly average of the 30-year mortgage rates net of inflation from the FRED database to measure the aggregate financial conditions.[6] For the following empirical analysis, I focus on the first differences in mortgage rates. Thus, a positive value of this difference represents the tightening of the financial condition, and similarly, a negative value denotes the loosening of financial conditions.

Motivating Facts I now document the relationship between consumption/residential investment and house price changes conditional on changes in financial conditions.

Figure 1 plots, for each MSA-quarter-level observation, the log annual changes of consumption against the log annual changes in house price separately for periods when there has been tightening (Panel (a)) and loosening (Panel (b)) of financial conditions, respectively. Figure 2 shows the same relationship for log annual changes in residential investment (Panel (a) for tightening and (Panel (b) for loosening of financial conditions). The straight lines are a linear fit of the observa-

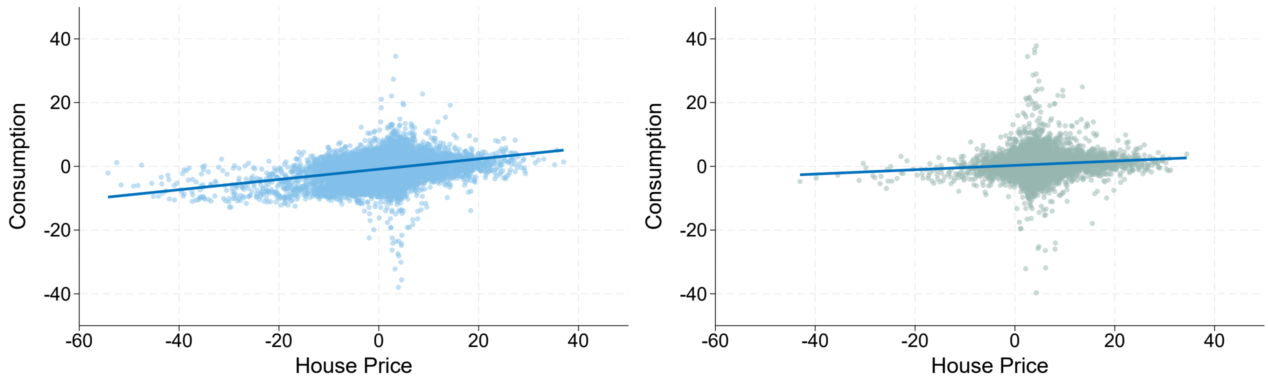
[4]Building permits are used as a proxy for residential investment due to a lack of data at the MSA level. In addition, this measure only represents upsizing to a bigger or better home and not improvements to existing houses.

[5]I also use house price indices from the Federal Housing Finance Agency (FHFA) to validate the robustness of the main results. See Appendix A.2.

[6]I verify the main results of the paper using a different measure of financial condition and find the baseline empirical results to be robust. The results are shown in Appendix A.1.

tions.

Figure 1: Consumption and House Prices across Financial Conditions



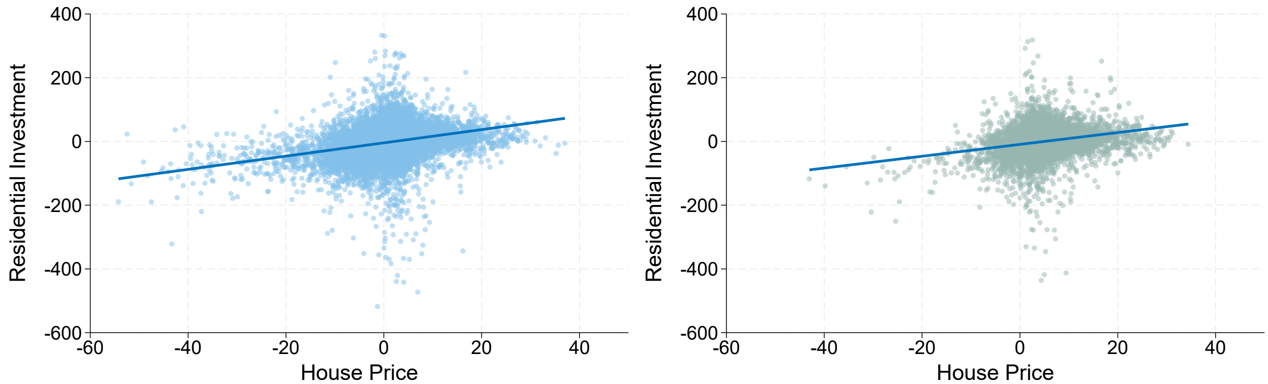
(a) Tightened Financial Conditions

(b) Loosened 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 the differenced mortgage rate is positive (i.e., tightening of financial conditions, Panel (a)) or negative (i.e., loosening of 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 when financial conditions tightened.

