House Prices, Investors, and Credit in the Great Housing Bust

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Abstract

I study the role of investors in stabilizing housing markets during the Great Housing Bust. Using transaction-level housing data, I distinguish between two types of investors that were active during this period: large corporate investors and small household investors. I estimate that following a mortgage credit contraction, house prices fell by 30 percent more in markets where household investors absorbed larger shares of house purchases. To rationalize this result, I build a heterogeneous agent model of the housing market featuring both types of investors. I show that equilibrium house prices fall sharply following a mortgage credit contraction when household investors are required to absorb falling housing demand. In contrast to corporate investors, household investors are sensitive to changing credit conditions and the illiquidity of housing assets. Prices must fall to generate sufficiently large returns to compensate previously indebted homeowners for the increase in borrowing required to invest in additional housing.

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1. Introduction

In the mid 2000s, an unprecedented housing boom ended in the Great Housing Bust. Following a sharp contraction in the availability of mortgage credit, house prices fell rapidly.[1] The literature explains the magnitude of these declines with a range of factors affecting homeowner demand for housing during this period.[2] However, in many of the housing markets in which homeowner demand fell, housing investors purchased an increasing share of the properties available for sale.[3] If investors substitute for the decline in homeowner purchases, then the magnitude of the housing bust will depend on the determinants of investor demand.

In this paper, I study the extent to which investors helped to stabilize housing markets in response to mortgage credit shocks during the Great Housing Bust. I show that investors substitute for falling homeowner demand, thereby dampening declines in house prices. However, the strength of this stabilization channel depends on certain characteristics of the investors themselves. Corporate housing investors behave like large, deep-pocketed buyers, while household investors rely on mortgage credit to finance their purchases. Consistent with this view, corporate investment activity is associated with significantly smaller house price declines than is household investment activity.

In this paper, I first present empirical estimates of the effect of investment on house prices following exogenous changes in mortgage credit. I find that an increase in the share of corporate investor purchases is associated with a 30 percent smaller decline in house prices than a similar sized increase in the share of household investor purchases. In the second part of the paper, I rationalize this result using a structural macroeconomic model of the housing market that features both types of investors. I show that house prices are much more stable following a mortgage credit shock when corporate investors absorb the decline in homeowner demand rather than household investors. This is because household investment demand is much less elastic with respect to house prices than is corporate investment demand. While corporate investment is associated with greater housing market stability, it is also associated with a much larger reallocation of the housing stock and thus a much larger decline in the homeownership rate. Nevertheless, households value stability so that total welfare is higher when corporate investors are more active in the housing market than are household investors.

In the empirical analysis, I use housing transaction data from the Zillow Transaction and Assessment database (ZTRAX) to study housing investment activity during the bust. This detailed micro-data shows that corporate and household investors differ in important aspects of their investment behavior. For example, corporate investors buy many more properties, trade property far more frequently, and are much less likely to use mortgage debt to finance their pur-

[1]On the overall decline in mortgage originations, see Justiniano et al. (2017). On the relationship between mortgage credit and house prices in the bust, see Mian et al. (2009) and Mian et al. (2018).

[2]For example, changes in: mortgage rates (Garriga et al., 2019), borrowing constraints (Greenwald, 2018), housing liquidity (Hedlund, 2016), beliefs about future house prices (Kaplan et al., Forthcoming), and risk-premia (Favilukis et al., 2017a).

[3]See Lambie-Hanson et al. (2018), Lambie-Hanson et al. (2019), Mills et al. (2019).

chases. I then test whether investment helps to stabilize house prices following a shock using zip code-level panel data on house prices, investment activity, and changes in mortgage credit. Due to the endogeneity between these housing market outcomes and other shocks that occurred during the housing bust, I adopt an instrumental variables regression strategy. I instrument for corporate and household investment activity using their own lags. Changes in credit are instrumented using the share of mortgages sold to non-government sponsored enterprises (GSEs) in secondary mortgage markets prior to the housing boom and bust. [4] As non-GSE activity fell sharply following the housing boom, markets that relied more on mortgages that were sold to these institutions faced larger contractions in mortgage credit and thus larger shocks to housing demand.[5]

The empirical results suggest that that greater housing investment actvity dampens house price declines following a mortgage credit contraction. On average, a one standard deviation decline in mortgage credit is associated with an 8.5 percent decrease in house prices. However, prices decrease just 5.2 percent in housing markets facing a one standard deviation increase in the corporate investor share of house purchases. In contrast, prices decline 7.4 percent in markets where the household investor share of purchases incresed by one standard deviation. Overall, an increasing share of corporate investment activity is associated with a 30 percent smaller decline in house prices than a similar sized increase in the share of household investor activity. These results suggest that corporate housing investment provides a much stronger stabilizing force in housing markets than does household investment.

To rationalize the empirical findings, I build a structural macroeconomic model of a housing market that features both types of investors. The model features heterogeneous life-cycle households who face uninsurable income risk, can choose to rent or buy houses, and use long-term mortgage debt to finance house purchases.[6] I introduce endogenous household investment decisions, which enable households to buy properties in addition to those in which they live. Like owner-occupied property, investment properties are traded subject to transaction costs and can be used as collateral for mortgage borrowing. Investment property also generates rental income and may earn capital gains following aggregate shocks. Corporate housing investment is conducted by a deep-pocketed, risk-neutral firm that maximizes profits generated by leasing properties in the rental market as well as trading those properties in the housing market. The corporate investors faces a convex housing portfolio cost, the curvature of which is governed

[4]The latter instrument resembles a mortgage credit supply shock, since rapidly rising non-GSE activity in the housing boom was associated with increases in mortgage borrowing and lower mortgage interest rate spreads. See Mian et al. (2009), Justiniano et al. (2017), and Mian et al. (2018).

[5]The mortgage credit instrument is constructed using Home Mortgage Disclosure Act (HMDA) data. A better measure of exposure to the mortgage credit supply shocks of the mid-2000s might come from mortgages sold directly into private label securitization (PLS), rather than to non-GSEs. However, the HMDA data appears to significantly undercount PLS mortgage purchases in the secondary market, as can be seen by comparing to the measures of total PLS activity reported in Justiniano et al. (2017). Nevertheless, in Section 3.5 I show that the main results are robust to using the more direct PLS measure.

[6]See recent examples in Favilukis et al. (2017a), Kaplan et al. (Forthcoming), Greenwald (2018), and Garriga et al. (2018).

by the elasticity of corporate investment demand with respect to housing returns. This cost is motivated by the empirical finding that even corporate investment does not perfectly stabilize house prices in response to shocks.[7]

I use the model to study housing market equilibrium responses to an exogenous, unexpected, temporary contraction of mortgage credit.[8] Since homeowners are both dependent on mortgage credit and hold most of the housing stock in steady state, the primary effect of the shock is to decrease homeowner demand for housing. While this causes equilibrium house prices to fall, the size of this decline depends on the investors that are active in the housing market at the time of the shock. To study this channel, I alter the concentration of corporate investors in the housing market following the shock by varying the elasticity of corporate investment demand. When the elasticity is high (low), corporate (household) investors purchase an increasing share of houses and there are small (large) declines in house prices following the credit shock. I also use the model to study the relative reluctance of household invetsors to purchase property during the housing bust. I find that when household investors are active in the housing market, the marginal investor during the housing bust is younger, less wealthy, and more indebted than investors in the steady state. Moreover, household investment is sensitive to the rise in mortgage costs and the illiquidity of housing assets. Thus, when household investors are active in the housing market prices must fall further to generate large enough returns to compensate new household investors for reallocating resources towards additional housing.

Finally, I consider the welfare implications associated with the presence of corporate investors during a housing bust. Although corporate investment activity is associated with more stable house prices, the high elasticity of corporate investment demand leads them to purchase more houses which causes a much steeper decline in the homeownership rate.[9] Additionally, if investment firms are owned by outsiders, the capital gains and rents earned by corporate investors do not accrue to households during the bust. Overall, households are better off when corporate investors are active in the housing market. However, there is significant heterogeneity in welfare changes. Young and poor households gain the most from housing market stability, while older and wealthier households (those most likely to be housing investors) are typically left worse off in the presense of active corporate investors.

[7]Mills et al. (2019) suggest that corporate investors face decreasing returns to scale since corporate investment is concentrated in the market for multi-family residential property which is easier to manage than dispersed, single-family properties. Chinco et al. (2015) show that local housing market knowledge is important for profitable residential investment, which may discourage out-of-town corporate investment activity. Additionally, significant disruptions in broader financial markets in the late 2000s may have affected the non-mortgage financing that corporate investors rely on for investment.

[8]Other housing boom and bust experiments using these shocks can be found in Justiniano et al. (2015), Favilukis et al. (2017a), and Greenwald (2018).

[9]Lambie-Hanson et al. (2019) present empirical evidence that the rise in corporate investment activity in the housing bust was associated with declining homeownership rates.

Related Literature. While the current paper focuses on the importance of housing investors during the 2000s housing bust, a prior empirical literature studies the influence of housing investors during the preceding housing boom. Haughwout et al. (2011) and Adelino et al. (2016) find that household investors accounted for an increasing share of mortgage borrowing during the boom. Mian et al. (2018) show increases in mortgage credit supply increased household investment activity during the boom. Garcia (2019) estimates that increased household investment amplified house prices during the boom. Haughwout et al. (2011), Adelino et al. (2016), and Mian et al. (2018) all find that greater household investor borrowing during the boom was associated with greater subsequent mortgage defaults and declines in house prices.

Lambie-Hanson et al. (2018) and Mills et al. (2019) document that large institutional investors purchased a greater share of houses during the housing bust. Mills et al. (2019) attribute some of this increase to the entry of large buy-to-lease investors in the late 2000s, and suggest that this investment activity supported house prices in this period. Lambie-Hanson et al. (2019) use instrumental variables regressions to show that higher corporate investment activity was associated with higher house prices and lower homeownership rates during the bust. Consistent with these papers, I also find that corporate investment activity stabilized house prices in the bust. I extend the analysis to show that household investors also supported house prices during this period, but by less than corporate investors.

In building a structural model of the housing market, I follow a large macroeconomic literature that studies the evolution of the 2000s housing boom and bust.[10]. Most of these models have in common a heterogeneous household structure with features that help explain households' exposures to fluctuations in housing markets: age, income risk, housing illiquidity, and long-term mortgage debt. In contrast to this literature, I introduce a role for both household and corporate investors in housing and rental markets. I then show that the composition of investors in the housing market affects the elasticity of investment demand, which determines the size of the equilibrium house price response to a mortgage credit contraction.

The influence of investors on the housing market during a boom and bust has also been studied in two recent papers.[11] Kaplan et al. (Forthcoming) introduce perfectly elastic corporate firms that trade houses and rent them to households. Following a contraction in mortgage credit, these corporate investors absorb the fall in homeowner demand and perfectly stabilize house prices. As a result, Kaplan et al. (Forthcoming) conclude that fluctuations in mortgage credit did not affect house prices during the 2000s housing boom and bust. In contemporaneous work, Greenwald et al. (2019) study a model with housing investment and housing market segmentation between rental and owner-occupied property. They show that market segmentation helps account for the observed effect of mortgage credit on house prices. In the current paper, I

[10]See recent papers by Iacoviello et al. (2013), Chen et al. (2020), Landvoigt et al. (2015), Hedlund (2016), Hurst et al. (2016), Favilukis et al. (2017a), Kaplan et al. (Forthcoming), Berger et al. (2017), Greenwald (2018), Garriga et al. (2018), Garriga et al. (2019), Diamond et al. (2019), and Greenwald et al. (2019).

[11]Chambers et al. (2009a), Sommer et al. (2018), and Favilukis et al. (2017b) also study the influence of housing investors, but in contexts unrelated to a housing boom and bust.

assume no housing market segmentation, but study the factors that affect the housing demand of investors themselves. I find that constrained household investors and less-than-perfectly elastic corporate investors help to account for variation in the house price response to a mortgage credit contraction.

2. Motivating Evidence

In this paper I make use of housing transactions data from the Zillow Transaction and Assessment Dataset (ZTRAX).[12] The full ZTRAX dataset contains more than 370 million transactions from across the US, and reports information on sales, prices, buyers, mortgages, property characteristics, and geographic information for residential and commercial properties. I restrict analysis to transactions for regular sales of residential, single-family houses, which excludes foreclosure sales, intra-family transfers, and transactions featuring builders, developers, or real estate agents. I drop all transactions with missing buyer addresses or missing buyer description information. Reliable ownership information is not available in every location, so I restrict the analysis to data from US states in which I observe buyers' addresses for at least 85 percent of transactions.[13] In the main empirical analysis, I aggregate data by zip code and restrict the sample to observations with at least 100 house sales in a given year. The final sample consists of zip codes containing approximately 40 percent of the US population as at the 2000 Census.

I determine ownership of purchased properties in two stages.[14] First, I infer owner-occupancy for each transaction by comparing the listed address of the buyer to the address listed for the property. I assume that owner occupiers are those whose address matches that of the property they purchased. Second, I separate purchases into those made by households and those made by corporate institutions. ZTRAX reports whether buyers are individuals, couples, trusts, legal partnerships, companies, government entities, or other kinds of organizations.

I define household owner-occupiers as buyers who are listed as individuals or couples.[15] I define investors as non-owner occupier house buyers. Household investors are coded as individuals or couples, while corporate investors are companies, partnerships, builders, developers, agents, contract owners, individuals doing business, or individual officers of organizations.[16]

Table 1 reports summary statistics for house purchase and buyer characteristics. For ease of exposition, I pool data across the US but split by boom and bust sub-samples. Panel A shows

[12]The conclusions drawn from the ZTRAX dataset are those of the researcher and do not reflect the views of Zillow. Zillow is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

[13]These states are: Alaska, Arizona, California, Colorado, Delaware, Florida, Iowa, Idaho, Indiana, Hawaii, Kentucky, Maryland, Minnesota, Missouri, Montana, North Dakota, New Jersey, New York, New Mexico, Nevada, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Texas, Utah, Washington, Wisconsin.

[14]See Appendix A for details.

[15]Trusts and trustees are excluded. House purchases by these entities make up around one to two percent of all transactions.

[16]Government entities, non-profits, and religious organizations are excluded from this definition. Of these, only government purchases are significant, constituting around 0.5 percent of all transactions.

that owner occupiers purchase around twice as many properties as household investors, who in turn purchase around three times as many properties as corporate investors. The owner-occupier share of purchases declined three percentage points between the boom and bust. This decline in homeowner purchases is consistent with the national decline in the homeownership rate from 69 to 67 percent between 2005 and 2010. The decline in homeowner demand is mirrored by a 1 percentage point increase in the household investor purchase share and a 2 percentage point increase in the corporate investor share.

Panel B presents a measure of the distribution of investor sizes. I report the fraction of individual investors that purchased different numbers of properties within each five-year period.[17] Household investment is heavily concentrated among buyers purchasing a single property. In contrast, corporate investment is skewed towards large investors, such as those buying more than 25 properties. These statistics are consistent with Haughwout et al. (2011), who show that in the 2000s around 70 percent of mortgage borrowing associated with household investors accrued to those with just two mortgages (i.e. one mortgage against a primary property and one against a secondary property).

[INSERT TABLE (1) HERE]

Panel C reports statistics summarizing financing, resales, and location of house buyers. The first row shows that owner occupiers are more likely to use mortgage financing than household investors, who in turn are more likely to use mortgages than corporate investors. Reflecting tighter credit during the bust, mortgage financing dropped by 7 percentage points for both owner-occupiers and corporate investors, and by 14 percentage points for household investors.[18] The second row of Panel C shows that the size of mortgages for both owner occupiers and household investors are similar, with LTV ratios of around 0.8 each. The third row of Panel C shows that owner occupiers and household investors are similar in that they are relatively unlikely to resell their properties within the first year after initial purchase. In contrast, one third of corporate investors resold their properties within 12 months. These statistics are comparable to Mills et al. (2019), who report 12-month resale rates in 2012 for owner-occupiers, household investors, and small corporate investors of 0.04, 0.17, and 0.45, respectively. The final row of Panel C shows that around one quarter of all investment is due to out-of-town buyers.[19] While the out-of-town buyer rate for household investors is little changed from boom to bust, the rate

[17] These statistics are computed by tracking transactions associated with each listed buying addresses. Note that this will overstate the number of properties purchased by an investor if they happen to change address and if the new occupant of that address also makes purchases in the sample period. I suspect this bias is small, and indeed the numbers reported here are comparable to those reported in Mills et al. (2019), who track individual investors by name rather than address.

[18] Unfortunately, the data does not report on non-mortgage sources of financing. For this reason it is not clear if, for example, corporate investors were affected by tighter non-mortgage credit due to the broader financial crisis during this period.

[19] I define an out-of-town purchase as one in which the buyer address is located in a different MSA to that of the property being purchased.

for corporate investors rises from 22 to 31 percent during this period.

In summary, corporate investors are much larger, trade housing assets more often, and rely less on mortgage financing to purchase properties than household investors. These stylized facts are consistent with a view of corporate investors as large, deep-pocketed house buyers, and household investors as small, constrained house buyers.

Figure 1 shows how the shares of houses purchased by owner occupiers, household investors, and corporate investors evolved during the housing bust. For illustration, I show house purchase shares for two housing markets that experienced especially large house price declines during this period: Maricopa County in Arizona, and Miami-Dade County in Florida.[20] In each housing market declining homeowner demand is represented by the fall in the owner-occupier share of purchases from 2007. However, investor shares responded differently in the two markets. In Arizona between 2007 and 2011, the household and corporate investor shares increased by 10 and 4 percentage points, respectively. In contrast, in Florida over the same period the household investor share fell 3 percentage points and the corporate investor share rose 21 percentage points. The goal of the empirical analysis is to assess whether house prices responded differently in markets such as these, where the fall in homeowner demand for housing was more likely to be absorbed by corporate or household investors.

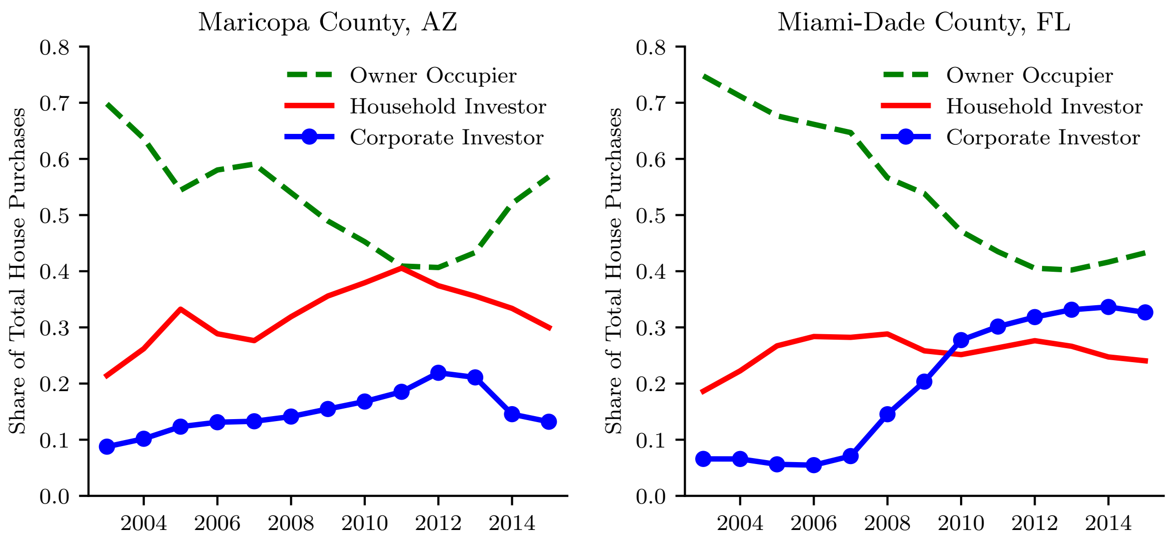

FIGURE 1
Housing Market Buyer Composition Through the Housing Bust

Note: Total house purchases are the sum of owner occupier, household investor, and corporate investor purchases. *Source*: Author's calculations using ZTRAX

[20]A broader cross-section of the changes in investor purchase shares is shown in Figure B.1 in Appendix B. The figure presents histograms of the growth in corporate and household investor shares across zip codes from 2006 to 2010.