The figures show that both consumption and residential investment depict a positive relationship with house prices across both changes in financial conditions. However, these trends reveal a striking pattern for consumption: The relationship is relatively stronger in periods when financial conditions have tightened. On the other hand, the response of residential investment is similar across both financial conditions. 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 when there is a tightening of financial conditions serves as a motivation for further verifying the causality of these relationships.

Figure 2: 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 differenced mortgage rate is positive (i.e., tightening of financial conditions, Panel (a)) or negative (i.e., loosening of 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 when financial conditions tightened.

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 changes in the financial conditions of the economy.

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

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

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. Δr is the difference in real mortgage rates from quarter t to the same quarter of the previous year where a positive value indicates a tightening of financial conditions during this period and loosening otherwise. The difference in mortgage rates represents the overall change in the financial conditions during the year (quarter to quarter) and 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 conditions have neither tightened nor loosened (i.e., the differenced mortgage rate is 0) 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 tightening and loosening of financial conditions in 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.[7]

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

[7] 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 and the product of this estimated coefficient along with the aggregate variable is used as a control.

regression is as follows:

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

where χ_t and π_i are respectively, time and MSA-level fixed effects. 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:

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

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. I include the same sets of controls to be consistent across specifications. The estimates from both specifications are shown in Table 1.

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***	1.16***	0.13***	0.75***
	(0.01)	(0.11)	(0.02)	(0.21)
House Prices × Financial Tightening	0.03***	-0.11	0.05***	-0.12
	(0.01)	(0.11)	(0.02)	(0.19)
MSA Fixed Effects	✓	✓	✓	✓
Quarter Fixed Effects	✓	✓	✓	✓
R-squared	0.33	0.22	0.32	0.20
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.

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 first row shows the response of consumption and residential investment to house prices when the financial conditions have remained the same (i.e., the difference in the mortgage rate is 0). In terms of magnitude, when financial conditions remain unchanged, consumption increases by 0.09%, and residential investment increases by 1.16%, 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 (0.13% 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 with the instrument (0.75% vs. 1.16%).

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 Wald test 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	✓
Wald Test Statistic	7262.88
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 whether consumption and residential investment respond differently to house price fluctuations when financial conditions change. Table 1, under both specifications, shows that consumption demonstrates a stronger response to a house price change when financial conditions have tightened with the difference being statistically significant. On the other hand, residential investment responds less, under both specifications, to house prices when financial conditions have tightened although the estimates are not statistically significant.

Comparing these responses to the empirical patterns documented in Section 2 confirms that consumption indeed responds more strongly to house price changes during periods of tightening in financial conditions. The response of residential investment, on the other hand, is weaker when financial conditions tighten compared to the almost identical response in Figure 2.

Table 3: Variation in Consumption (C) and Residential Investment (RI) Responses to a Housing Price Increase across the Financial States

	OLS					IV				
	-2 std.	-1 std.	0	+1 std.	+2 std.	-2 std.	-1 std.	0	+1 std.	+2 std.
C	0.05	0.07	0.09	0.10	0.13	0.07	0.10	0.13	0.16	0.19
RI	1.30	1.23	1.16	1.10	1.02	0.90	0.83	0.75	0.67	0.60

Notes: The numbers are constructed as follows: $\beta_1 + \beta_2 \times n(\sigma_{\Delta r})$, where n is the number of standard deviations from the mean. The standard deviation of the index is 0.63.

In order to assess the magnitude of the results, Table 3 reports the response of consumption and housing investment to house price changes with varying degrees of changes in the financial conditions. The estimates in Table 3 show that the consumption response depicts an upward-sloping curve as financial conditions tighten, whereas residential investment decreases. Quantitatively, these effects are substantially large. For instance, under OLS, the marginal effect of housing wealth on consumption increases by 44% $\left(\frac{0.13-0.09}{0.09} \times 100\right)$ when the tightening of financial condition increases by two standard deviations from the average, while the corresponding effect is even stronger under IV—it increases by 46% $\left(\frac{0.19-0.13}{0.13} \times 100\right)$.

In summary, the response of consumption when financial conditions tighten is opposite to what one may expect. This is because, despite an improvement in their housing wealth, tightening of financial conditions can impact households' ability to extract funds from financial institutions, which may result in lower consumption and residential investment response. To shed light on the perhaps counterintuitive empirical evidence presented in Table 1, I argue that, in conjunction with the hindrance in households' borrowing ability, 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 in response to house prices might explain the evidence shown above. 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 when financial conditions are such that it hinders their ability to borrow. Thus, a house price increase when financial conditions tighten 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 life-cycle model of homeowners to study the role of financial states in evaluating the effect of house prices on consumption and residential investment. The motivation to use a life-cycle model is threefold. First, the literature has documented and it is a well-known fact for U.S. microdata (see, Section 5.2) that households accumulate housing wealth and climb the housing ladder over their life cycle. Second, capturing these realistic life-cycle profiles will allow us to obtain realistic heterogeneous responses of households to aggregate shocks. Third, the average of these heterogeneous outcomes might not be identical to that of a representative household model. Therefore, 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. and there is aggregate uncertainty in the current market mortgage rates, i.e., they evolve stochastically over time.[8] More importantly, both these properties have significant implications for households' interest payments and their decision to refinance when mortgage rates fluctuate. Therefore, the mortgage rate is fixed unless the household decides to refinance its loan, and the market mortgage rate changes over time. 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

[8]According to the National Mortgage Database, almost 95% of the mortgages in the U.S. are fixed-rate mortgages.

mortgage origination cost. Households can invest in housing, with a fixed cost, which captures either moving to a better house or improving the existing house. 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.

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 depending on the direction and size of housing investments. The fixed cost (**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 first component represents the transaction cost in the event of an upsizing denoted as the fraction of the home value, where $1 + \underline{h}^U$ is the threshold of the new home size relative to their home size in the previous period. Hence, in sum households must pay $f^U ph'$, where p is the unit price of a house. If the household decides to increase housing investment that is less than 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 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 where 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 $f^b b'$ if they decide to refinance an existing mortgage. Households are subject to a collateral constraint—defined as the minimum equity requirement—that must be satisfied if they decide to refinance:

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

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 market 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 ($\tilde{r}^b$) which as mentioned previously stochastically evolves over time. The process is elaborated in Section 5. Formally, the mortgage rate for the household at any point in time is determined as follows:

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

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 decide 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

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

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 existing mortgage rate, respectively:

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

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

$$a' \geq 0,$$

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

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 or not, 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. The model period 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 ages between 21 and 25 in the Panel Study of Income Dynamics (PSID).

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

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 which is inconsistent with the rates observed in PSID. Therefore, I set the value of η to 6 so that the average amount borrowed against their home equity remains constant during retirement as observed in the data. 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.

I follow Zhou (2022) in 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) to match the fraction of households who are upsizing or making an improvement. 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.

The mortgage rate is computed as the 30-year fixed rate mortgage net of inflation during the period 1994 to 2015 in the U.S. In the model, the current market mortgage rates evolve stochastically and are assumed to take three states: low, medium, and high. The corresponding values in each state are constructed in two steps. First, I sort the mortgage rates in an ascending order. The sorted mortgage rates are then divided into terciles and the values for each state are computed as the average of each tercile. The resuting grid points are given by: $\{\tilde{r}_L, \tilde{r}_M, \tilde{r}_H\} = \{2.51\%, 3.95\%, 5.95\%\}$. The transition probability matrix for the mortgage rates is assumed to have the following properties. First, I assume that mortgage rates cannot move directly between the high and low mortgage rates. Second, by construction, the fraction of each mortgage rate state is the same. Third, the probability of making a transition from the medium mortgage rate to either of the other rates is the same. Thus, under these assumptions, the only parameter that needs to be determined is the transition from the medium state ($\tilde{r}_M$) to the other states ($\tilde{r}_L$ or $\tilde{r}_H$) which is denoted by γ. This parameter is estimated by computing the frequency of transition to the low or high conditional on the current state being in the medium state. The resulting probability matrix is given below:

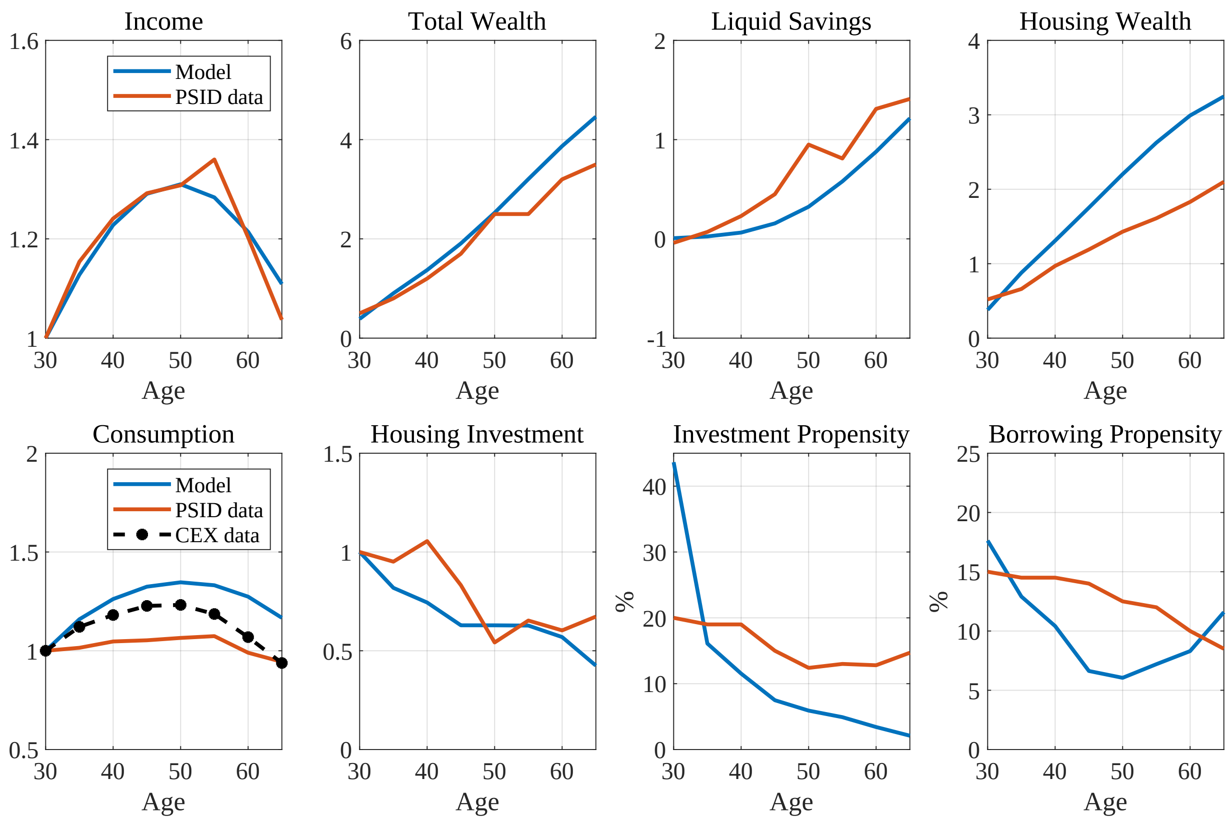
$$\Pi = \begin{bmatrix} 1-\gamma & \gamma & 0 \\ \gamma & 1-2\gamma & \gamma \\ 0 & \gamma & 1-\gamma \end{bmatrix} = \begin{bmatrix} 0.75 & 0.25 & 0 \\ 0.25 & 0.5 & 0.25 \\ 0 & 0.25 & 0.75 \end{bmatrix}.$$

Finally, house prices (p) are normalized to be one. The liquid asset return (r^a) is set to 1%, which is the average of the real 1-year treasury rate in the same period as that in the mortgage rate construction.

5.2 Life-Cycle Properties

Figure 3 shows the life-cycle profiles from 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.

Figure 3: Life-cycle Profiles



Notes: This figure compares the life-cycle profiles from 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.

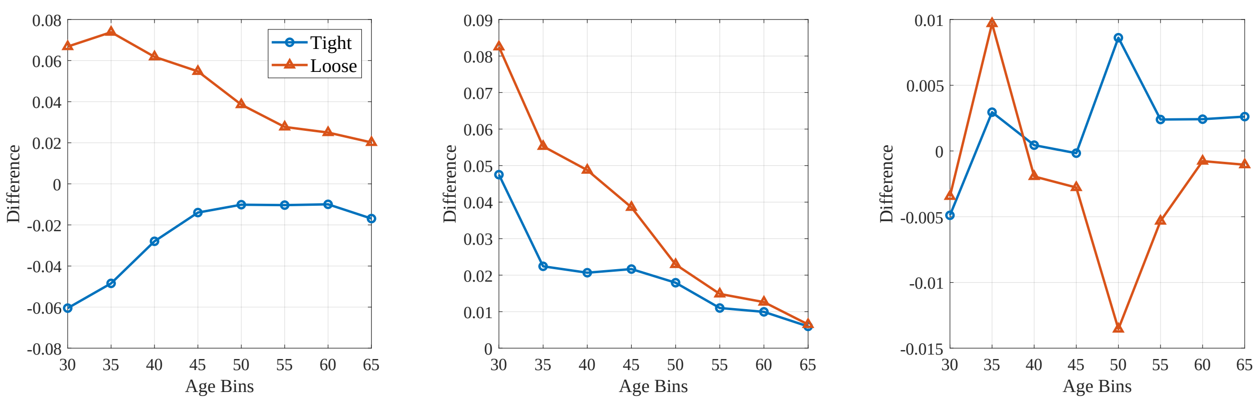
The model's ability to capture how housing investment varies with other household decisions, in particular with borrowing decisions, over the life cycle plays a vital role in determining the trade-off between consumption and residential investment to aggregate disturbances. Specifically, the model exhibits 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) and display significant heterogeneity across the age distribution. Such heterogeneity in their investment decisions across age groups will naturally lead to heterogeneous responses to aggregate shocks by age group.