3. EMPIRICAL ANALYSIS

3.1. *House Price Responses to Mortgage Credit and Housing Investment*

In this section I present an empirical analysis of the investment stabilization channel of housing markets. I test whether the response of house prices to negative mortgage credit shocks depends on housing investment activity. If investment demand substitutes for the decline in homeowner demand following the shock, house prices should fall by less when investors buy a greater share of the houses available for purchase.

To estimate the effects of changes in mortgage credit and housing investment, I use an instrumental variables regression strategy with annual, zip code-level panel data over the period 2007 to 2010. The second-stage regression of the 2SLS specification is given by:

$$\begin{aligned}\Delta \log P_{z,t} = \alpha_{c,t} + \gamma\Delta \log P_{z,t-1} + \zeta\Gamma_{z,t} + \beta\Delta \log M_{z,t} \\ + \delta_1 \left(\Delta \log M_{z,t} \times \Delta Corporate\ Investor\ Share_{z,t}\right) \\ + \delta_2 \left(\Delta \log M_{z,t} \times \Delta Household\ Investor\ Share_{z,t}\right) + \varepsilon_{z,t}\end{aligned} \quad (1)$$

where the subscripts z and t denote a given zip code and year, $\Delta \log P_{z,t}$ is growth in real house prices, $\Delta \log M_{z,t}$ is growth in mortgage credit, and $\Delta Corporate\ Investor\ Share_{z,t}$ and $\Delta Household\ Investor\ Share_{z,t}$ are annual changes in the fraction of houses purchased by each type of investor. A county-by-year fixed effect $\alpha_{c,t}$ controls for county-specific trends in house price growth during the housing bust. I include the lag of the dependent variable $\Delta \log P_{z,t-1}$ to absorb any serial correlation in house price growth. Finally, the vector $\Gamma_{z,t}$ includes controls for the levels of corporate and household investor purchase shares, as well as other zip-code level controls controls.

Changes in mortgage credit are represented by changes in local mortgage originations.[21] To capture the effect of the investment stabilization channel, I interact the change in mortgage credit with changes in the local shares of houses purchased by corporate and household investors. Conditional on a negative mortgage credit shock, a shift in the composition of house buyers towards investors represents a substitution of homeowner demand for investor demand. The larger is this change in housing market composition and the smaller is the associated change in house prices, the stronger is the investment stabilization channel.

With respect to the values of the estimated coefficients, the housing investment stabilization channel predicts that $\beta \geq 0$, $\delta_1, \delta_2 \leq 0$, and $|\delta_1| \geq |\delta_2|$. First, since tightening mortgage credit decreases housing demand, house prices should fall implying that $\beta \geq 0$. Second, if investment demand substitutes for falling homeowner demand following credit tightening, an increasing investor share of purchases should be associated with higher house price growth. This implies that $\delta_1, \delta_2 \leq 0$. Third, if corporate investment demand is more elastic than household investment demand, a given increase in the corporate investor share is associated with a

[21] Favara et al. (2015), Mian et al. (2018), and Greenwald et al. (2019) also estimate the effect of mortgage credit on house prices.

larger increase in house prices than for the same sized increase in the household investor share. This implies that $|\delta_1| \geq |\delta_2|$.

3.2. *Data*

Zip-code level house prices $P_{z,t}$ come from Zillow's publicly available house price indexes, and are available at an annual frequency from 1996. Zip-code level mortgage originations $M_{z,t}$ are computed from Home Mortgage Disclosure Act (HMDA) data. HMDA provides loan-level data about all US mortgage applications and originations. I restrict the analysis to all originated mortgages issued for the purpose of buying a home. I then use information about the location of each mortgage to aggregate data to the zip code-level.[22]

The additional controls in $\Gamma_{z,t}$ are log-changes in per-capita pre-tax income, employment by firms within the zip code, and growth in real annual payrolls of firms within the zip code. Per-capita income by zip is reported in the IRS Statistics of Income (SOI). Zip code-level employment and payroll statistics are reported by the County Business Patterns (CBP) survey. All nominal variables are deflated by the CPI for all urban consumers from FRED.

Section 3.5 discusses a range of robustness exercises that make use of a range of additional controls. This makes use of local demographics and housing characteristics data from the 2000 Decennial Census. Housing supply elasticities at the MSA-level are reported in Saiz (2010). Data on zip code-level bank information is provided by the Federal Deposit Insurance Corporation. Appendix A reports additional details.

3.3. *Instrumental Variables for Mortgage Credit and Investment*

Changes in mortgage credit and investor purchase shares are likely to be endogenous to other determinants of local house prices. For this reason, I estimate Equation (1) via 2SLS using instrumental variables for the changes in mortgage credit and its interactions with the changes in investor purchase shares. This requires the use of three instrumental variables.

3.3.1. Instrument for Mortgage Originations. First, changes in mortgage originations $\Delta \log M_{z,t}$ are predicted using a measure of local exposures to mortgage credit supply shocks. This is given by the share of mortgages sold in the secondary mortgage market to non-Government Sponsored Enterprises (GSEs) between 1998 and 2000, denoted $\lambda^{nonGSE}_{z,98-00}$. The relationship between non-GSE mortgage purchases and mortgage credit supply is discussed in the literature. Justiniano et al. (2017) show that beginning in 2003, non-GSE institutions experienced a rapid increase in both the volume of mortgage purchases and market share in the secondary mortgage market. This culminated in a near-total collapse of non-GSE activity in

[22] Note that value of mortgage originations is affected by changes in house prices, hence the use of mortgage originations as the relevant measure of mortgage credit.

2008.[23] Justiniano et al. (2017) argue that the rise and fall of non-GSE activity resembled a mortgage credit supply shock because the rise in non-GSE activity coincided with an increase in both mortgage originations and a decline in mortgage interest rate spreads over the risk-free rate. Additionally, Mian et al. (2009) show that locations with more exposure to non-GSE activity experienced more rapid growth in mortgage originations, more subprime mortgage borrowing, as well as higher mortgage default rates from 2005 to 2007. Mian et al. (2018) show that prior exposure to non-GSE activity predicted larger house price fluctuations in the boom and bust.

The non-GSE share instrument $\lambda^{nonGSE}_{z,98-00}$ is constructed using HMDA data. First, I measure mortgage originations as all home purchase mortgages originated by one institution and sold to another institution within a reporting year. Then, following Mian et al. (2009), I compute the number of mortgages sold to non-GSE institutions. These institutions include: those purchasing explicitly for use in private securitization; commercial banks, savings banks, or savings associations; life insurance companies, credit unions, mortgage banks, or finance companies; purchases by affiliate institutions of the originator; and other types of purchaser.[24] I construct non-GSE shares for the period 1998 to 2000 to ensure that local exposures to mortgage credit supply shocks are uncorrelated with contemporaneous developments in housing markets during the housing bust. The 1998 to 2000 period is convenient since it occurs prior to the increase in non-GSE activity in the mid-2000s, but is not so early that it fails to predict subsequent developments in mortgage markets.

The left panel of Figure 2 plots the distribution of non-GSE shares across US zip codes. There is significant cross-sectional variation, with a mean share of 0.33 and a standard deviation of 0.11. The right panel of Figure 2 plots the national growth rates of total mortgage originations, mortgages sold to non-GSE institutions, and mortgages sold to the GSEs (i.e. Fannie Mae and Freddie Mac). Non-GSE mortgage purchase activity was significantly more volatile than overall mortgage origination growth during the boom and bust. To understand the significance of the cross-sectional heterogeneity in mortgage credit supply shock exposure, note that from 2006 to 2007 mortgage origination in zip codes at the 10^{th} and 90^{th} percentiles of the non-GSE share distribution would have contracted by 13 and 32 percent, respectively, if local originations had followed the national decline in non-GSE mortgage activity.

3.3.2. Instruments for Housing invesment activity. Second, interactions between mortgage credit and changes in housing investor shares are predicted by the interactions between the mortgage credit instrument and lags of the changes in housing investor shares. The instruments are denoted by, respectively, $\lambda^{nonGSE}_{z,98-00} \times \Delta Corporate\ Investor\ Share_{z,t-1}$ and $\lambda^{nonGSE}_{z,98-00} \times \Delta Household\ Investor\ Share_{z,t-1}$. The use of lagged changes in investor shares

[23]Drechsler et al. (2019) show that the market share of mortgages sold into private label securitization – those mortgages bought by non-GSEs and packaged into mortgage backed securities – began to slowly increase after 2012.

[24]See Appendix A for more details about the HMDA data. I also consider variations on this instrument in robustness exercises reported in Section 3.5.

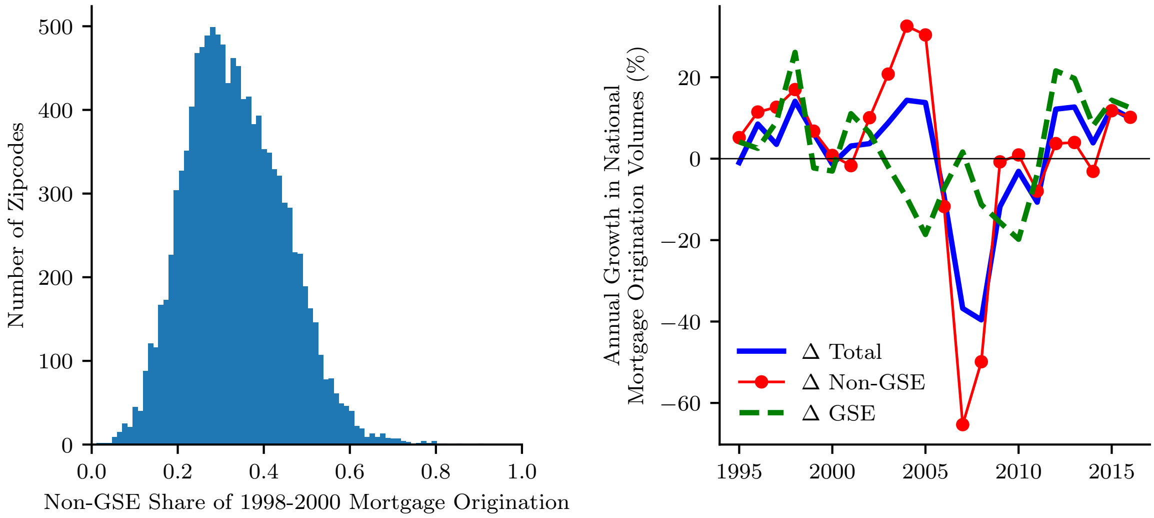

FIGURE 2

Local Mortgage Origination Shares and National Mortgage Origination Volumes

Notes: Total mortgage origination growth includes mortgages that were originated but not sold to the secondary market within a given year.
Source: Author's calculations using HMDA.

as instruments for investor activity is valid if they are uncorrelated with all other omitted contemporaneous determinants of house prices, conditional on controls. To alleviate concerns about endogeneity, in Section 3.5 I consider robustness tests that control for a range of possible confounding factors. I find that the estimated effects of housing investment activity on house prices is largely unaffected by controls for differences in: the size of the housing boom preceding the housing bust; local housing supply; the structure of the local banking market; household demographics; and the composition of local housing stocks.

Two recent papers in the literature have made progress in developing alternative instruments for housing investment activity. Garcia (2019) uses the local fraction of vacation properties as an instrument for household investment activity during the housing boom. Unfortunately, this instrument is less useful for studying the effects of investment by corporations or households that are landlords.[25] Lambie-Hanson et al. (2019) use variation in exposure to a program instituted by Fannie Mae and Freddie Mac giving preference to homeowners over investors seeking to buy foreclosed properties as an instrument for corporate investment activity. This instrument also has drawbacks in the current context. Because the policy change predicts a shift towards homeowner purchases, it does not separately identify the effects of corporate and household investment.

[25] Household investment during the housing bust appears to have risen on the back of landlord purchase activity: Figure B.6 in Appendix B shows that between 2008 and 2011 the fraction of household landlords rose from 5.9 to 7.3 percent.

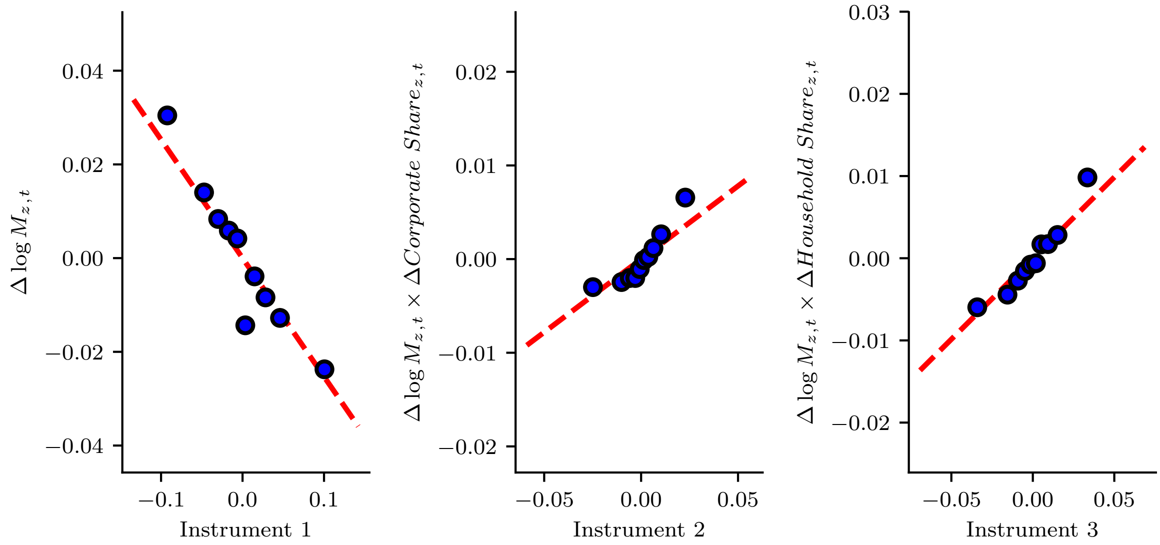

FIGURE 3

Effect of Mortgage Credit Instrument on Local Mortgage Origination Growth

Notes: Bin scatter plots of residualized explanatory variables and instruments, each representing a first stage regression in the 2SLS procedure. The residualized variables are reproduced from the fitted values from estimates of Equation (1). Each explanatory variable is plotted against the instrument that predicts it. These instruments are: instrument 1 = $\lambda^{nonGSE}_{z,98-00}$; instrument 2 = $\lambda^{nonGSE}_{z,98-00} \times \Delta CorporateShare_{z,t-1}$; instrument 3 = $\lambda^{nonGSE}_{z,98-00} \times \Delta HouseholdShare_{z,t-1}$. The slopes of the red dashed lines report the first stage regression coefficients on the respective instruments.

Sources: Author's calculations using data from BLS, CBP, 2000 Census, FRED, HMDA, Zillow, ZTRAX.

3.3.3. Instrument Relevance. The results of the first stage regressions using the above instruments are reported in Table C.1 in the Appendix, and illustrated in Figure 3. Each panel of Figure 3 shows binned scatter plots of the instrument relevant to each explanatory variable, where all variables are residualized relative to the other controls in the regression. The dashed red line shows estimated first stage relationship between instrument and explanatory variable (aksi see Table C.1). The instruments strongly predict changes in mortgage originations and its interactions with the corporate and household investor shares of house purchases.

3.4. *Results*

Table 2 reports the results of estimating Equation (1). All model specifications are estimated via 2SLS, using the instruments described in Section 3.3. Column (1) reports the average effect of changes in mortgage credit on local house price growth. Columns (2) through (4) estimate the effects of corporate and household investment activity conditional on changes in mortgage credit.

[INSERT TABLE (2) HERE]

I estimate an elasticity of house prices to mortgage credit in the range of 0.26 to 0.29. This suggests that a one standard deviation decrease in mortgage credit is associated with a 7.45 to 8.52 percent decline in house prices. These estimates are consistent with those previously reported in the literature using other instrumental variables methods. Favara et al. (2015) use changes in banking regulation as an instrument for changes in mortgage originations and estimate an elasticity of 0.14. Mian et al. (2018) use local exposures to financial institutions with a high proportion of non-core liabilities as a measure of exposure to mortgage credit growth. Using zip code-level data from 2006 to 2010, they find that a one standard deviation increase in exposure to high non-core liabilities lenders is associated with a 5 to 8 percent decline in house prices during this period.

Next consider the effect of housing investment activity on house prices conditional on changes in mortgage credit. Columns (2) and (3) of Table 2 include the interaction terms separately, and Column (4) jointly estimates the effects. As predicted, the coefficients on the investment interaction terms are negative, with the coefficient on corporate investment significantly more negative than the coefficient on household investment. The latter is confirmed in the final rows of Column (5), which reports a rejection of the Wald test null hypothesis of equality between the coefficients.

To interpret the coefficients, note that a simultaneous decrease in mortgage credit and increase in investor purchases is associated with an increase in house prices. This increase in prices is relative to the decrease in prices that would have occurred under the effect of tightening mortgage credit alone. A mortgage credit shock decreases housing demand, but as investment activity substitutes for this decline in demand, the share of houses purchased by investors rises. Overall, house prices decline, but by less than they would have if investors had not supplanted the fall in homeowner purchases.

To interpret the magnitude of the coefficients taking both the baseline and interaction effects into account, consider a simultaneous standard deviation decrease in mortgage credit and standard deviation increase in the share of house purchases made by investors. From the estimates in Columns (2) and (4), an increase in corporate investment activity is associated with a 4.73 to 5.24 percent decline in house prices. Relative to the independent effect of mortgage credit, corporate investment activity dampens the decline in house prices by 37 to 39 percent. From Columns (3) and (4), an increase in household investment activity is associated with a 7.44 to 7.45 percent decline in house prices. Relative to the baseline effect of a decline in mortgage credit, household investment activity reduces the decline in house prices by 2 to 13 percent. These estimates suggest that corporate investors have a much larger influence on house prices than do household investors. Given the same change in mortgage credit and investor house purchase shares, corporate investment is associated with a 30 to 36 percent smaller decline in house prices than is household investment.

In general, the results suggest that housing investors have a stabilizing effect on house prices following a mortgage credit shock. However, the results are also consistent with the view that corporate investors are much more elastic than household investors. In response to shocks, corporate investors are better able to absorb the available houses for sale, thereby substituting for the fall in homeowner demand, and dampening the decline in house prices. This contrasts with housing markets in which relatively inelastic household investors purchase a much smaller share of the houses available for sale, and prices fall by much more. In Section 4 I build a structural macroeconomic model to study these differences in investment behavior in more detail.