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 stochastic steady state of the model and then simulate a one-time permanent increase in house price. To examine how the impact of house price increases depends on financial conditions, I assume this house price shock is accompanied by tightening (i.e., a transition from the medium to the high mortgage rate) or loosening (i.e., a transition from the medium to low mortgage rate) of financial conditions. The household policy functions are then analyzed in each case.

Heterogeneous Impact Responses Figure 4 plots the impact responses of household borrowing, residential investment, and consumption over different age groups to a 1% permanent house price increase under both tightening (circle) and loosening (triangle) of financial conditions.

Figure 4: Household Response to House Price Changes: Tightening vs. Loosening of Financial Conditions



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

Notes: The vertical axis is measured as the level changes in policy functions caused by a house price shock accompanied by tightening or loosening financial conditions. The horizontal axis shows five-year age bins starting from age 26.

The model generates significant heterogeneity across age groups in households' response toward house price changes contingent on financial conditions. A house price increase leads to a lower likelihood of borrowing when financial conditions tighten and the magnitude of the change varies across age groups as shown in Panel (a) of Figure 4. Residential investments (Panel (b)) increase and the size of the response is relatively larger for younger households than households later in their life cycle. In contrast, Panel (c) shows that the pattern of consumption response over age is substantially different. Specifically, the model generates an increase in consumption for middle-aged and older households under tighter financial conditions. The increase is, on average, relatively larger for the former group and more importantly, is substantially larger for both age groups relative to a loosening of financial conditions. On the other hand, the youngest age group reduces their consumption when there is a tightening in the financial conditions.

When financial conditions loosen, 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 responses are opposite to those when financial conditions tighten. Specifically, younger households increase consumption whereas middle-aged and older households substantially decrease their consumption in response to the improvement in housing equity.

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 changes in the financial conditions are not taken into consideration. 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). If the house price increase occurs when financial conditions have tightened such that the mortgage rates have increased, these economic forces will most likely be weaker. However, the impact responses for middle-aged households in Figure 4 show the opposite for consumption. I argue that the reason behind this outcome—described more below—is the response of residential investment to house prices under each financial state, which significantly characterizes the corresponding age-specific consumption behavior.

Households earlier in their life cycle have three features that shape their response: (i) lower income and liquid assets, (ii) being at the lower rungs of the housing ladder and having barely accumulated housing equity, and (iii) having a higher propensity to borrow. In response to the house price increase, younger households would want to use the housing equity gain to increase both their consumption and residential investment under both financial regimes. However, the increase in consumption and residential investment when financial conditions have tightened is fairly limited for younger households relative to other households. This is because younger households on average already have a higher mortgage balance. Therefore during tight financial conditions, they are less likely to borrow even when they face a house price increase (see Figure 4, Panel (a)) which translates into a decrease in consumption and a muted increase in housing investment.[9] On the other hand, younger households increase both their consumption and residential investment accompanied by higher borrowings to higher house prices in a loose financial market as depicted in Figure 4.

In contrast, the consumption of middle-aged households increases relatively more during tighter financial periods whereas the response of residential investment is significantly muted. This is because these households have accumulated sufficient home equity (i.e., a lower mortgage balance). As a result, this gives them sufficient room to make additional borrowings on their improved housing value. Moreover, middle-aged households are closer to their preferred home size, and as residential investments incur fixed costs, which are generally larger in size, households are reluctant to engage in higher housing investments and instead shift the majority of the gains in their housing equity to raise consumption when financial conditions are stringent. This is the financial-state-dependent substitution channel between consumption and residential investment that generates a stronger consumption response in tighter financial conditions. Finally, the consumption response of older households to higher house prices in a tight financial regime is much more muted. As older households are near the end of their life cycle, and given that they have a low propensity to borrow, the wealth effect of a housing price increase is relatively small.

Overall, the model generates significant heterogeneity in the response of consumption and residential investment to house prices across age groups and more importantly, the responses

[9]The consumption response under tighter financial conditions for the five-year bins of the younger age group (i.e., 25-35) is not monotonic. However, on average the response is slightly negative.

vary with changes in aggregate financial conditions. The model demonstrates a financial-state-dependent substitution effect between consumption and residential investment for the majority of the households across the age distribution. Given that the empirical evidence is an average response at the MSA level, it is thus unclear whether the responses of younger households are at odds with the empirical results. However, as most households in the model depict a stronger response of consumption when financial conditions tighten, the financial-state-dependent substitution mechanism highlighted in this section provides a good explanation for the puzzling empirical evidence of consumption documented in Section 3.