3.5. *Robustness*

3.5.1. Alternative Mortgage Credit Instruments. To construct the instrument for mortgage origination growth, I follow Mian et al. (2009) in computing the share of non-GSE institution activity in the secondary mortgage market. Mian et al. (2009) note that non-GSE activity is a proxy for mortgages that are sold into Private Label Securities (PLS), and the use of these mortgage-backed assets was strongly associated with the mortgage credit boom and bust (Justiniano et al., 2017). However, it is not the case that every non-GSE institution that purchased mortgages in the secondary market packaged them for use in PLS. For example, Figure B.5 in the Appendix shows that the HMDA-reported volume of mortgages originated for sale directly to PLS is less than a quarter of the volume sold to non-GSE institutions more broadly.[26]

To account for the possibility that non-GSE activity misrepresents movements in PLS, and thus is less related to 2000s mortgage credit supply shocks, Table C.2 reports results using alternative definitions of the mortgage credit instrument. Columns (1) and (4) report the benchmark results from Table 2; Columns (2) and (5) report results using the share of mortgages sold directly to PLS; and Columns (3) and (6) report results using the share of mortgages sold to PLS as well as non-banks.[27] The mortgage credit instrument constructed using only PLS activity is much weaker than either of the other instruments. This does not affect the primary finding regarding the effects of investment activity: corporate investor activity continues to be associated with much smaller house price declines in response to credit shocks than is household investor activity.

Table C.5 in the Appendix reports results using growth in the number of mortgage denials as the measure of mortgage credit, rather than growth in the number of mortgage originations. Again, the results of this exercise are quantitatively similar to those presented in the benchmark analysis.

3.5.2. Additional Controls. Table C.3 in the Appendix explores whether the results are sensitive to the inclusion of controls for other plausibly confounding factors. Column (2) con-

[26] It is worth noting, however, that the level of direct-to-PLS sales in HMDA appears to be significantly underreported relative to more direct measures of PLS activity reported elsewhere. See, for example, Justiniano et al. (2017).

[27] Non-banks are unlikely to hold individual mortgages for the purpose of balance sheet management, and so are more likely to have purchased mortgages for the purpose of securitization. See Appendix A for details about the definition of non-banks in HMDA data.

trols for the size of the run-up in house prices between 2001 and 2006. Column (3) controls for several measures of housing supply, including: county-level annual growth in the number of housing units permitted; the Saiz (2010) housing supply elasticity at the CBSA level interacted with year-dummies; and the fraction of houses built prior to 1990 and the fraction of houses with four or fewer rooms, both measured at the zip code level and interacted with year-dummies.[28] Column (4) includes controls for the structure of the local banking market in 2000, including: the fraction of deposits held by banks that have a within-state headquarters; the Herfindahl index for deposits held across branches; and the Herfindahl index for deposits held across institutions.[29] Finally, Column (5) includes controls for local demographic factors in 2000 including: median age; fraction of households with no more than high school education; and the fraction of owner-occupiers.[30]

Table C.3 shows little change in the estimates when conditioning on prior house price rises, local housing supply, and local banking competition. However, the inclusion of the demographic controls has some impact on the estimated coefficients. Although the changes are not statistically significantly different from the benchmark results, I find that the direct effect of mortgage credit is smaller, and the coefficients on the measures of investor activity are larger. Nevertheless, it is still the case that corporate investor activity is associated with smaller declines in house prices than household investor activity in response to credit shocks.

3.5.3. Alternative Samples. Table C.4 in the Appendix reports results using alternative data samples. Column (2) extends the sample period back to 2006 and through to 2012, which allows for housing markets with earlier or later turning points in house prices.[31] Column (3) increases the minimum number of house sales in a zip code in a year from 100 to 250. This restriction excludes smaller zip codes and those that had few house sales during the housing bust. Column (4) excludes the so-called Sand States, whose housing markets tended to have much larger fluctuations in house prices in the 2000s. I find little qualitative difference in results across these samples, although I find significantly more dampening of house prices associated with corporate investors in the large-zip codes sample. This is consistent with evidence presented in Mills et al. (2019) that large institutional investors were more active in large metropolitan areas during this period.

[28]Graham et al. (2020) show that the local composition of house characteristics is a strong predictor of local house price growth during the 2000s housing boom and bust.

[29]The structure of the local banking market may affect mortgage credit supply, as discussed in Drechsler et al. (2019) and Favara et al. (2015).

[30]Demographics may predict mortgage credit supply, as discussed in Albanesi et al. (2017).

[31]Ferreira et al., 2011 estimate the turning points in local house prices during the boom and find that these start dates begin anywhere between the late 1990s and early 2006.

4. Model

I build a macroeconomic model of the housing market in order to rationalize the main empirical findings of the paper. The model features heterogeneous, life-cycle households that make endogenous rental, homeownership, and housing investment decisions. Both homeowners and investors have access to long-term mortgages. In addition, a corporate housing investment firm buys and sells properties, which it also leases to renters. I use the model to study the housing market response to an exogenous mortgage credit contraction. Following the shock, the behavior of owner-occupiers, household investors, and corporate investors determines equilibrium house prices.

4.1. *Environment*

4.1.1. Life-cycle. Households live for a finite number of periods with age indexed by $j \in [1, \cdots, J]$. Households earn labor income during working life, retire after age J_{ret}, and die with certainty at age J.

4.1.2. Preferences. Household preferences are defined over non-durable consumption c, housing services s, and end-of-life bequests of wealth w. Lifetime utility is given by

$$\mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1} u(c_j, s_j) + \beta^J v(w_{J+1})\right]. \tag{2}$$

Period utility is given by

$$u(c, s) = \frac{(c^{\chi} s^{1-\chi})^{1-\sigma}}{1-\sigma}, \tag{3}$$

where χ is the share of consumption in non-housing services. Housing services are chosen each period by renting households, and are adjusted infrequently by home-owning households. The bequests function $v(\cdot)$ is defined over networth remaining at the end of life w_{J+1}. The function describes a warm-glow bequest motive given by:

$$v(w) = \psi \frac{(w + \underline{w})^{1-\sigma}}{1-\sigma},$$

where w is the amount of the bequest, ψ is the strength of the bequest motive, and $\underline{w}$ governs the luxuriousness of bequests.[32]

4.1.3. Endowments. Households receive labor income while working, and a pension during retirement. Labor income consists of a deterministic component, a persistent stochastic component, and a transitory stochastic component. In retirement households receive a fixed

[32]The warm-glow bequest motive is discussed in De Nardi (2004). Kaplan et al. (Forthcoming) and Favilukis et al. (2017a) use warm-glow bequests to capture the observed size of and dispersion in household wealth holdings.

fraction of the deterministic and persistent components of income they received in the final period of working life. Log-income is given by:

$$\log m_j = \begin{cases} g_j + y_j + z_j, & \text{for } j \leq J_{ret} \\ \log \omega + g_{J_{ret}} + y_{J_{ret}}, & \text{for } j > J_{ret}. \end{cases}$$

During working life, g_j follows a deterministic age profile, y_j follows an AR(1) process, and z_j is an IID shock. The replacement rate of income during retirement is ω. This arrangement proxies for dispersal from retirement accounts accumulated during working life. Conditioning on the final period of deterministic and persistent income is a tractable way of modeling the relationship between the size of retirement accounts and recent working-life income.

4.1.4. Liquid Assets. Households can save, but may not borrow, in a liquid asset a. The return on liquid assets is fixed at r. In the initial period of life households may receive bequests in the form of liquid assets.

4.1.5. Housing. Housing services are acquired by renting or owning property. In addition, households may purchase property for the purposes of investment. For tractability I assume that households must own a primary property before purchasing an investment property.[33]

Rental services s are a continuous choice each period, subject to the restriction that $s \leq \bar{s}$, and where P_r is the price paid per rental unit. Both owner-occupied and investment properties are chosen from a finite set of available properties $\mathcal{H}$. Houses are purchased at the per-unit price P_h. All property sales are subject to a transaction cost f_s proportional to the total value of property sold. Households pay for routine maintenance to avoid housing depreciation at rate δ. The cost of depreciation is proportional to the market value of all properties.

Investment properties generate rental income at the rental rate P_r. Household investors pay a per-period cost ϕ proportional to the size of the investment property. This cost represents additional maintenance and management costs associated with renting property to non-owner occupying tenants.

Note that in the steady state equilibrium house prices and rents are constant. However, in response to shocks prices adjust along the transition path. As a result, properties may earn capital gains for both homeowners and household investors.

4.1.6. Mortgages. Households can finance property using mortgage debt. In order to economize on state variables, a single mortgage is secured against the combined value of owner-occupied and investment properties. Mortgages are long-term debt contracts. During the mortgage term, a fixed payment is required in every period unless the mortgage is refinanced or properties are sold and the mortgage is repaid. For tractability, mortgages are amortized over

[33] In the Survey of Consumer Finances, around 13% of household with residential investment property report not owning a primary property.

the remaining life of a household. In this way, mortgage duration approximates the 30-year mortgage contracts common in the US housing market.

Let b denote an outstanding mortgage balance and r_b the mortgage interest rate. An age j household has $J - j$ years remaining on the mortgage, which yields the following mortgage payment in the current period:[34]

$$\pi_j(b, r_b) = \frac{r_b(1 + r_b)^{J+1-j}}{(1 + r_b)^{J+1-j} - 1} b.$$

The end-of-period mortgage balance reflects accumulated interest during the period less the mortgage payment: $b' = (1 + r_b)b - \pi(b, r_b)$. The mortgage interest rate is larger than the risk-free interest rate, $r_b > r$, reflecting un-modeled term premia and default risk. Households can repay a mortgage more quickly than the schedule given by the constant amortization formula, however this requires refinancing which is costly.

At origination, mortgages are subject to a maximum loan-to-value (LTV) ratio constraint, given by

$$b \leq \theta_b P_h(h' + i'),$$

where θ_b is the maximum LTV ratio, and $P_h(h' + i')$ is the combined value of owner-occupied and investment property. Following Greenwald (2018), new mortgages are also subject to a payment-to-income (PTI) constraint. Since investors earn rental income from their investment properties, the PTI constraint includes both labor income and gross rental income:

$$\pi_j(b, r_b) \leq \theta_m \left(m_j + P_r i'\right).$$

where θ_m is the maximum PTI ratio.

New mortgages require the payment of both fixed and proportional costs at origination. The fixed cost, F_b, is paid regardless of the size of mortgage, while the cost f_b is proportional to the amount borrowed. The proportional cost reflects the discount points levied on new mortgages, while the fixed cost reflects other origination fees associated with new mortgages.

4.1.7. Household Decision Problems. Households enter a period with the state vector $\mathrm{s} = \{a, h, i, b, y\}$, where a is liquid assets, h is the owner-occupied house size, i is the investment property size, b is the outstanding mortgage balance, and y is the persistent component of labor income. A household chooses between renting (R), maintaining its housing portfolio while making any required mortgage payments (N), and adjusting its housing portfolio and mortgage debt (A). The discrete choice of a household at age j with state s is

$$V_j(\mathrm{s}) = \max\left\{V_j^R(\mathrm{s}), V_j^N(\mathrm{s}), V_j^A(\mathrm{s})\right\},$$

[34]The exponent $J + 1 - j$ ensures that households have repaid the entirety of the mortgage by the final period of life J, and that networth is always non-negative at the end of life.

where V_j^R is the value function of a renter, V_j^N is the value function of an owner that does not adjust, and V_j^A is the value function of an owner that adjusts its property portfolio.

A renting household purchases housing services, consumes non-durable goods, and saves in liquid assets. Any previously held property is sold and outstanding mortgages are repaid with the proceeds. At the end of the period, renters carry forward no housing assets or mortgage debt. The renter's problem at age j is

$$\begin{aligned} V_j^R(\mathbf{s}) = \max_{c,a',s} \quad & u(c,s) + \beta \mathbb{E}\left(V_{j+1}(\mathbf{s}')\right) \\ \text{s.t.} \quad & c + a' + P_r s + b(1+r_b) = m_j + (1+r)a + (1-f_s)P_h(h+i) \\ & a' \geq 0,\ h' = 0,\ i' = 0,\ b' = 0 \end{aligned} \tag{4}$$

A non-adjusting household consumes non-durable goods, enjoys the housing services generated by the existing house, saves in liquid assets, pays housing maintenance costs, makes a mortgage payment, and receives rental income if it holds investment property. The problem of a non-adjusting household at age j is

$$\begin{aligned} V_j^N(\mathbf{s}) = \max_{c,a'} \quad & u(c,h) + \beta \mathbb{E}\left(V_{j+1}(\mathbf{s}')\right) \\ \text{s.t.} \quad & c + a' + \delta P_h(h+i) + \pi_j(b,r_b) = m_j + (1+r)a + (P_r - \phi)i \\ & b' = b(1+r_b) - \pi_j(b,r_b) \\ & a' \geq 0,\ h' = h,\ i' = i \end{aligned} \tag{5}$$

An adjusting household may consume non-durable goods and housing services, purchase new properties, sell previously held properties, repay outstanding mortgage balances, originate a new mortgage, save in liquid assets, pay maintenance costs, and receive rental income on investment property. The problem of an adjusting household at age j is

$$\begin{aligned} V_j^A(\mathbf{s}) = & \max_{c,a',h',i',b'} u(c,h') + \beta \mathbb{E}\left(V_{j+1}(\mathbf{s}')\right) \\ \text{s.t.} \quad & c + a' + \mathbb{1}_{h' \neq h} P_h(h' - (1-f_s)h) + \mathbb{1}_{i' \neq i} P_h(i' - (1-f_s)i) \\ & + \delta P_h(h'+i') + b(1+r_b) = m_j + (1+r)a + (1-f_b)b' - \mathbb{1}_{b'>0}F_b + (P_r - \phi)i' \\ & b' \leq \theta P_h(h'+i') \\ & \pi(b,r_b) \leq \theta_y\left(m_j + P_r i'\right) \\ & a' \geq 0 \end{aligned} \tag{6}$$

Note that an adjusting household can refinance its mortgage by not adjusting its housing and investment properties: $h' = h$, $i' = i$.

4.1.8. Corporate Rental Firm. An unconstrained risk-neutral corporate investment firm is held by owners outside of the local economy and who have access to the risk-free liquid asset. The firm trades and rents property each period, pays regular maintenance costs, and pays a convex portfolio holding cost associated with the number of houses held. The firm maximizes the present discounted value of profits via:

$$\Pi(I) = \max_{I'} \quad P_r I' + P_h I - (1+\delta)P_h I' - P_h Q(I') + \frac{1}{R}\mathbb{E}\left[\Pi(I')\right]$$
$$\text{s.t.} \qquad Q(I') = \kappa^{-(1+1/\varepsilon)} \frac{I'^{1+1/\varepsilon}}{(1+1/\varepsilon)}$$

where $Q(\cdot)$ is the convex holding cost function. The first order condition yields

$$I' = \kappa^{1+\varepsilon} \left(\frac{P_r + \frac{1}{R}\mathbb{E}\left[P_h'\right] - (1+\delta)P_h}{P_h} \right)^{\varepsilon} \tag{7}$$

which is the corporate firm's investment demand curve. The demand curve is a function of the return to housing before holding costs, so increases in returns due to rising rents or temporarily declining house prices induce greater corporate housing investment. The parameter ε represents the elasticity of corporate investment demand. When $\varepsilon = \infty$, demand is perfectly elastic and the rental rate is pinned down by $P_r = (1+\delta+1/\kappa)P_h - \frac{1}{R}\mathbb{E}\left[P_h'\right]$. When $\varepsilon = 0$, corporate investment demand is perfectly inelastic and is given by $I' = \kappa$.

The corporate investment firm presented here is closely related to models of corporate rental investment described in the literature. For example, in Kaplan et al. (Forthcoming) the corporate firm buys and sells properties that it leases in the rental market. However, the firm faces a linear cost structure so that the first order condition generates the standard Jorgensonian user-cost formula for the rental rate. This case is nested by the current formulation, as can be seen when $\varepsilon = \infty$.

4.1.9. Equilibrium. The solution of the model consists of general equilibrium in both housing and rental markets. In the housing market, the price P_h is such that net housing demand from homeowners, household investors, and corporate investors is satisfied by a constant housing supply $\bar{H}$. In the rental market, the rental rate P_r is such that household rental demand is satisfied by the rental properties provided by household and corporate investors. Appendix D contains a definition of the recursive competitive equilibrium. Appendix D provides details of the algorithm for computing equilibrium.

4.2. *Steady State Calibration*

I calibrate the model to capture salient features of the US housing market in the mid 2000s, immediately prior to the housing bust. Panel A of Table 3 reports externally calibrated model parameters. The model period is one year, households work for 41 periods (age 25 to 65) and die after 56 periods (age 80). The risk aversion parameter is set to 2, as is standard in the macroeconomics literature. The income process consists of the parameters for the deterministic age-profile, the persistent AR(1) component, and the transitory IID component of income. I follow a standard procedure for estimating the parameters of the deterministic and stochastic income processes using data from the Panel Study of Income Dynamics. The estimated persistence and volatility parameters are consistent with those reported elsewhere.[35] The replacement rate for retirement income is set at 50 percent of final period non-transitory income following Díaz et al. (2008).

[INSERT TABLE (3) HERE]

The risk-free interest rate r is set to 1.5%, which matches the real rate on 10-year Treasury bills reported in FRED from 2003 to 2006. The mortgage interest rate r_b is set to 3.15%, which corresponds to the real rate on 30-year mortgages over the same period. The proportional cost of originating a mortgage, f_b, is set at 0.5% of the size of the mortgage, consistent with the average size of mortgage origination fees and discount points in the mid 2000s. The proportional cost of selling a house, f_s, is set to 6%, in line with various estimates of property sales costs. The required maintenance (depreciation) rate for residential property δ is set to 3% following Harding et al. (2007). For computational tractability, I make the strong simplifying assumption that only one house size (i.e. $\underline{h}$) is available for purchase as either owner-occupied or investment property.[36] I set the the maximum LTV and PTI ratios to 0.9 and 0.4, respectively, consistent with mortgage originations during the boom (Greenwald, 2018).

Bequests received at the beginning of life are calibrated to reproduce the distribution of networth for young households.[37] I use data for households aged 23 to 25 pooled across the SCF samples in 1998, 2001, 2004, and 2007. I split households into five income bins, and within each bin compute the fraction of households with positive networth. For households with positive networth in each bin, I compute quantiles of the networth-to-income distribution. Liquid asset bequests are then allocated to households across the initial income distribution in the model according to the empirical distribution of networth-to-income.[38]

Finally, I set the corporate elasticity of investment demand ε to zero. The elasticity governs the response of corporate investment to changes in housing returns, which only occur outside of the steady state. When $\varepsilon = 0$, I calibrate the corporate holding cost scale parameter κ to match the share of purchases made by corporate investors. As discussed in Section 4.3, a one-to-one mapping between ε and κ allows for experiments that keep the steady state constant when varying the elasticity ε.

I use simulated method of moments (SMM) to calibrate the parameters $\{\beta, \chi, \bar{w}, \psi, \underline{h}, F_b, \phi, \kappa, \bar{H}\}$. Note that I use an over-identified SMM procedure because many of the cross-sectional household statistics used as moments are correlated with each

[35] See, for example, estimates from similar exercises in Floden et al. (2001), Storesletten et al. (2004), Guvenen (2009), and Heathcote et al. (2014). Details of the estimation are reported in Appendix D.

[36] I verified that this assumption does not significantly affect the distribution of property ownership or indebtedness.

[37] This is similar to the procedure adopted elsewhere in the literature, for example, Chambers et al. (2009b) and Kaplan et al. (Forthcoming).

[38] I opt for this relatively simple procedure to avoid the difficulty of distributing observed liquid assets, houses, investment properties, and mortgage debt to households in the model.

other (e.g. wealth, homeownership, and indebtedness). The calibrated parameters are reported in Panel B of Table 3

The discount factor β governs both household wealth accumulation and indebtedness. The weight on non-durable consumption in the utility function χ determines the share of housing services in consumption, which indirectly affects both homeownership rates and indebtedness. The bequest parameters ψ and $\bar{w}$ affect savings behavior and wealth inequality as households approach the end of their lives. The minimum housing size $\underline{h}$ is associated with the affordability of housing relative to renting, which influences the homeownership rate of the young, and the indebtedness of both homeowners and investors conditional on holding a mortgage. The landlord cost ϕ affects returns for household investors and so affects both rates of investment and investor indebtedness. The fixed mortgage origination cost F_b determines the rate of mortgage refinancing. The investment firm cost κ sets the level of corporate housing demand, which determines the share of house purchases made by the corporate sector. Finally, the supply of housing $\bar{H}$ determines the homeownership rate.

[INSERT TABLE (4) HERE]

Table 4 reports the fit between the model and data for the targeted moments and a range of non-targeted moments. For consistency with the definition of networth in the model, networth in the data is owner-occupied and investor property less mortgage debt, plus liquid assets minus liquid liabilities.[39] I measure investment ownership as the fraction of households that own secondary residential property. While 15 percent of households do so, only half as many report receiving rental income in the past year. Although all households with secondary property in the model are landlords, I opt to target the higher rate of secondary property ownership since I cannot distinguish between household motivations for purchasing property in the housing transactions data reported in Section 2. All mortgage holding rates, LTV ratios, debt-to-income ratios, and networth statistics are computed using the combination of primary and secondary property mortgage debt. Data on mortgage refinancing is taken from Bhutta et al. (2016), who report an annual rate of 12 percent for 2007. The corporate and household investor shares of house purchases are computed as the median share across zip codes from 2005 to 2007.

Figures 4 and 5 compare ownership rates and mortgage LTV ratios in the model and data, over the life-cycle and the distribution of wealth.[40] Although these are untargeted moments, they are important for understanding the distribution of exposures to mortgage credit shocks and the propensity to invest in housing. Figure 4 shows that homeownership and investment property ownership rates rise with both age and wealth. While homeownership rises quickly with age as households save for the down-payment on a house, housing investment occurs later

[39] Following Kaplan et al., 2014, liquid assets are defined as: checking, saving, money market and call accounts, plus directly held mutual funds, stocks, corporate bonds and government bonds. Liquid liabilities are: credit card balances.

[40] Additionally, Figures B.7, B.8, and B.9 in Appendix B report household wealth and mortgage holding rates over the life-cycle and wealth distribution.

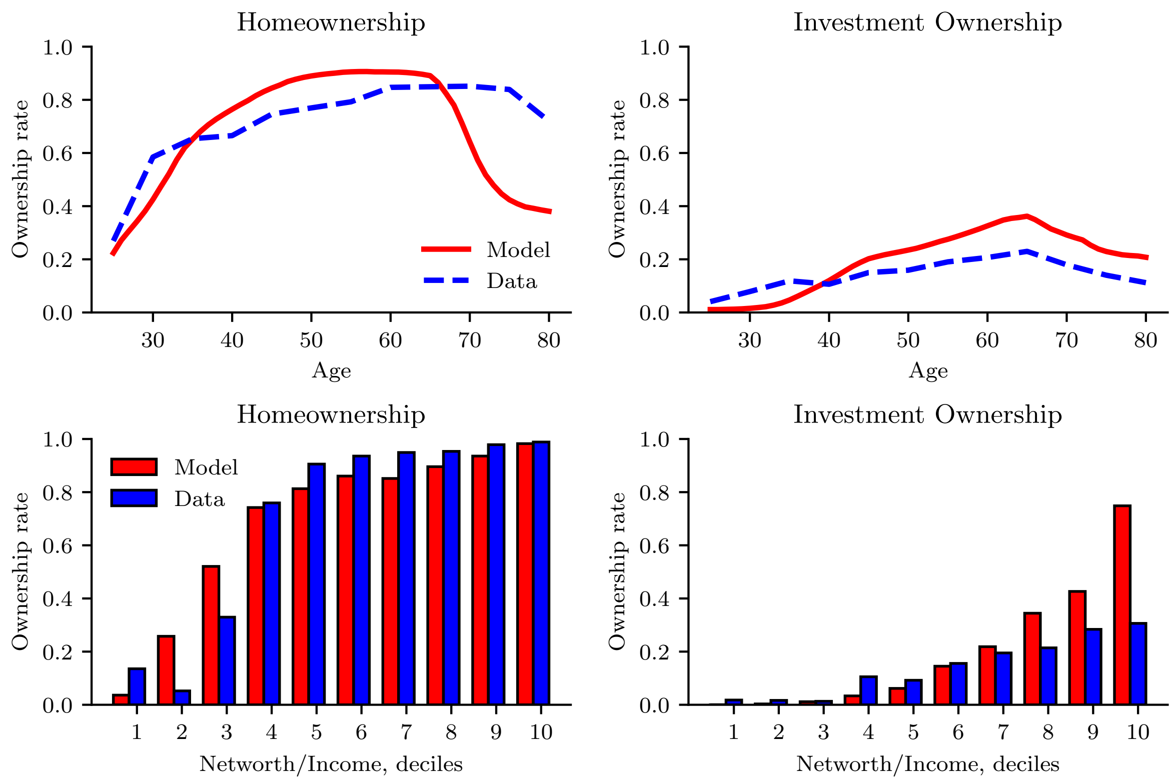

FIGURE 4
Ownership Rates by Age and Wealth

Notes: Data moments computed from the 2007 SCF. Moments by wealth are median values within each decile of the networth-to-income distribution.

in life and among wealthier households. In order to own investment property, households must either commit to large mortgage payments or holding a large fraction of wealth in housing equity. This is less attractive to young and poor households who need to build liquid wealth to insure against income shocks. Older and wealthier households invest as they pay down their primary mortgage debt and begin to accumulate wealth for retirement and bequests. Moreover, the rental income generated by investment properties is valuable to older households whose retirement income is much lower than the labor income they earned during working life. Figure 5 shows that mortgage debt is held by both homeowners and investors, both the young and the old, and both the poor and the wealthy. As households age and become wealthier, they pay down mortgage debt and LTV ratios fall. Note, too, that because investors tend to be both older and wealthier than other homeowners, they hold smaller debt loads on average.

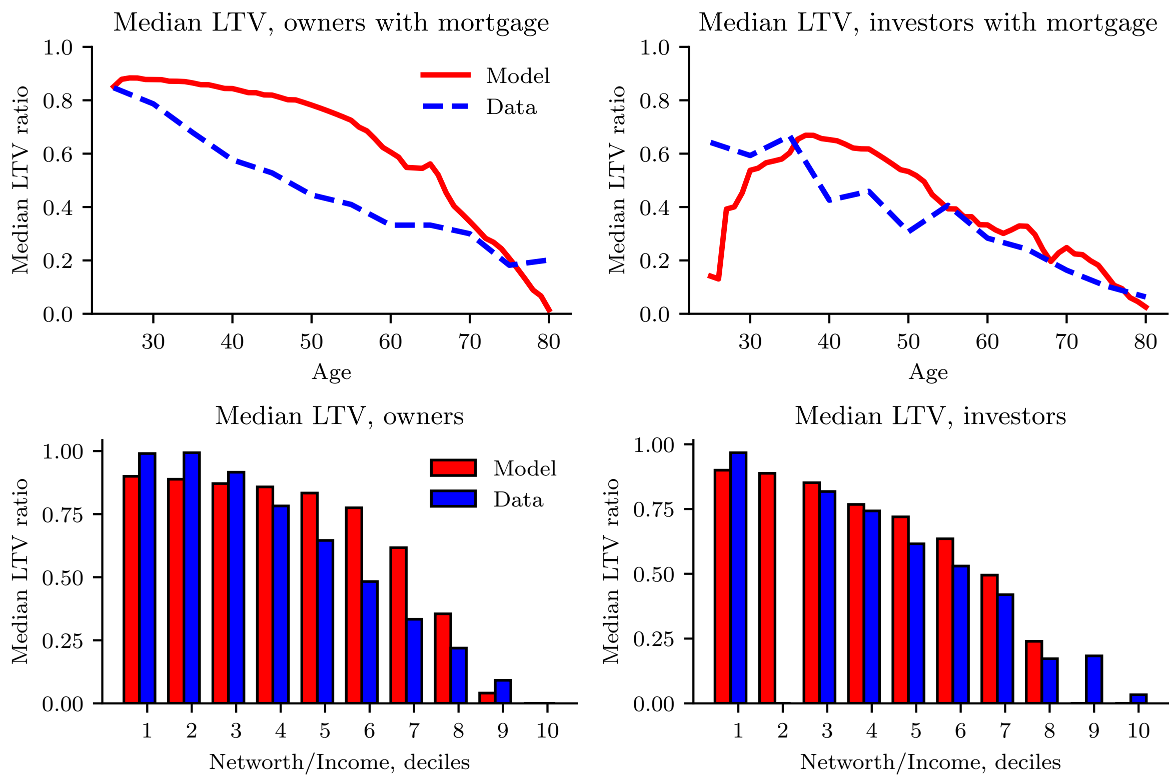

FIGURE 5
Loan to Value Ratios by Age and Wealth

Notes: Data moments computed from the 2007 SCF. For consistency with the model, LTV ratios are computed for homeowners and investors with either primary property or secondary property mortgage debt. Moments by wealth are median values within each decile of the networth-to-income distribution.

4.3. *Response to Mortgage Credit Shocks*

I now use the model to study the role that investors play in stabilizing housing markets during a mortgage credit contraction. To do this, the steady state of the model is perturbed by a transitory, unexpected negative shock to mortgage credit.[41] I then compare equilibrium responses across economies that differ by the composition of investors in the housing market following the shock.

Table 5 summarizes the components of the mortgage credit shock.[42] First, the mortgage interest rate spread, $r_m - r$, rises by one percentage point, consistent with the increase in the 30-year mortgage rate spread over the ten-year treasury rate observed in the data.[43] Second, the mortgage origination cost f_b rises 0.25 percentage points, consistent with the increase in mort-

[41] For similar model experiments see Iacoviello et al. (2013), Hedlund (2016), Guerrieri et al. (2017), Kaplan et al. (Forthcoming), Favilukis et al. (2017a), Greenwald (2018), Garriga et al. (2018), and Garriga et al. (2019).

[42] Appendix D reports the results of separate shocks to the different components of the combined mortgage credit shock discussed here.

[43] Justiniano et al. (2017) estimate that during the boom the mortgage rate spread fell 80 basis points in response to the expansion in mortgage credit supply.

gage origination fees and discount points on 30-year mortgages observed in the data. Finally, the LTV and PTI constraints θ_b and θ_m each decrease by 10 percentage points, consistent with the evidence in Greenwald (2018). The shock lasts seven years, corresponding to the housing bust from 2006 to 2012.

[INSERT TABLE (5) HERE]

To rationalize the results of Section 3, I compare the equilibrium responses across economies with different compositions of investors following the credit shock. That is, I compare equilibria in which corporate or household investors are more active in the housing market following the shock. I do this by varying the elasticity of corporate investment demand ε. When ε is zero, the corporate investor does not respond to changes in house prices or rents. When ε is greater than zero, the corporate investor is sensitive to changes in returns and invests more in response to changes in prices and rents. And when ε is large, the corporate investor is more sensitive to price changes than the household investor, and decreases in homeowner demand are entirely absorbed by increasing corporate investment activity.

To ensure that economies with different investor compositions only vary by the elasticity of corporate investment demand, I exploit a one-to-one mapping between the corporate investor cost parameter κ and the elasticity ε. For a given steady state equilibrium with prices P_h and P_r and corporate investment demand I', Equation (7) yields

$$\kappa(\varepsilon) = (I')^{\frac{1}{1+\varepsilon}} \left(\frac{P_r + \frac{1}{R}P_h - P_h(1+\delta)}{P_h} \right)^{\frac{-\varepsilon}{1+\varepsilon}}. \tag{8}$$

Thus, κ varies with ε so that the steady state of the economy remains unchanged.

From the results in Section 3, I use the estimated house price responses associated with each type of investor to infer appropriate values of the corporate investment demand elasticity ε. In the first economy, I normalize ε to zero. In the second economy, I choose ε so that the decline in house prices on impact is 30 percent smaller than in the economy with $\varepsilon = 0$. This corresponds to the estimated decline in prices for markets facing a one standard deviation increase in the share of corporate purchases relative to markets facing a one standard deviation increase in household investor purchases.[44] To match this relative change in prices, I set $\varepsilon = 24$.

Figure 6 compares impulse responses to the mortgage credit shock across the two economies. The primary result is that housing market outcomes are more volatile in the economy that relies on household investment activity following the shock rather than corporate investment activity. The credit shock raises the cost of mortgage borrowing and tightens borrowing constraints. The primary effect of these changes is to reduce homeowner demand for housing since in the steady state virtually all homeowner purchases are made using a mortgage. As homeowner demand falls, the equilibrium response differs markedly across the two economies. When ε is high, house prices are much more stable than when $\varepsilon = 0$: on impact

[44] See Section 3.4.

prices fall by 28 percent less, and after four years house prices fall by 45 percent less. In addition, as households sell property and shift toward renting, rental rates rise. Like prices, rental rates are more stable when corporate investors are active following the shock rather than household investors.

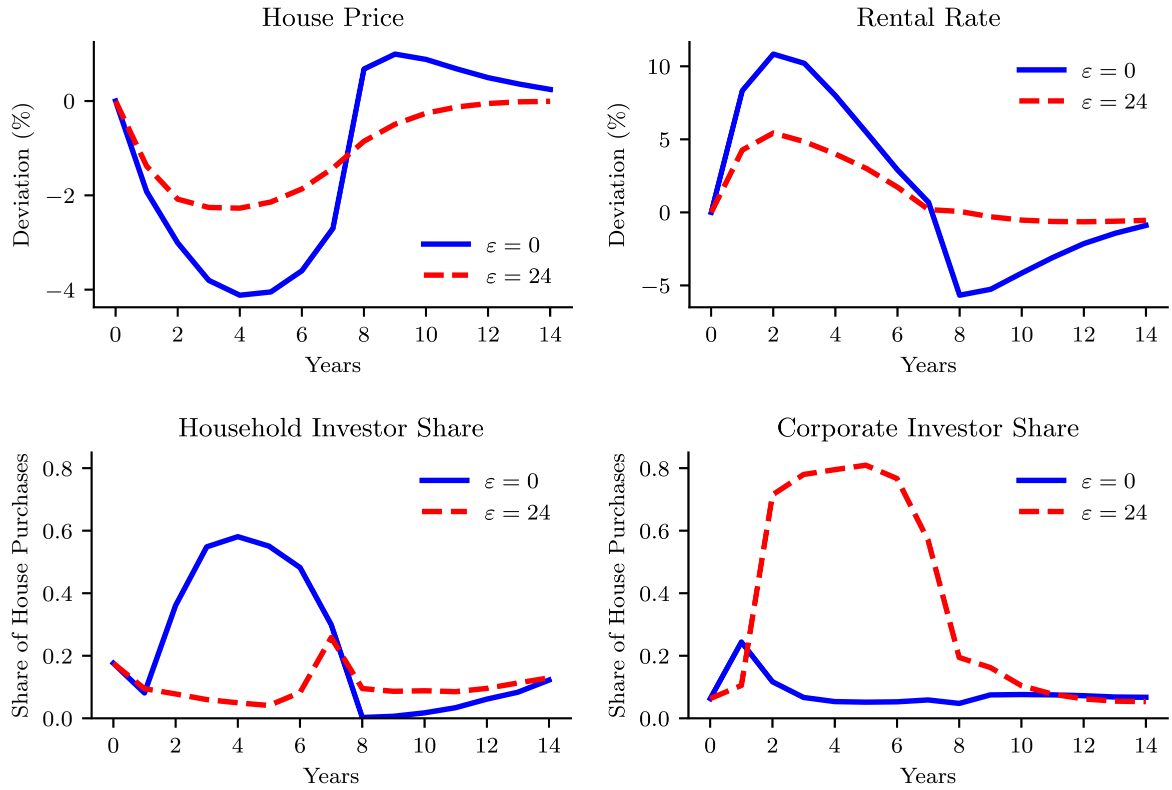

FIGURE 6
Impulse Responses to a Negative Mortgage Credit Supply Shock

Notes: Impulse responses to a negative mortgage credit supply shock lasting seven years. Responses plotted for economies with $\varepsilon = 0$ and 24.

The effect of changing the corporate elasticity can also be seen in the differences in the composition of investors following the shock. When $\varepsilon = 0$, household investors absorb an increasing share of total house purchases, while the corporate purchase share is relatively flat. When ε is high, corporate investors purchase an increasing share of houses, while the household investor share declines. Note, too, that the corporate investor share rises by much more in the latter economy than does the household investor share in the former. Since household investment activity is associated with larger price movements and smaller changes in house purchase shares, the implied elasticity of household investment demand must be much lower than the elasticity of corporate investment demand. I discuss this further in Section 4.4.

Figure 7 shows that the differences in investor composition and house purchase activity are large enough to affect overall property ownership rates. When the corporate investor is active in the housing market, it purchases such a large fraction of the housing stock that the homeown-

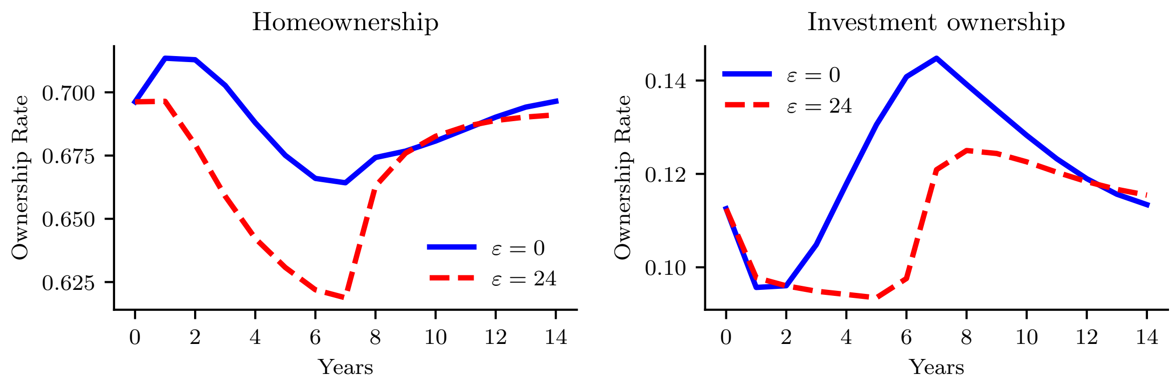

FIGURE 7
Impulse Responses to a Negative Mortgage Credit Supply Shock

Notes: Impulse responses to a negative mortgage credit supply shock lasting seven years. Responses plotted for economies with $\varepsilon = 0$ and 24.

ership rate declines by more than six percentage points, and household investment ownership rates decline more than one percentage point. In contrast, when household investors are active in the housing market, homeownership initially rises but eventually declines by less than two percentage points, while household investment ownership rises by nearly two percentage points over the course of the shock. The larger decline in homeownership rates associated with rising corporate investment activity is consistent with the empirical evidence Lambie-Hanson et al. (2019). They show that housing markets with greater corporate investment activity experienced larger declines in homeownership rates during the housing bust. In the model, this occurs because corporate investment demand is a close substitute for homeowner housing demand, so that corporate investors purchase a large number of the properties that homeowners would have bought in the absence of the mortgage credit shock.