Policy Implications These heterogeneous consumption responses across age groups are important for evaluating the households' welfare implications of housing market fluctuations over their life cycle. In particular, a policymaker would be interested in determining which households along the age distribution and in what way are affected by their policy instrument that aims to stabilize the housing market. Moreover, being able to determine the households' responses will allow policymakers to predict the outcome of their intervention.

Suppose that the policymakers would like to tighten their policy rate and thus the financial conditions (mortgage rate) to stabilize the housing market. This may turn out to be unfavorable as it may harm households who have a higher propensity to borrow. However, given the age-specific consumption responses of the model displayed in Figure 4, making financial conditions stringent allows households to in fact increase consumption. Based on this outcome, the welfare cost of this contractionary policy might not seem large. Nonetheless, delaying housing investments to smoothen consumption implies that they remain stagnant at lower rungs of the housing ladder for a substantial portion of their lifetime. Governments in most developed countries design policies that are aimed at improving the affordability and quality of houses for households. Thus, making it difficult for households to climb to higher rungs of the housing ladder can carry negative welfare effects in the long run.

In summary, to completely determine the effects of stabilizing the housing market through intervening in financial markets, the policymaker would require assessing the trade-off between consumption and housing investment as these are close substitutes for households and have different welfare implications.

7 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 when financial conditions tighten while residential investment responds less. 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 middle-aged and older households is consistent with the aggregate empirical evidence whereas younger households respond less to house price changes in tighter 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. Specifically, I highlight 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 more prevalent for middle-aged and older households though it is relatively stronger for the former age group. This is because the majority of them are closer to their preferred house size leading to unresponsive investment and higher consumption when financial conditions tighten. In contrast, younger households reduce their consumption and display a slight increase in residential investment because these households already have a higher mortgage balance that needs to be paid off and thus tighter financial conditions refrain them from borrowing further to increase their consumption or improve their home.

References

Adrian, Tobias, Nina Boyarchenko, and Domenico Giannone. 2019. "Vulnerable Growth." *American Economic Review*, 109(4): 1263–1289.

Aladangady, Aditya. 2017. "Housing Wealth and Consumption: Evidence from Geographically Linked Microdata." *American Economic Review*, 107(11): 3415–3446.

Attanasio, Orazio P, Laura Blow, Robert Hamilton, and Andrew Leicester. 2009. "Booms and Busts: Consumption, House Prices and Expectations." *Economica*, 76(301): 20–50.

Berger, David, Veronica Guerrieri, Guido Lorenzoni, and Joseph Vavra. 2018. "House Prices and Consumer Spending." *The Review of Economic Studies*, 85(3): 1502–1542.

Boar, Corina, Denis Gorea, and Virgiliu Midrigan. 2022. "Liquidity Constraints in the US Housing Market." *The Review of Economic Studies*, 89(3): 1120–1154.

Campbell, John Y, and Joao F Cocco. 2007. "How do House Prices Affect Consumption? Evidence from Micro Data." *Journal of Monetary Economics*, 54(3): 591–621.

Cloyne, James, Kilian Huber, Ethan Ilzetzki, and Henrik Kleven. 2019. "The Effect of House Prices on Household Borrowing: A New Approach." *American Economic Review*, 109(6): 2104–2136.

Davidoff, Thomas. 2016. "Supply Constraints are not Valid Instrumental Variables for Home Prices because they are Correlated with Many Demand Factors." *Critical Finance Review*, 5(2): 177–206.

Gilchrist, Simon, and Egon Zakrajšek. 2012. "Credit Spreads and Business Cycle Fluctuations." *American Economic Review*, 102(4): 1692–1720.

Guren, Adam M, Alisdair McKay, Emi Nakamura, and Jón Steinsson. 2021. "Housing Wealth Effects: The Long View." *The Review of Economic Studies*, 88(2): 669–707.

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

Mian, Atif, and Amir Sufi. 2011. "House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis." *American Economic Review*, 101(5): 2132–2156.

Mian, Atif, and Amir Sufi. 2014. "House Price Gains and US Household Spending from 2002 to 2006." National Bureau of Economic Research 20152.

Mian, Atif, Kamalesh Rao, and Amir Sufi. 2013. "Household Balance Sheets, Consumption, and the Economic Slump." *The Quarterly Journal of Economics*, 128(4): 1687–1726.

Saiz, Albert. 2010. "The Geographic Determinants of Housing Supply." *The Quarterly Journal of Economics*, 125(3): 1253–1296.