Figure 7 also shows that following the shock, existing household investors sell property due to the rising cost of mortgage financing. As a result, the investment ownership rate initially falls but as house prices continue to decline and the returns on housing rise, new households become investors and investment ownership rises.[45]

The differences in the paths of house prices and rental rates across economies is reflected in the expected rates of return on housing. Figure 8 reports annualized, five-year expected rates of return on housing for a risk-neutral investor who buys in cash.[46] The larger decline in prices and rise in rents in the economy with active household investors is associated with

[45]It is interesting to note that these results resemble the path of the national share of landlords reported in tax data, as shown in Figure B.6 in Appendix B.

[46]Returns are given by:

$$ER_t^{5yr} = \frac{\sum_{k=0}^{T-1} \frac{1}{R^k}(P_{r,t+k} - \phi) + \frac{1}{R^T}\mathbb{E}_t\left[(1-f_s)P_{h,t+T}\right] - P_{h,t} - \sum_{k=0}^{T-1}\frac{1}{R^k}\delta P_{h,t+k}}{P_{h,t}}.$$

Note that returns would differ for investors using mortgage finance to purchase a property.

higher expected returns over the course of the shock. In equilibrium, higher expected returns are necessary to attract additional household investment following the shock since household demand for houses is less elastic than that of corporate investors.

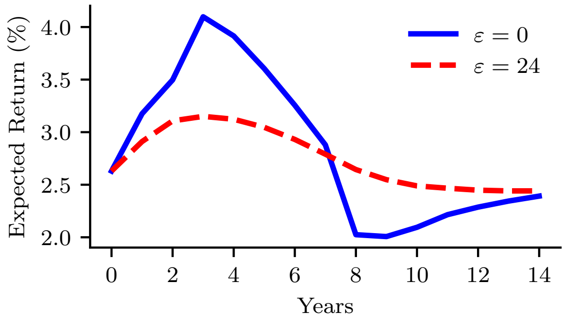

FIGURE 8
Five-Year Expected Housing Return, Annualized

The results presented here contrast with those in Kaplan et al. (Forthcoming), who argue that credit shocks alone have no effect on house prices, but have significant effects on the homeownership rate. This is because the corporate investor in Kaplan et al. (Forthcoming) is equivalent to a corporate investor in the current model where $\varepsilon \to \infty$.[47] As credit shocks cause households to move out of owner-occupied housing and into rental housing, a perfectly elastic corporate investor absorbs the housing stock and rents it to new household tenants. Because the corporate investor is perfectly elastic, ownership of the housing stock changes hands, but prices do not change. Greenwald et al. (2019) try to resolve this lack of price movement in response to credit shocks by introducing segmented housing markets. Market segmentation prevents investors from purchasing owner-occupied property, so to clear housing markets prices must fall enough to induce additional homeowner demand. In the current paper, housing markets are not segmented. However, the characteristics of investors themselves affect the sensitivity of investment demand to housing returns. When investors are relatively inelastic – as are household investors – prices must fall following a credit shock in order to induce additional investment to absorb the decline in homeowner demand.

4.4. *The Determinants of Household Investment*

House prices fall further when household investors, rather than corporate investors, are required to absorb the decline in homeowner demand following a mortgage credit shock. In this section I study why households require such large returns on housing in order to induce additional investment during a housing bust. I consider how household investment activity is influenced by wealth and indebtedness, house prices and rental rates, the illiquidity of housing, and losses on primary property wealth. Each of the following model experiments is conducted relative to the benchmark economy in which $\varepsilon = 0$ and corporate investors are inactive.

[47] See the discussion of the corporate investor in Section 4.1.

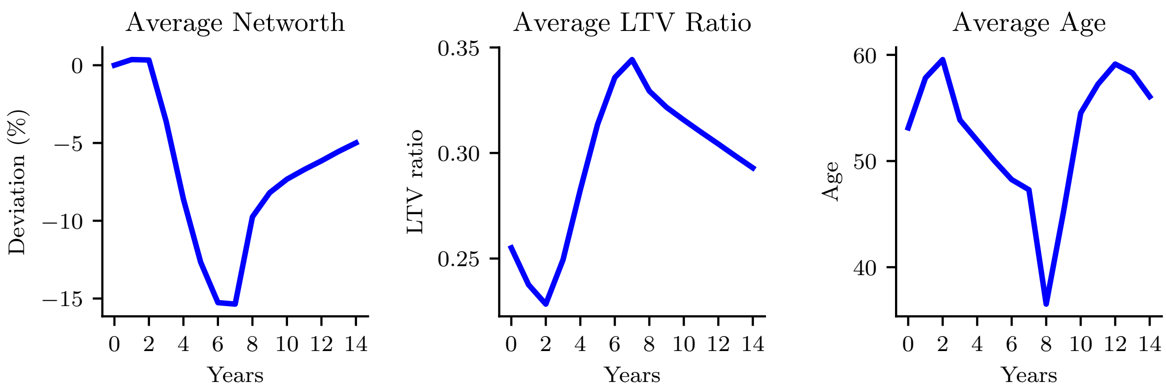

FIGURE 9
Wealth and Indebtedness of the Marginal Household Investor

Figure 9 shows that the characteristics of new housing investors change markedly over the course of the shock. Household investors during this period are younger, less wealthy, and more indebted than are new investors in the steady state. Figure 10 emphasizes these results by showing the change in the balance sheets of new property buyers. By the fifth year of the housing bust, new investors are taking on much significantly more debt than they do in the steady state. This contrasts with home buyers in the bust, who are much less leveraged than home buyers in the steady state.

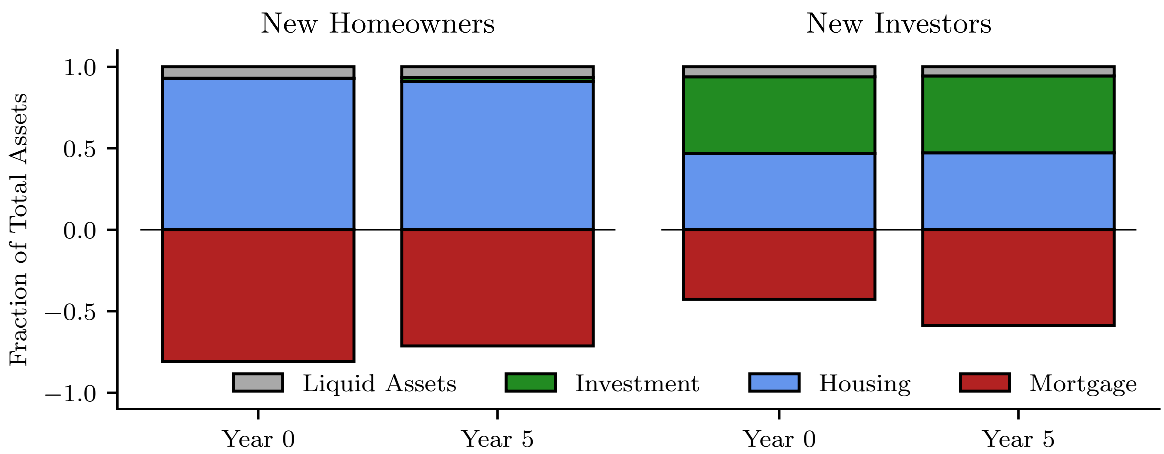

FIGURE 10
Change in Balance Sheets of New Property Buyers from Steady State to Bust

Notes: The figure shows the balance sheet composition of new home and investment property buyers in the steady state and in the fifth year of the mortgage credit shock. Balance sheets are pooled across all home buyers and investment property buyers, respectively.

During the mortgage credit contraction, homeowner demand falls and household investors are required to purchase properties. At the steady state rate of return, all households for which housing investment is an attractive option have already invested. Thus, additional investment during the bust must come from younger, poorer, and more indebted households. But to induce these households to invest, prices must fall to generate large enough returns to compensate for the reallocation of resources towards investment property. These returns must also compensate for the higher cost of financing this investment, since investors in the bust use more mortgage debt when mortgage costs are high.

[INSERT TABLE (6) HERE]

The effect of the mortgage credit shock on household investment itself can be seen by comparing investment behavior in partial and general equilibrium, as reported in Table 6. In partial equilibrium, the shock causes investment activity to fall significantly: investment purchases remain 52 percent below steady state in the fifth year of the shock (first column), and investment ownership rates remain 23 percent below steady state (second column). In general equilibrium, investment purchases and investor ownership rates rise rapidly from the third year of the shock onward. Note, too, that housing investment purchases are much more sensitive to the change in returns than are home purchases. The third column shows that the decline in house prices in general equilibrium has a very muted effect on home purchase activity relative to partial equilibrium. Thus, while the mortgage credit shock discourages both investor and homeowner purchases, it is largely investors who are drawn into housing markets by the increase in housing returns.

Figure 11 shows that the increase in housing returns that induces additional household investment is related to the change in house prices rather than the change in rental rates. Each of the lines represents a different partial equilibrium experiment: the solid blue line holds both house prices and rental rates constant, the dashed red line holds rents constant but allows house prices to follow their general equilibrium path, and the green circled line holds prices constant but allows rents to follow their general equilibrium path. When house prices fall as they do in general equilibrium, both the investment purchase share and ownership rate rise significantly over the course of the shock. In contrast, when only rental rates adjust, investment activity is largely unchanged relative to the partial equilibrium in which no prices adjust. Thus, household investment activity is primarily motivated by the higher expected capital gains generated by the decline in house prices following the mortgage credit shock.

As new household investors enter the housing market during the bust, they must reallocate liquid assets to illiquid investment property. An important source of housing illiquidity is the housing resale cost f_s. Although households can earn capital gains on housing by buying properties during the bust and reselling during the recovery, transaction costs reduce the net return on holding investment property during this period. Therefore, the equilibrium path of house prices following the mortgage credit shock embeds a housing liquidity premium.[48]

[48] Boar et al. (2020) stress the importance of the illiquidity of owner-occupied property for explaining household consumption responses to income shocks. Hedlund (2016) studies endogenous housing liquidity premia in a search and matching model of the housing market.

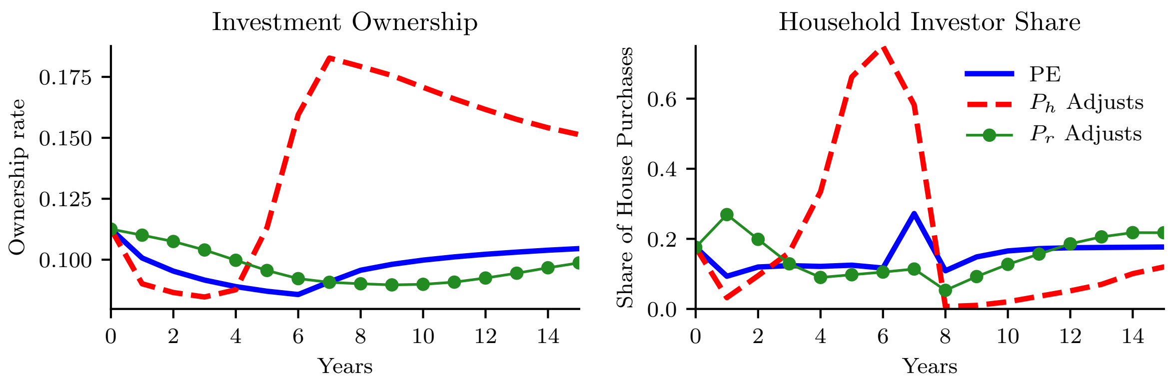

FIGURE 11
Household Investment in Partial Equilibrium

To assess the importance of this liquidity premium, I re-compute impulse responses to the shock while holding $f_s = 0$ for investment properties only. I set $f_s = 0$ for eight years, which enables investors to resell their properties costlessly during the first year of the housing recovery. Figure 12 shows that in comparison to the baseline economy, house prices fall by less, and household investment activity rises by more and more rapidly during the course of the shock. Temporarily lower investment transaction costs encourage household investors to purchase properties during the housing bust, but also to resell properties before costs rise again. This results in a sharp drop in investment ownership rates at the end of the housing bust. However, this is also when homeowner demand for houses rises, so the reallocation of properties from investors to homeowners prevents house prices from overshooting, as occurs in the baseline economy. By the fourth year of the credit shock, house prices fall by one fifth less in the model with lower investment transaction costs. This suggests that the liquidity premium on investment properties accounts for as much as 20 percent of the decline in house prices in the economy with active household investors.

Finally, I study the effect of the changes in household wealth along the transition path on households' willingness to invest in housing. Figure 13 shows the wealth losses experienced by homeowners in the first period following the mortgage credit shock, before further decisions are made. Although house prices decline by only two percent on impact, housing and total wealth decline by much more for less wealthy and more indebted households. For example, homeowners in the highest quintile of the LTV distribution lose more than 15 percent of their housing networth and more than 10 percent of their total networth following the shock. Since homeowners invest in secondary property as their wealth rises, the decreases in primary housing wealth may discourage households from investing even when expected returns are high.

Figure 14 illustrates a partial equilibrium experiment in which the price of investment property follows the equilibrium house price path, but the price of owner-occupied property remains at its steady state value. This means that existing homeowners do not lose wealth along the transition path, but can purchase investment properties at a discount relative to the steady state price

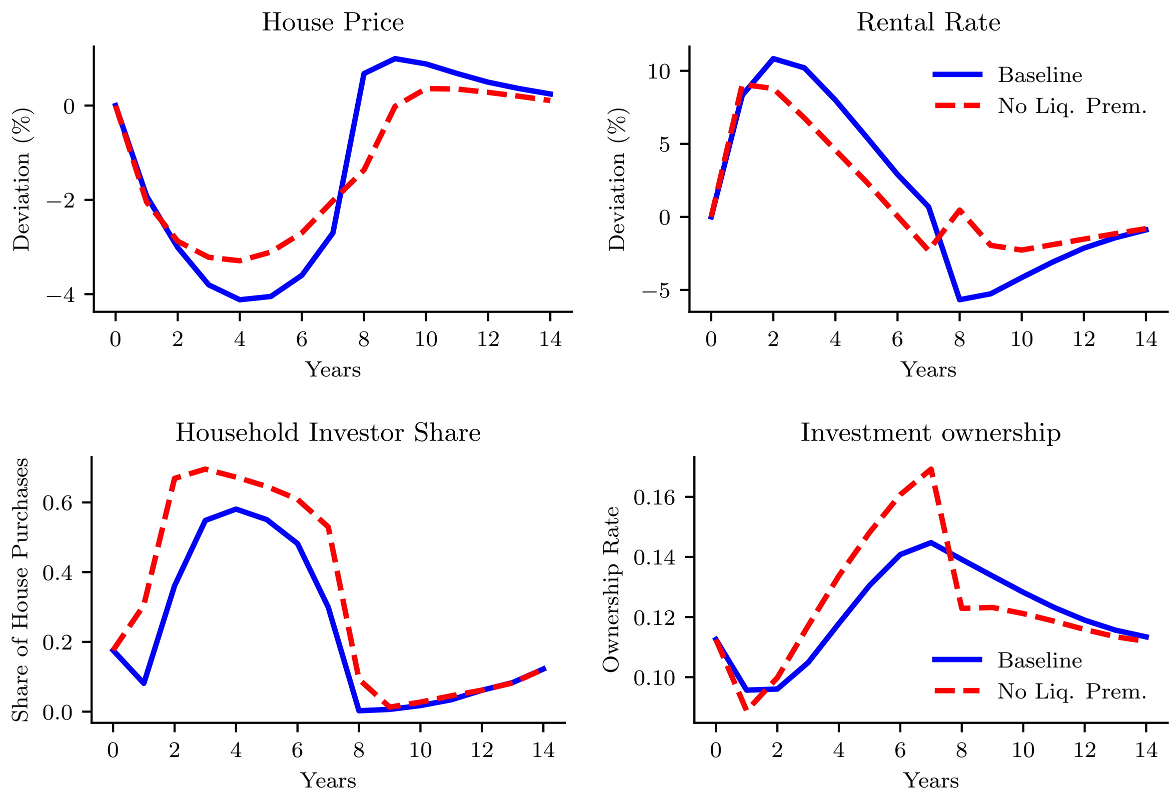

FIGURE 12

Impulse Responses With Lower Investment Property Transaction Costs

Notes: Impulse responses to a negative mortgage credit supply shock lasting seven years. Both sets of responses are for economies with $\varepsilon = 0$. The red dashed lines show responses for an economy in which the property transaction cost for investment properties f_s is set to zero for eight years.

of housing. The impulse responses show that investment ownership initially falls by less and then rises by more over the course of the credit shock. However, the household investor share of house purchases is largely unchanged relative to the baseline. This suggests that while the loss of primary property wealth causes many household investors to disinvest, it does not discourage households from becoming investors. Nevertheless, the experiment shows that net household investment demand decreases when households face losses in wealth due to declining house prices.

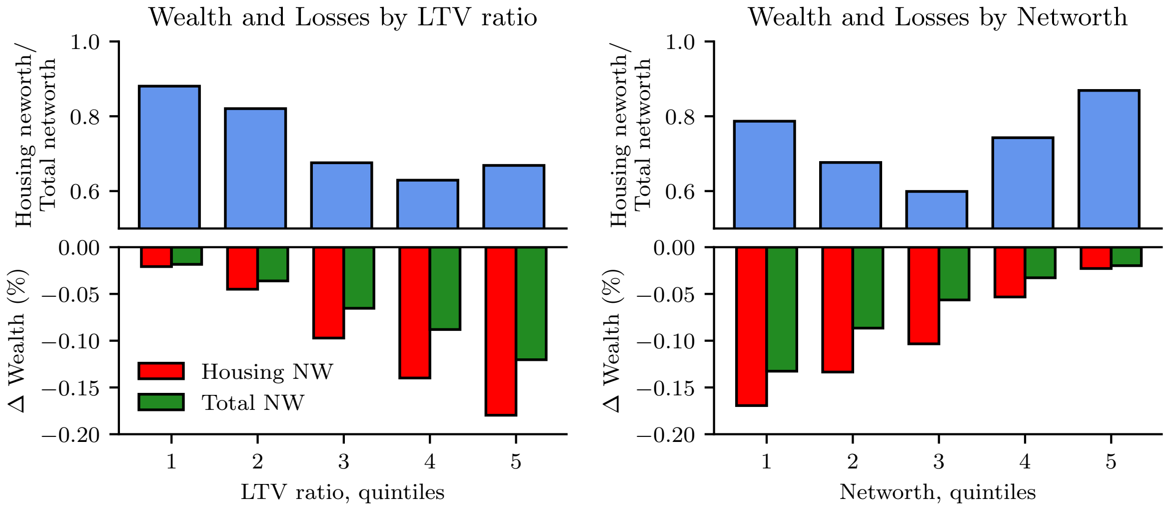

FIGURE 13

Homeowner Wealth Losses Given Initial House Price Decline After Credit Shock

Notes: The upper panels of each figure show the average fraction of networth held in housing networth. The lower panels of each figure show the average percentage decrease in housing and total networth following the decline in house prices in the first period after the mortgage credit shock. The left and right panels report values for quintiles of the distributions of homeowner LTV ratios and networth, respectively.

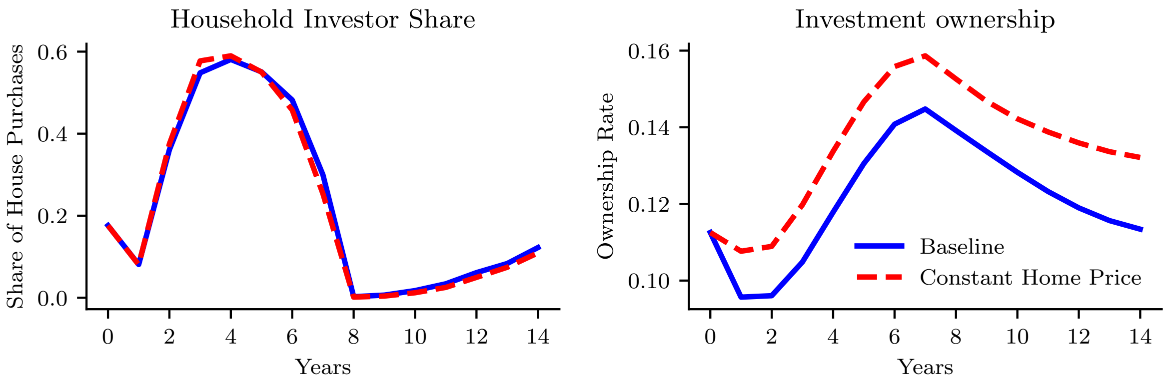

FIGURE 14

Impulse Responses With the Home Prices Held Constant

Notes: Impulse responses to a negative mortgage credit supply shock lasting seven years. Responses for economies with $\varepsilon = 0$. The red dashed lines show responses for an economy in which the price of investment property follows the equilibrium path associated with the baseline economy, but where the price of owner-occupied property is held constant.

4.5. *Housing Investment and Household Welfare*

The previous results show that housing investment plays an important role in stabilizing housing markets during a housing bust. Because corporate investors are much more elastic than household investors, house prices and rental rates are much more stable when corporate investors are more prevalent in the housing market following a mortgage credit shock. However, corporate investment activity is also associated with much larger declines in the homeownership rate. Moreover, the profits earned by corporate investors do not accrue to households since the investment firms are not owned by households within the economy.[49]

[INSERT TABLE (7) HERE]

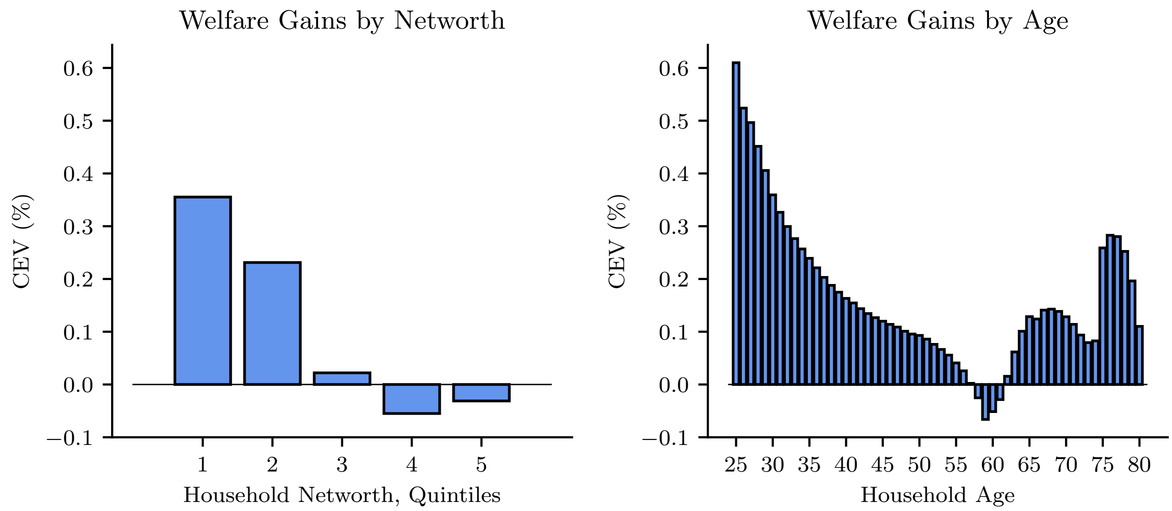

FIGURE 15
Household Welfare by Wealth and Age

Notes: Consumption Equivalent Value (CEV) is the percentage gain in life-time consumption by moving from the economy with $\varepsilon = 0$ to the economy with $\varepsilon = 24$. A positive CEV indicates that households prefer outcomes in the latter economy. Within-group welfare comparisons are for households that would have been in a given quintile of the networth distribution or of a given age in the first period of the shock in the baseline economy with $\varepsilon = 0$.

I now evaluate whether the housing market stability associated with corporate investors is welfare improving for households. Household welfare is measured by the consumption equivalent value (CEV) of moving from the economy in which household investors dominate the housing market following a shock ($\varepsilon = 0$), to the economy in which corporate investors dominate the housing market following a shock ($\varepsilon = 24$). The CEV is computed for all households alive in the first period of the mortgage credit supply shock.[50] Note that in the steady state of the

[49]Table 1 in Section 2 shows that the share of out-of-town corporate investors increased during the housing bust.

[50]Corporate investment firms are held by owners that live outside of the local economy, so that corporate profits do not contribute to household welfare. This is similar to the analysis in Favilukis et al. (2017b), where assessment of city-level housing policy excludes the effects on out-of-town buyers.

model, household welfare is identical in both economies, since the elasticity of the corporate investor only affects household and equilibrium outcomes along the transition path in response to a shock.

Table 7 reports the welfare gains of moving from the economy with active household investors to the economy with active corporate investors. The first column shows that overall households enjoy a 0.17 percent gain in life-time consumption due to the stabilizing effect of corporate housing investment. However, this gain is spread unequally, as only 46 percent of households are better off. The remaining columns show that renters gain significantly from the housing market stability, while owners and investors are somewhat worse off. Renters benefit from the much slower increase in rental rates associated with corporate investment activity. When housing markets are less stable, homeowners experience larger losses of wealth on their homes. However, because the mortgage credit shock is temporary, welfare losses are small for the majority of homeowners that do not expect to sell their house during this period. Household investors prefer the economy with less stable housing markets, since they earn higher rents and pay lower depreciation costs due to lower house prices. Additionally, some homeowners and investors benefit from the more unstable housing market by selling their properties at a profit when house prices overshoot their steady state value after the housing bust (see Figure 6).

Figure 15 shows how the welfare gains are distributed across networth and age. Both poorer and younger households gain the most from housing market stability. This is because younger households are more likely to be renters, and because poorer households spend a larger fraction of available resources on rent. Retired households also gain from housing market stability, as they are likely to sell their houses and return to renting in the near future. Unstable housing markets mean both lower selling prices and higher rents for these households.

5. CONCLUSION

In this paper I studied the role of housing investors in stabilizing housing markets during the Great Housing Bust. I used transaction-level housing data to show that as homeowner demand for housing declined in the late 2000s, both corporate and household investors purchased larger shares of the houses available for purchase. In the formal empirical analysis, I estimated heterogeneous house price responses to exogenous changes in mortgage credit given differences in corporate and household investor activity across housing markets. I showed that increases in both types of investor activity are associated with smaller house price declines following a contraction of mortgage credit. However, corporate investor activity is associated with a 30 percent smaller decline in house prices than is household investor activity. These results suggest that corporate investment activity played a much more effective stabilization role in housing markets than did household investment during the bust.

In the second half of the paper, I presented a structural macroeconomic model of the housing market to rationalize these differences in corporate and household behavior. Following the recent macro-housing literature, the core of the model features heterogeneous, life-cycle households that make endogenous housing and mortgage finance decisions in the face of uninsurable income risk. I build on that literature by introducing roles for both household and corporate investors. The behavior of these investors is motivated by micro-evidence showing that corporate investors are larger, trade houses more frequently, and do not rely on mortgage credit to finance purchases like household investors.

I calibrate the model to match the estimated relative decline in house prices across housing markets with larger increases in corporate versus household investment activity following the shock. In line with the empirical estimates, I show that in response to an exogenous mortgage credit shock, house prices decline by much more when household investors are active in housing markets, rather than corporate investors. Household investment is less responsive than corporate investment in the housing bust. I sow that this is because younger, poorer and more indebted households are required to become investors in the bust. Additionally, household investors are affected by the deterioration in mortgage credit conditions, the illiquidity of housing assets, and changes in wealth due to the decline in the value of primary property.

Following the mortgage credit shock, corporate investment activity is associated with more stable prices and rents, but larger declines in homeownership rates. In a final exercise I show that household welfare is higher when corporate investors contributed to housing market stability, despite the lower equilibrium rates of homeownership. However, the welfare gains associated with corporate investment activity are widely dispersed and largely concentrated among younger and poorer households.

One limitation of the model is that the overall magnitude of equilibrium house price responses to mortgage credit shocks are too small. For example, when household investors are active in the housing market, the model only generates 25 percent of the estimated decline in house prices following a one standard deviation mortgage credit shock. This low volatility of house prices suggests that the elasticity of household investment demand is too high. Several extensions to the model could help to address this problem: the availability of mortgage default could exclude a larger group of households from mortgage-financed investment; property and capital gains taxes would reduce the returns to housing; idiosyncratic and aggregate house price risk would generate housing risk premia (see Landvoigt et al., 2015); and assets with higher returns such as stocks and equities would increase the opportunity cost of housing investment (see Favilukis et al., 2017a). I leave each of these extensions to future research.

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TABLE 1

Summary Statistics

	Pooled, 2001-2005			Pooled, 2006-2010		
	Owner Occupier	Household Investor	Corporate Investor	Owner Occupier	Household Investor	Corporate Investor
A. Share of Total Purchases	0.64	0.28	0.08	0.61	0.29	0.10
B. Buyer Size:						
Number of Properties: 1		0.65	0.14		0.65	0.15
Number of Properties: 2-5		0.24	0.19		0.22	0.20
Number of Properties: 6-25		0.07	0.22		0.07	0.21
Number of Properties: 26+		0.04	0.45		0.06	0.43
C. Financing, Resales, Location:						
Using a Mortgage	0.77	0.56	0.21	0.70	0.42	0.14
Median LTV Ratio	0.80	0.80	0.89	0.80	0.80	0.90
Resold Within 12 Months	0.06	0.12	0.35	0.04	0.10	0.32
Resold Within 24 Months	0.12	0.20	0.47	0.07	0.15	0.41
Out of Town		0.24	0.22		0.25	0.31
Observations	14,987,559			14,045,690		

Notes: Median LTV ratios are conditional on purchases using a mortgage where the LTV ratio is less than 2.
Sources: Author's calculations using ZTRAX.

TABLE 2

Effect of Mortgage Credit and Investor Activity on Local House Prices

	$\Delta \log P_{z,t}$			
	(1)	(2)	(3)	(4)
$\Delta \log M_{z,t}$	0.260^{***}	0.260^{***}	0.266^{***}	0.298^{***}
	(0.053)	(0.064)	(0.053)	(0.077)
$\Delta \log M_{z,t} \times$				
$\Delta Corporate\ Inv.\ Share_{z,t}$		-2.147^{***}		-2.599^{***}
		(0.530)		(0.665)
$\Delta \log M_{z,t} \times$				
$\Delta Household\ Inv.\ Share_{z,t}$			-0.114	-0.716^{**}
			(0.243)	(0.344)
Method	2SLS	2SLS	2SLS	2SLS
Sample	2007-2010	2007-2010	2007-2010	2007-2010
Observations	14,160	14,160	14,160	14,160
Zipcodes	3,960	3,960	3,960	3,960
Counties	470	470	470	470
Fixed Effects	County $\times$ Year	County $\times$ Year	County $\times$ Year	County $\times$ Year
Adjsuted R-squared	0.44	0.39	0.43	0.27
F-statistics				
$F_{1\|\cdot}$	22.16	28.06	33.65	34.88
$F_{2\|\cdot}$	–	36.27	154.28	43.48
$F_{3\|\cdot}$	–	–	–	75.56
Wald Statistic	–	–	–	13.85
p-value	–	–	–	0.00

*Notes: All models estimated via 2SLS. The instrument for mortgage origination growth is local exposure to non-GSE mortgage purchases from 1998-2000. Changes in investor shares of house purchases are instrumented with their own lagged values. All models condition on: lagged house price growth; the contemporaneous shares of house purchases by each type of investor; the change in log-real per capita pre-tax zip code-level income; the change in log-employment by firms within the zip code; the change in log-real annual payroll by firms within the zip code.All models include county-by-year fixed effects. Column (1) reports the F-statistic for the first stage regression of the mortgage mortgage credit instrument on mortgage origination growth. Columns (2) through (4) report conditional F-statistics for the mortgage credit instrument and the instruments for the interactions between mortgage origination growth and the change in investor shares. Column (4) reports a Wald test for the hypothesis of equality between the coefficients on the interaction terms. Standard errors (reported in parentheses), F-statistics, and Wald test-statistics are clustered at the county level. *, **, *** denote significance at the 10%, 5%, and 1% levels.*

Sources: Author's calculations using data from BLS, CBP, FRED, HMDA, IRS, Zillow, ZTRAX.

TABLE 3

Model Parameters

Description	Parameter	Value	Source
A. Externally Calibrated Parameters			
Length of life (years)	J	56	Standard
Retirement age (years)	J_{ret}	41	Standard
Risk aversion	σ	2	Standard
Persistence of income shocks	ρ_y	0.948	PSID, own calculations
Std. dev. of persistent income shocks	σ_y	0.178	PSID, own calculations
Std. dev. of transitory income shocks	σ_z	0.294	PSID, own calculations
Retirement income replacement rate	ω	0.500	Díaz et al. (2008)
Risk free interest rate	r	0.0150	FRED
Mortgage interest rate	r_b	0.0315	FRED
Proportional mortgage origination cost	f_b	0.005	FRED
Proportional housing transaction cost	f_s	0.060	Standard
Housing depreciation rate	δ	0.030	Harding et al. (2007)
Maximum LTV ratio	θ_b	0.900	Greenwald (2018)
Maximum PTI ratio	θ_m	0.400	Greenwald (2018)
Elasticity of corporate demand	ε	0.000	See text
B. Internally Calibrated Parameters			
Discount factor	β	0.891	Calibrated
Non-durable share	χ	0.739	Calibrated
Bequest luxuriousness	$\bar{w}$	9.519	Calibrated
Bequest desirability	ψ	242.390	Calibrated
Minimum house size	$\underline{h}$	2.144	Calibrated
Fixed mortgage origination cost	F_b	0.026	Calibrated
Housing supply	$\bar{H}$	1.909	Calibrated
Landlord cost	ϕ	0.014	Calibrated
Corporate rental cost	κ	0.005	Calibrated

TABLE 4

Model Fit to Targeted and Non-Targeted Moments

Description	Model	Data	Source
A. Targeted Moments			
Homeownership rate	0.69	0.69	FRED, 2006
Investment ownership rate	0.20	0.15	SCF, 2007
Fraction of owners with mortgage	0.79	0.76	SCF, 2007
LTV ratio, owners with mortgage, p50	0.77	0.51	SCF, 2007
Mortgage debt/income, owners with mortgage, p50	1.98	1.53	SCF, 2007
Fraction of investors with mortgage	0.66	0.74	SCF, 2007
LTV ratio, investors with mortgage, p50	0.39	0.38	SCF, 2007
Mortgage debt/income, investors with mortgage, p50	1.55	1.52	SCF, 2007
House value/income, owners, p50	2.58	2.98	SCF, 2007
Networth/income, p50	0.98	1.18	SCF, 2007
Median networth ratio, ages 65-80 to 40-55	1.74	1.72	SCF, 2007
Homeownership rate, age$\geq$70	0.46	0.83	SCF, 2007
Homeownership rate, age$\leq$35	0.44	0.51	SCF, 2007
Annual mortgage refinancing rate	0.10	0.12	Bhutta et al. (2016)
Corporate investor share of purchases	0.08	0.07	ZTRAX, 2005-2007
B. Non-Targeted Moments			
Networth/income, p10	0.18	0.00	SCF, 2007
Networth/income, p90	5.25	7.66	SCF, 2007
Housing networth/networth, owners, p10	0.42	0.48	SCF, 2007
Housing networth/networth, owners, p50	0.76	0.95	SCF, 2007
Housing networth/networth, owners, p90	0.95	1.07	SCF, 2007
Investor share of total household-held housing	0.31	0.43	SCF, 2007
Household investor share of purchases	0.25	0.24	ZTRAX, 2005-2007
Annual fraction of houses sold	0.03	0.10	Ngai et al. (2019)
Household investor share of rental stock	0.99	0.88	Chambers et al. (2009a)
Corporate investor share of rental stock	0.01	0.12	Chambers et al. (2009a)

TABLE 5

Exogenous Negative Mortgage Credit Shock

Description	Parameter	Boom Value	Bust Value
Mortgage interest rate	r_b	0.0315	0.0415
Proportional mortgage origination cost	f_b	0.0050	0.0075
Maximum LTV ratio	θ_b	0.90	0.80
Maximum PTI ratio	θ_m	0.40	0.30

Notes*: Exogenous changes to parameter values for a negative mortgage credit shock. The shock unexpectedly switches the parameters from the boom to the bust state for seven years, and then reverts.*

TABLE 6

The Sensitivity of Property Purchases to a Mortgage Credit Supply Shock

	Δ Investment Purchases (%)		Δ Investment Ownership (%)		Δ Home Purchases (%)		Δ Home Ownership (%)	
Year	*p.e.*	*g.e.*	*p.e.*	*g.e.*	*p.e.*	*g.e.*	*p.e.*	*g.e.*
1	−89.3	−88.1	−10.5	−15.0	−84.3	−77.1	−5.1	2.5
2	−77.8	10.7	−15.3	−14.7	−70.5	−62.9	−9.2	2.4
3	−69.5	195.0	−18.6	−6.8	−58.2	−52.1	−12.5	0.9
4	−62.3	289.5	−21.0	4.7	−45.2	−43.3	−14.9	−1.2
5	−51.5	282.6	−22.7	16.0	−29.7	−36.1	−16.5	−3.0

*Notes: Housing market activity in response to the mortgage credit supply shock under general equilibrium (*g.e.*) and partial equilibrium (*p.e.*). All variables measured as percent deviations from steady state.*

TABLE 7

Household Welfare Improvement with Elastic Corporate Investors

	All	Renters	Homeowners	Investors
CEV	0.166	0.320	-0.002	-0.158
Fraction with CEV$\geq$0	0.464	0.983	0.230	0.167

Notes*: Welfare comparisons are made for households that are alive in the first period of the shock. Consumption Equivalent Value (CEV) is the percentage gain in life-time consumption by moving from the economy with $\varepsilon = 0$ to the economy with $\varepsilon = 24$. A positive CEV indicates that households prefer outcomes in the latter economy. Group welfare comparisons are for households that would have been renters, homeowners, or investors in the first period of the shock in the baseline economy with $\varepsilon = 0$.*

A. Data

Data Sources

- Individual housing transaction data comes from Zillow's Assessment and Transaction Database (ZTRAX). This data is proprietary, but is available from Zillow by request. For information regarding access, contact see http://www.zillow.com/ztrax.

- Zipcode house prices come from Zillow's publicly available house price data at http://www.zillow.com/data.

- Zipcode income is from the IRS Statement of Income (SOI) statistics at https://www.irs.gov/statistics/.

- Zipcode demographic characteristics are from the 2000 Census, available at https://factfinder.census.gov/.

- Zipcode employment and county employment by industry is from the County Business Patterns data, available at https://www.census.gov/programs-surveys/cbp/data/datasets.html.