Tauchen, George. 1986. "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions." *Economics Letters*, 20(2): 177–181.

Wong, Arlene. 2021. "Refinancing and the Transmission of Monetary Policy to Consumption." mimeo.

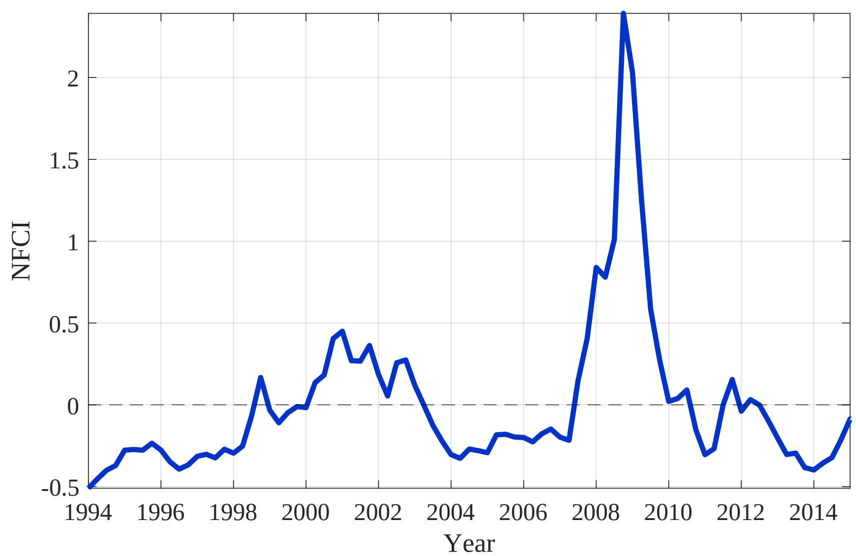
Zhou, Xiaoqing. 2022. "Mortgage Borrowing and the Boom-Bust Cycle in Consumption and Residential Investment." *Review of Economic Dynamics*, 44: 244–268.

A Robustness

A.1 Empirical Results using NFCI

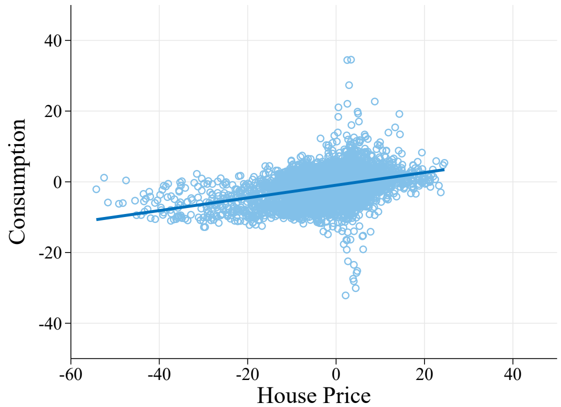
In this section, I verify the robustness of the empirical findings shown in Sections 2 and 3 using a different financial indicator.

Figure A.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, 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 A.1 above plots the quarterly time series of the index.

Figure A.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.

Table A.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.

Table A.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.

Table A.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.

A.2 FHFA

The table below reproduces the estimates as in Table 1 with house price data from the Federal Housing Finance Agency.