- Census tract-to-zipcode crosswalk files are retrieved from the Department of Housing and Urban Development at https://www.huduser.gov/portal/datasets/usps_crosswalk.html.

- County unemployment data is from the Bureau of Labor Statistics, available at https://www.bls.gov/lau/data.htm.

Zillow Transaction and Assessment Database

The full ZTRAX dataset contains more than 370 million public records from across the US for residential and commercial properties. Each transaction in ZTRAX contains information on the characteristics of a property and sale including transaction date, property type, sale type, buyer type, and so on.

The ZTRAX data is held in state-level files, each of which contains the entire set of assessment records and transactions for that state. The availability of information associated with each transaction varies by state, but also may vary across counties within states. Three states – Rhode Island, Tennessee, and Vermont – have various missing data in the ZTRAX database, and are excluded from the analysis entirely. For several other states, non-mandatory disclosure and outright prohibitions on the reporting of transactions prices mean that a very large proportion of transactions feature sales with prices reported as zero or missing.[51] For these states, property deeds and assessment records may still be reported to the ZTRAX database. I collect

[51] See http://www.zillowgroup.com/news/chronicles-of-data-collection-ii-non-disclosure-states/ for more details.

data on housing characteristics for these states, but I cannot use the transaction data on sales prices.[52] Instead, for these states I use publicly available, geographically aggregated Zillow house price indexes.

Identifying Ownership Status in ZTRAX

ZTRAX contains several variables describing ownership characteristics for house buyers. The two most important are a *Buyer Description* and *Occupancy Status*.

The buyer description variable indicates whether the buyer in a given transaction is an individual, a couple, a trust, a legal partnership, a company, a government entity, or some other kind of organization. The variable is populated in ZTRAX for virtually every transaction. I identify household owners as those buyers who are individuals, couples, and trusts. I identify institutional owners as those buyers who are legal partnerships, companies, government entities, or other organizations.

The occupancy status variable describes the stated or inferred occupancy status of the buyer of a property. Unfortunately, this variable is missing for a large number of transactions, is altogether unavailable for several states, and varies in quality over time and space within states. Instead of using the occupancy status variable, I identify occupancy from other information available in ZTRAX. ZTRAX provides a character string describing the street address of every property sold. Additionally, the street address of the buyer of a property is also provided. In many states over 90 percent of transactions are accompanied by a buyer address. I identify owner-occupiers as those whose listed buyer address exactly matches the address of the purchased property.[53]

Finally, I identify household owner-occupiers as household owners from their buyer description information and who are owner-occupiers from their address information. I identify household property investors as household owners who are not owner-occupiers. And I identify institutional property investors as non-household owners.

Home Mortgage Disclosure Act Database

HMDA provides loan-level data on the universe of mortgage applications and originations in the US. A variety of information is reported about each loan. Location information about each loan is reported at the Census tract, county, MSA, and state levels. Zip code information is not provided, so I match Census tracts to zip codes using a tract-to-zip code crosswalk file provided by the Department of Housing. Because tracts may fall into more than one zip code, I use information on the share of tract residences in each zip code to weight each variable. To

[52] The states with large numbers of missing transaction data are: Alaska, Idaho, Indiana, Kansas, Maine, Mississippi, Montana, New Mexico, Texas, Utah, and Wyoming

[53] I also tried a fuzzy matching algorithm to compare addresses. Fuzzy matching enables identification of owner-occupiers when one of the listed addresses is mis-spelled. I found that this did not make a large difference to the number of identified owner-occupied properties.

construct my measures of mortgage credit, I use the following variables associated with each loan in HMDA: Loan Purpose, Action Taken, Type of Purchaser, and Loan Amount.

Loan Purpose indicates whether a mortgage was used for a home purchase, home improvement, or refinancing. The main results only use home purchase mortgages.

Action Taken indicates whether the reporting institution originated a particular mortgage, denied an application for the mortgage, or purchased the mortgage from another institution. I only use mortgages that were originated by the reporting institution. Note that mortgages purchased by an institution need not have been originated in the reporting year. Additionally, these mortgages are likely to have been reported by originating institutions already, and so their inclusion would likely lead to double-counting.

Type of Purchaser indicates whether and to which institution a mortgage was sold. The first categorization includes mortgages that were not originated or were not sold within the year (HMDA code: 0). Conditional on having been originated, these are mortgages that the originator has chosen to keep on its balance sheet, at least for the time being. Note that nothing precludes the originator from selling this mortgage in the future. The remaining categories specify the type of institution that purchased the mortgage. The first four institutions are the GSEs: Fannie Mae, Ginnie Mae, Freddie Mac, and Farmer Mac (HMDA codes: 1,2,3,4). The remaining five categories cover non-GSEs: institutions purchasing explicitly for use in private securitization (HMDA code: 5); purchases by commercial banks, savings banks, or savings associations (HMDA code: 6); purchases by life insurance companies, credit unions, mortgage banks, or finance companies (HMDA code: 7); purchases by affiliate institutions of the originator (HMDA code: 8); and other types of purchaser (HMDA code: 9). This final category includes banks and thrift holding companies. See https://www.ffiec.gov/hmda/faqreg.htm#purchaser. Both Mian et al. (2009) and Mian et al. (2018) define non-GSE purchases as those associated with these final five categories of purchaser.

I use three measures of exposure to credit supply shocks. First, I use only mortgages sold explicitly into private label securitization (HMDA code: 5). Second, I use a broader measure that also includes mostly non-banks that are unlikely to hold mortgages for balance sheet management and so are likely to be purchasing mortgages for the purpose of securitization (HMDA codes: 5, 7, 9). Finally, I use the broad, non-GSE measure used in Mian et al. (2009) and Mian et al. (2018) (HMDA codes: 5, 6, 7, 8, 9).

B. Additional Figures

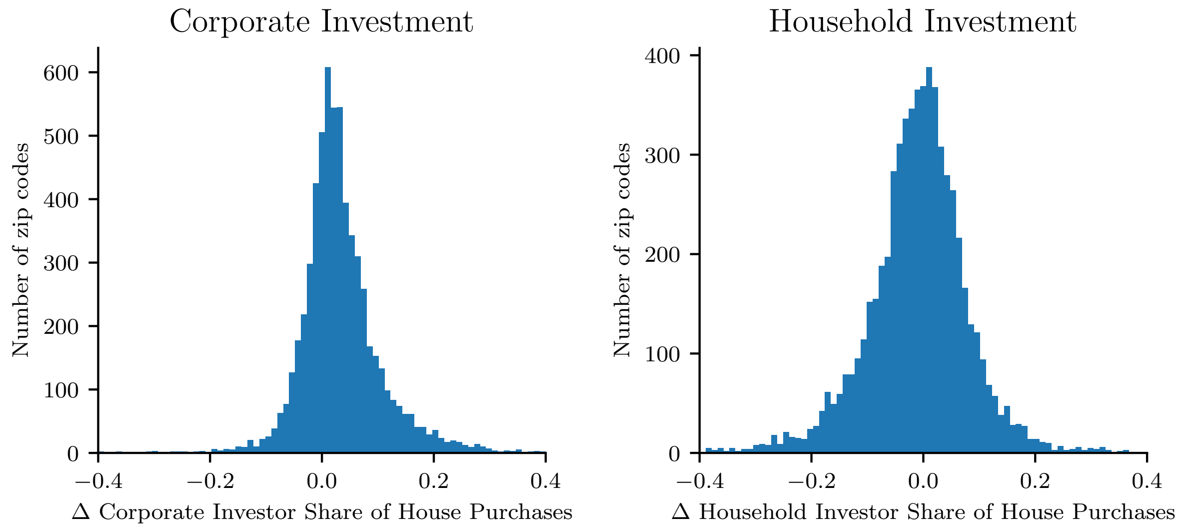


FIGURE B.1
Change in Investor Shares of House Purchases Across Zip Codes, 2006-2010

Source: Author's calculations using ZTRAX

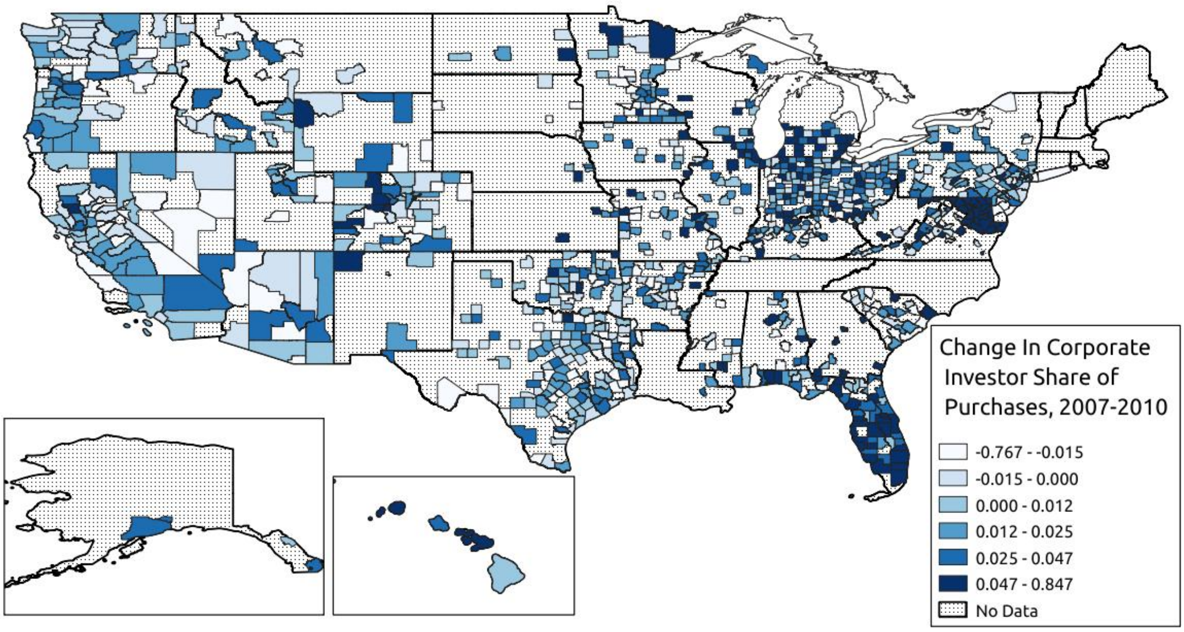
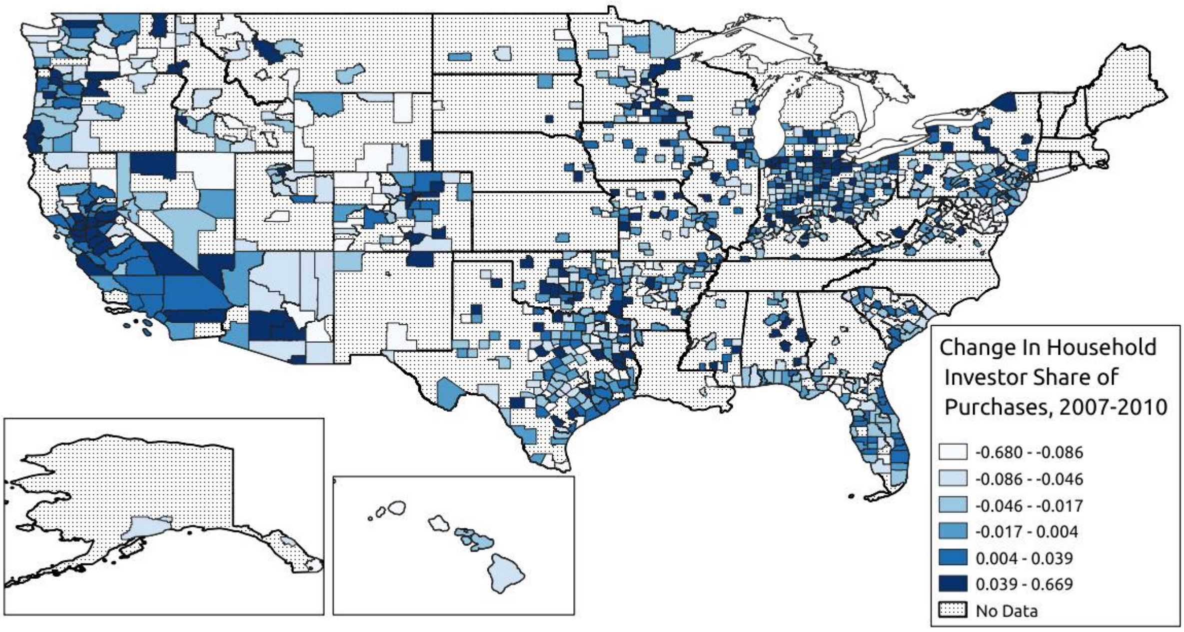


FIGURE B.2
Changes in Corporate Investor Share of Purchases Across Counties, 2006-2010

Source: Author's calculations using ZTRAX

(a) Change in Household Investor Purchases



(b) Changes in Household Investor Share of Purchases Across Counties, 2006-2010

Source: Author's calculations using ZTRAX

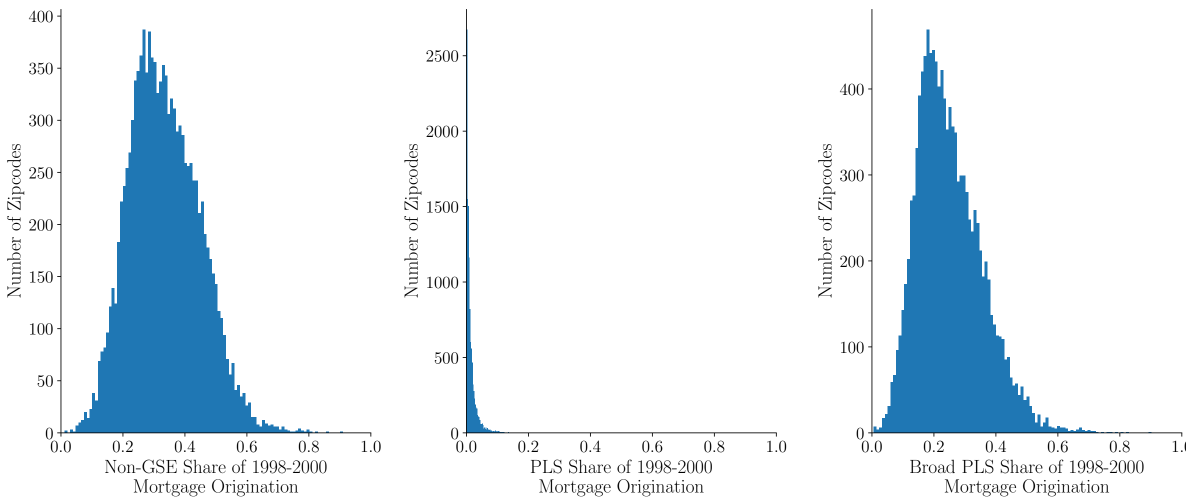


FIGURE B.4
Local Mortgage Origination Shares

Notes: Local mortgage origination shares by purchaser type between 1998 and 2000: non-GSE purchasers; direct-to-PLS purchasers; direct-to-PLS and non-bank purchasers.
Source: Author's calculations using HMDA.

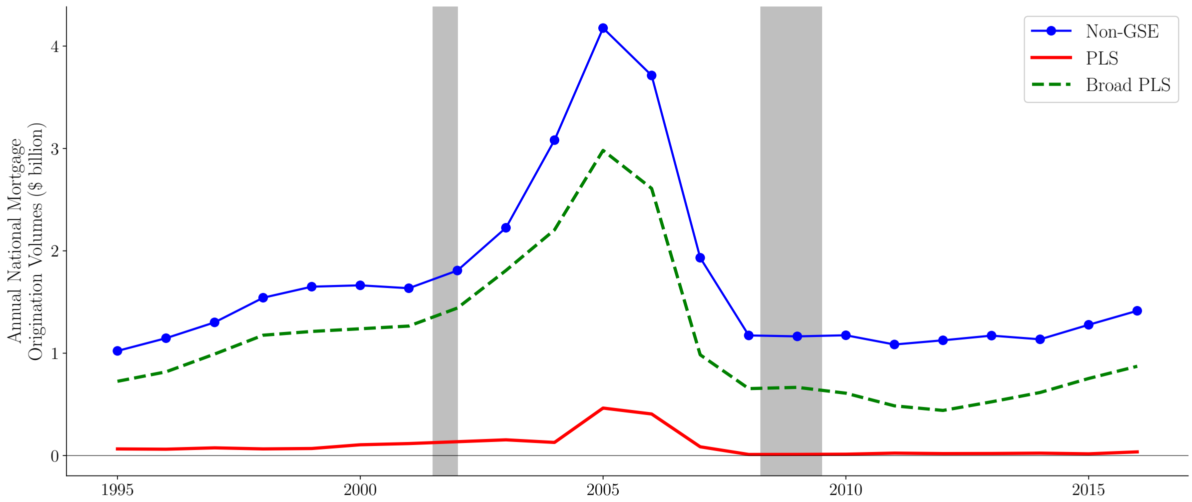


FIGURE B.5
National Mortgage Origination Volumes

Notes: Annual national mortgage origination volumes by purchaser type.
Source: Author's calculations using HMDA.

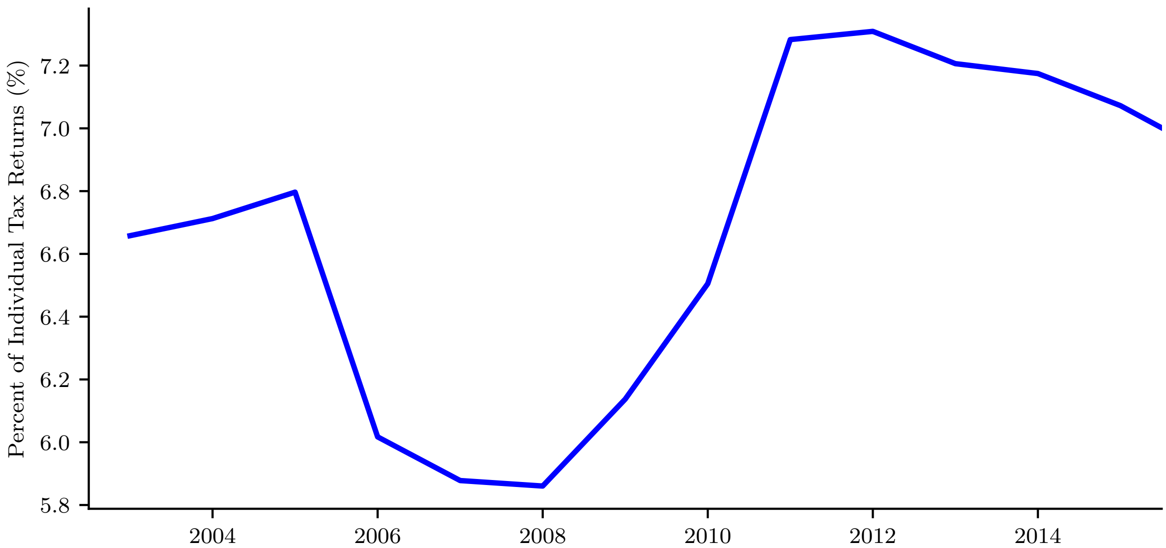


FIGURE B.6
Fraction of Households Holding Rental Property

Notes: Fraction of individual tax payers reporting holding rental properties on tax return Schedule E, Form 1040.
Source: Author's calculations using IRS Statistics of Income data.