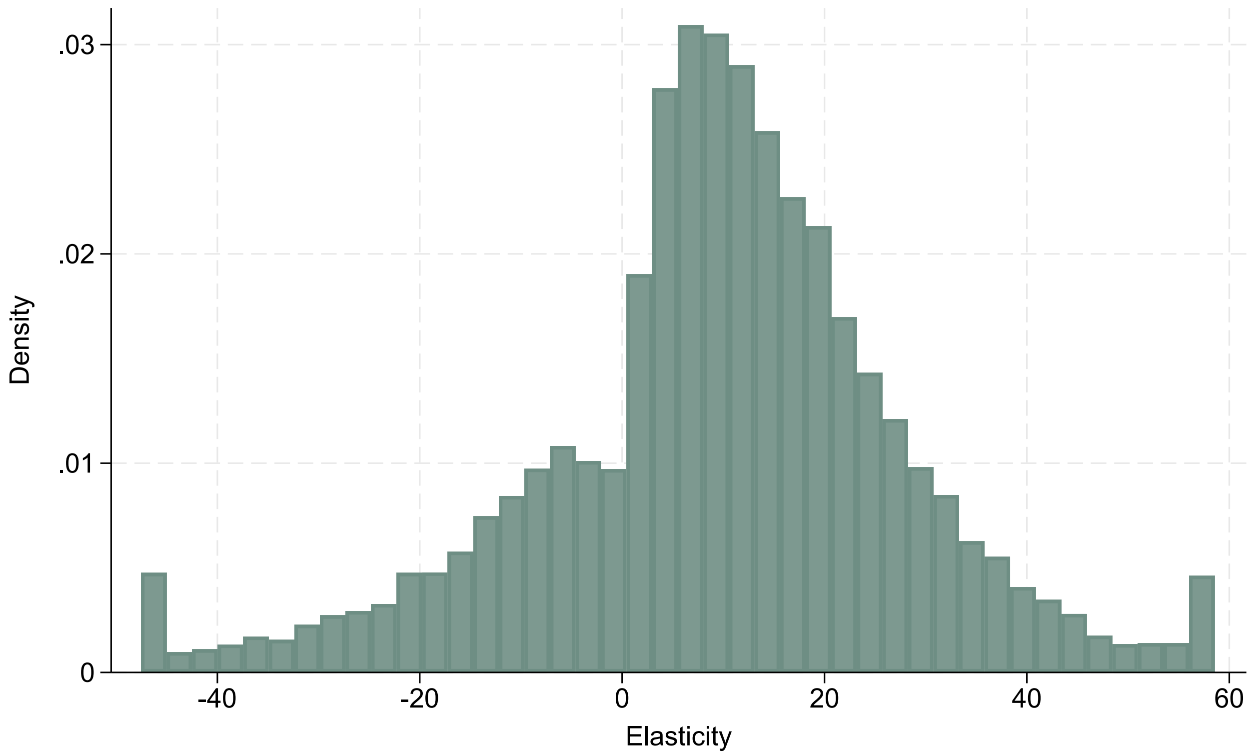
Table A.4: Robustness with FHFA House Prices

	OLS		IV	
	(1)	(2)	(3)	(4)
	Consumption	Residential Investment	Consumption	Residential Investment
House Prices	0.09***	0.90***	0.14***	0.78***
	(0.01)	(0.13)	(0.02)	(0.22)
House Prices × Financial Tightness	0.03***	0.23*	0.05***	-0.03
	(0.01)	(0.15)	(0.02)	(0.20)
MSA Fixed Effects	✓	✓	✓	✓
Quarter Fixed Effects	✓	✓	✓	✓
R-squared	0.32	0.22	0.32	0.20
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.

B Saiz Instrument

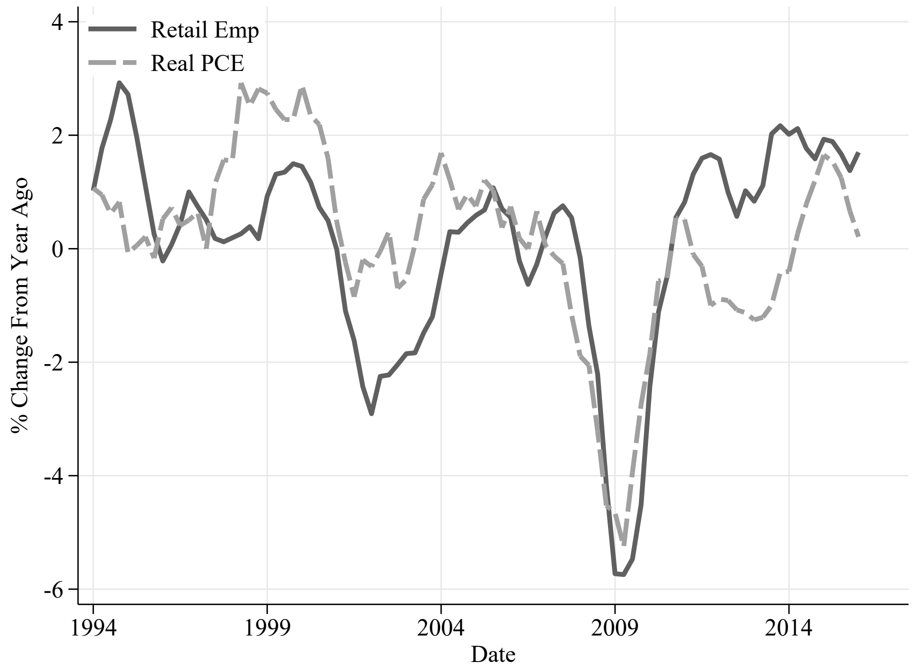
Figure B.1: Histogram of Housing Supply Elasticity (18.6 st.dev)



Notes: The figure plots the housing supply elasticity for each MSA during the time period of 1994(Q1)-2015(Q4).

C Measure of Consumption

Figure C.1: Comparison of Retail Employment Growth versus Personal Consumption Expenditure



Notes: The figure plots the 4-quarter change in aggregate retail employment and the 4-quarter aggregate change in real personal consumption expenditure during the time period of 1994(Q1)-2015(Q4). Source Guren et al. (2021).