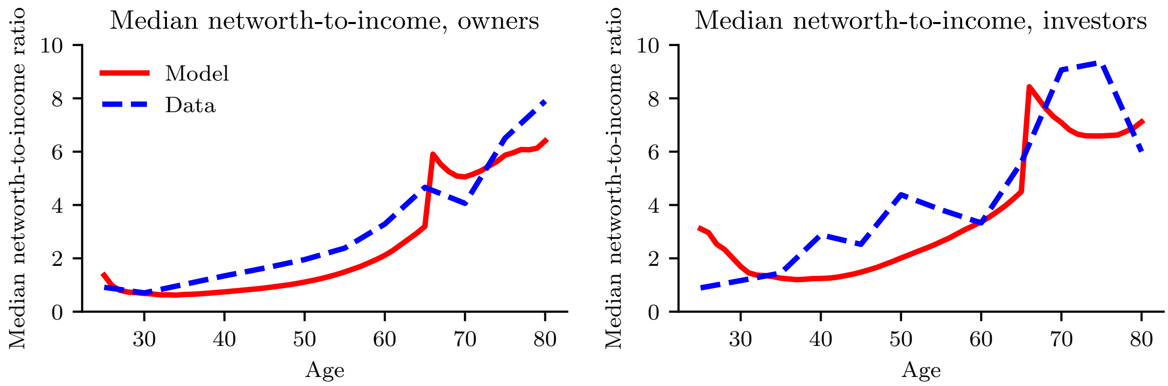


FIGURE B.7
Household Networth Over the Life-Cycle

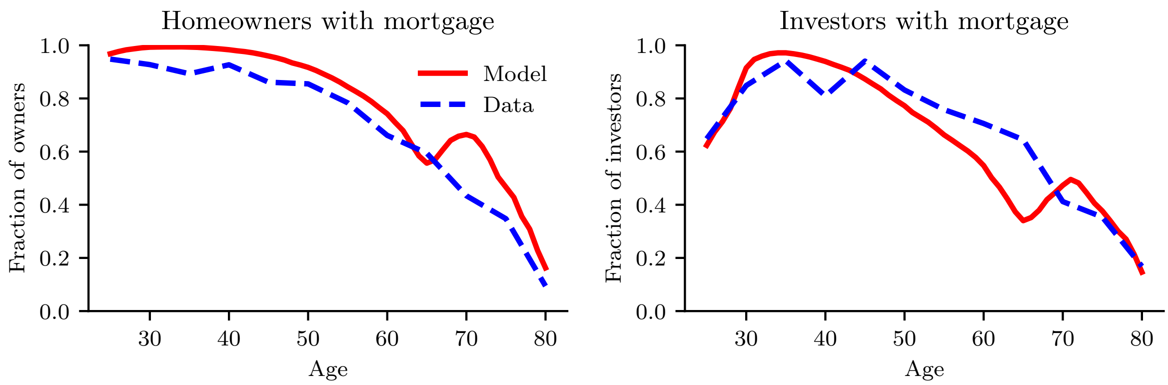


FIGURE B.8
Household Mortgage Holding Rates Over the Life-Cycle

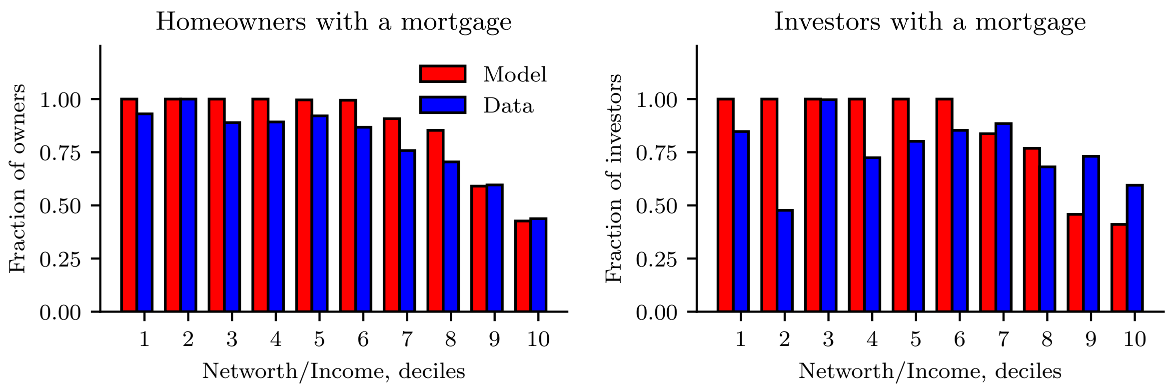


FIGURE B.9
Household Mortgage Holding Rates Over the Wealth Distribution

Notes: Data moments computed from the 2007 SCF. Moments by age are computed for centered, five-year windows for ages 25 to 80. For consistency with the model, mortgage holding rates in the data are computed for homeowners and investors with either primary property or secondary property mortgage debt.

C. Additional Tables

TABLE C.1

First Stage Regressions of the 2SLS Procedure

	(1)	(2)	(3)
$\lambda^{nonGSE}_{z,98-00}$	-0.253^{***}	-0.003	-0.008
	(0.052)	(0.003)	(0.005)
$\lambda^{nonGSE}_{z,98-00} \times$ $\Delta Corporate\ Investor\ Share_{z,t-1}$	0.904^{***}	0.156^{***}	0.056
	(0.236)	(0.047)	(0.044)
$\lambda^{nonGSE}_{z,98-00} \times$ $\Delta Household\ Investor\ Share_{z,t-1}$	0.350^{***}	0.025	0.197^{***}
	(0.118)	(0.027)	(0.029)
Sample	2007-2010	2007-2010	2007-2010
Observations	14,149	14,149	14,149
Zipcodes	3,960	3,960	3,960
Counties	470	470	470
Fixed Effects	County × Year	County × Year	County × Year
F-statistic	23.59	11.04	45.07

Notes: First stage regressions for the 2SLS procedure following the specification in Equation (**??**)*. Column (1) reports the first stage regression for growth in mortgage originations. Column (2) reports the first stage regression for growth in mortgage originations interacted with the change in the corporate investor share of house purchases. Column (3) reports the first stage regression for growth in mortgage originations interacted with the change in the household investor share of house purchases. All models condition on: lagged house price growth; the contemporaneous shares of house purchases by each type of investor; the change in log-real per capita pre-tax zip code-level income; the change in log-employment by firms within the zip code; the change in log-real annual payroll by firms within the zip code. All models include county-by-year fixed effects. Each column reports the F-statistic for the instrument associated with the explanatory variable of that first stage regression. Standard errors (reported in parentheses) and F-statistics are clustered at the county level. *, **, *** denote significance at the 10%, 5%, and 1% levels.*

Sources: Author's calculations using data from BLS, CBP, FRED, HMDA, IRS, Zillow, ZTRAX.

TABLE C.2

Effect of Mortgage Credit and Investor Activity on Local House Prices: Alternative Instruments

	$\Delta \log P_{z,t}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \log M_{z,t}$	0.260^{***}	0.282^{***}	0.358^{***}	0.298^{***}	0.428^{*}	0.515^{***}
	(0.053)	(0.081)	(0.043)	(0.077)	(0.223)	(0.107)
$\Delta \log M_{z,t} \times$						
$\Delta Corporate\ Inv.\ Share_{z,t}$				-2.599^{***}	-3.938^{*}	-4.616^{***}
				(0.665)	(2.113)	(1.373)
$\Delta \log M_{z,t} \times$						
$\Delta Household\ Inv.\ Share_{z,t}$				-0.716^{**}	-0.665	-1.000^{*}
				(0.344)	(0.493)	(0.528)
Method	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Mortgage Instrument	Non-GSE	PLS	Broad PLS	Non-GSE	PLS	Broad PLS
Sample	2007-2010	2007-2010	2007-2010	2007-2010	2007-2010	2007-2010
Observations	14,160	14,160	14,160	14,160	14,160	14,160
Zipcodes	3,960	3,960	3,960	3,960	3,960	3,960
Counties	470	470	470	470	470	470
Fixed Effects	County × Year	County × Year	County × Year	County × Year	County × Year	County × Year
F-statistics						
$F_{1\|\cdot}$	22.16	12.85	26.22	34.88	5.85	36.00
$F_{2\|\cdot}$	–	–	–	43.48	5.33	37.00
$F_{3\|\cdot}$	–	–	–	75.56	7.56	57.99
Wald Statistic	–	–	–	13.85	2.59	8.50
p-value	–	–	–	0.00	0.11	0.00

*Notes: All models estimated via 2SLS. The instruments for mortgage origination growth consist of: local exposure to non-GSE mortgage purchases from 1998-2000 (Columns (1) and (2)); local exposure to mortgages sold directly into PLS from 1998-2000 (Columns (2) and (4)); local exposure to mortgages sold into PLS or to non-banks from 1998-2000 (Columns (3) and (6)). In all models, changes in investor shares of house purchases are instrumented with their own lagged values. All specifications include the same set of controls as in Table 2.All models include county-by-year fixed effects. Columns (1) to (3) report F-statistics for the first stage regression of the relevant mortgage mortgage credit instrument on mortgage origination growth. Columns (4) to (6) report conditional F-statistics for the mortgage credit instruments and the instruments for the interactions between mortgage origination growth and the change in investor shares. Columns (4) to (6) also report Wald tests for the hypothesis of equality between the coefficients on the interaction terms. Standard errors (reported in parentheses), F-statistics, and Wald test-statistics are clustered at the county level. *, **, *** denote significance at the 10%, 5%, and 1% levels.*

Sources: Author's calculations using data from BLS, CBP, FRED, HMDA, IRS, Zillow, ZTRAX.

TABLE C.3

Effect of Mortgage Credit and Investor Activity on Local House Prices: Additional Controls

	$\Delta \log P_{z,t}$				
	(1)	(2)	(3)	(4)	(5)
$\Delta \log M_{z,t}$	0.298^{***}	0.306^{***}	0.291^{***}	0.262^{***}	0.179^{**}
	(0.077)	(0.069)	(0.059)	(0.073)	(0.090)
$\Delta \log M_{z,t} \times$					
$\Delta Corporate\ Inv.\ Share_{z,t}$	-2.599^{***}	-2.789^{***}	-3.233^{**}	-2.353^{***}	-1.709^{***}
	(0.665)	(0.675)	(1.266)	(0.586)	(0.476)
$\Delta \log M_{z,t} \times$					
$\Delta Household\ Inv.\ Share_{z,t}$	-0.716^{**}	-0.869^{***}	-0.232	-0.746^{**}	-0.457^{**}
	(0.344)	(0.314)	(0.660)	(0.361)	(0.216)
Method	2SLS	2SLS	2SLS	2SLS	2SLS
Sample	2007-2010	2007-2010	2007-2010	2007-2010	2007-2010
Additional Controls	Benchmark	$\Delta \log P_{z,01-06}$	Housing Supply	Bank Competition	Demographics
Observations	14,160	13,670	9,735	12,584	13,706
Zipcodes	3,960	3,960	3,960	3,960	3,960
Counties	470	470	470	470	470
Fixed Effects	County × Year	County × Year	County, Year	County × Year	County × Year
F-statistics					
$F_{1\|\cdot}$	34.88	32.51	34.00	45.36	17.48
$F_{2\|\cdot}$	43.48	38.92	25.30	55.10	27.85
$F_{3\|\cdot}$	75.56	60.10	44.48	84.54	77.94
Wald Statistic	13.85	13.36	5.23	13.78	9.74
p-value	0.00	0.00	0.02	0.00	0.00

*Notes: All models estimated via 2SLS. The instrument for mortgage origination growth is local exposure to non-GSE mortgage purchases from 1998-2000. Changes in investor shares of house purchases are instrumented with their own lagged values. All specifications include the same set of controls as in Table 2.Additionally, Column (2) controls for local house price growth between 2001 and 2006. Column (3) includes controls for local housing supply: the change in log-number of total housing units permitted at the county level; the Saiz (2010) housing supply elasticity at the MSA level interacted with year-dummies; the fraction of houses built prior to 1990 and the fraction of houses with four or fewer rooms, both measured at the zip code level and interacted with year-dummies. Because the supply elasticity is ineracted with time and MSAs frequently overlap with counties, this specification include county and year fixed effects, rather than county-by-year fixed effects. Column (4) includes controls for the structure of the banking market measured in the year 2000 at the zip code level and interacted with year-dummies: the fraction of deposits held by banks that have a within-state headquarters; the Herfindahl index for deposits held across branches; the Herfindahl index for deposits held across institutions; Column (5) includes controls for local demographic factors measured in the year 2000 at the zip code level and interacted with year-dummies: median age; fraction of households with no more than high school education; the fraction of owner-occupier households. Each column reports conditional F-statistics for the mortgage credit instrument and the instruments for the interactions between mortgage origination growth and the change in investor shares. Additionally, Wald statistics report test results for the hypothesis of equality between the coefficients on the interaction terms. Standard errors (reported in parentheses), F-statistics, and Wald test-statistics are clustered at the county level. *, **, *** denote significance at the 10%, 5%, and 1% levels.*

Sources: Author's calculations using data from BLS, BPS, CBP, Census, FDIC, HMDA, IRS, Zillow, ZTRAX.

TABLE C.4

Effect of Mortgage Credit and Investor Activity on Local House Prices: Alternative Samples

	$\Delta \log P_{z,t}$			
	(1)	(2)	(3)	(4)
$\Delta \log M_{z,t}$	0.298^{***}	0.234^{**}	0.351^{***}	0.182^{***}
	(0.077)	(0.107)	(0.134)	(0.065)
$\Delta \log M_{z,t} \times$				
$\Delta Institutional\ Inv.\ Share_{z,t}$	-2.599^{***}	-2.029	-5.035^{***}	-1.115^{*}
	(0.665)	(1.459)	(1.641)	(0.609)
$\Delta \log M_{z,t} \times$				
$\Delta Household\ Inv.\ Share_{z,t}$	-0.716^{**}	-0.275	-1.054^{*}	-0.270
	(0.344)	(0.369)	(0.613)	(0.385)
Method	2SLS	2SLS	2SLS	2SLS
Sample	Benchmark	2006–2012	$N_{sales,z,t} \geq 300$	No Sand States
Observations	14,160	24,953	8,268	6,673
Zipcodes	3,960	4,494	2,562	2,010
Counties	470	511	361	297
Fixed Effects	County × Year	County × Year	County × Year	County × Year
F-statistics				
$F_{1\vert\cdot}$	34.88	6.71	21.23	51.73
$F_{2\vert\cdot}$	43.48	5.95	21.84	29.64
$F_{3\vert\cdot}$	75.56	237.56	27.41	61.64
Wald Statistic	13.85	2.05	10.07	3.83
p-value	0.00	0.15	0.00	0.05

*Notes: All models estimated via 2SLS. The instrument for mortgage origination growth is local exposure to non-GSE mortgage purchases from 1998-2000. Changes in investor shares of house purchases are instrumented with their own lagged values. All specifications include the same set of controls as in Table 2.Each column reports results using the same model specification, but with alternative data samples: Column (2) expands the sample period to 2006 through 2012; Column (3) includes only zip codes with at least 250 house sales in any given year; Column (4) excludes data from the "Sand States" and Florida (AZ, CA, CO, FL, NM, NV, TX, UT). Each column reports conditional F-statistics for the mortgage credit instrument and the instruments for the interactions between mortgage origination growth and the change in investor shares. Additionally, Wald statistics report test results for the hypothesis of equality between the coefficients on the interaction terms. Standard errors (reported in parentheses), F-statistics, and Wald test-statistics are clustered at the county level. *, **, *** denote significance at the 10%, 5%, and 1% levels.*

Sources: Author's calculations using data from BLS, BPS, CBP, Census, FDIC, HMDA, IRS, Zillow, ZTRAX.

TABLE C.5

Effect of Mortgage Denials and Investor Activity on Local House Prices

	$\Delta \log P_{z,t}$			
	(1)	(2)	(3)	(4)
$\Delta \log M_{z,t}$	0.217^{***}	0.218^{***}	0.217^{***}	0.235^{***}
	(0.059)	(0.065)	(0.056)	(0.068)
$\Delta \log M_{z,t} \times$				
$\Delta Corporate\ Inv.\ Share_{z,t}$		-1.249^{***}		-1.445^{***}
		(0.364)		(0.450)
$\Delta \log M_{z,t} \times$				
$\Delta Household\ Inv.\ Share_{z,t}$			-0.002	-0.327
			(0.170)	(0.221)
Method	2SLS	2SLS	2SLS	2SLS
Sample	2007-2010	2007-2010	2007-2010	2007-2010
Observations	14,149	14,149	14,149	14,149
Zipcodes	3,960	3,960	3,960	3,960
Counties	470	470	470	470
Fixed Effects	County × Year	County × Year	County × Year	County × Year
F-statistics				
$F_{1\|\cdot}$	23.10	25.90	29.62	27.40
$F_{2\|\cdot}$	–	47.25	175.22	46.36
$F_{3\|\cdot}$	–	–	–	140.28
Wald Statistic	–	–	–	10.24
p-value	–	–	–	0.00

*Notes: All models estimated via 2SLS. The instrument for the growth in mortgage denials is local exposure to non-GSE mortgage purchases from 1998-2000. Changes in investor shares of house purchases are instrumented with their own lagged values. All specifications include the same set of controls as in Table 2.Column (1) reports the F-statistic for the first stage regression of the mortgage mortgage credit instrument on mortgage origination growth. Columns (2) through (4) report conditional F-statistics for the mortgage credit instrument and the instruments for the interactions between mortgage origination growth and the change in investor shares. Column (4) reports a Wald test for the hypothesis of equality between the coefficients on the interaction terms. Standard errors (reported in parentheses), F-statistics, and Wald test-statistics are clustered at the county level. *, **, *** denote significance at the 10%, 5%, and 1% levels.*

Sources: Author's calculations using data from BLS, CBP, FRED, HMDA, IRS, Zillow, ZTRAX.

D. Additional Model Details

Income Process

During their working life, household income is constituted by deterministic and stochastic components. The deterministic component of income is follows a hump-shaped life-cycle profile. The stochastic component of income follows a standard composite of persistent and transitory elements. The persistent component of log-income follows an AR(1) process, and the transitory component is an IID shock. Thus, log-income at any age j is given by

$$\log m_j = \log g_j + \log y_j + \log z_j$$

where g_j is the deterministic life-cycle component, y_j is an AR(1) process following $\log y_j = \rho \log y_{j-1} + \varepsilon_j$ with $\varepsilon_j \sim \mathcal{N}(0, \sigma_y^2)$, and z_j is an IID shock where $\log z_j \sim \mathcal{N}(0, \sigma_z^2)$. To calibrate this income process, I follow a standard minimum-distance estimation procedure from the literature (see Floden et al. (2001), Storesletten et al. (2004), Guvenen (2009), and Heathcote et al. (2014)).

I gather data on individual earnings from the Individual Data File from the 1999 to 2007 waves of the PSID. I filter observations according to the following criteria. I keep male household heads between the ages of 25 and 65 who were respondents in a given panel year. I drop observations for individuals who were retired, permanently disabled, home-makers, and students. I keep only individuals who were in families (or their split-offs) that were in the 1968 core sample, which was constructed as a representative cross-sectional sample of the population. I drop observations with missing information on age, education, and labor income, or for which labor income is non-positive. To measure earnings I use the annual earnings variable. Note that income is reported for the 2 years prior to the sampling date. For example, income reported in 1999 is actually annual earnings from 1997. I deflate this earnings measure using annual CPI from the associated reporting year (i.e. not the sample year). To remove the influence of outliers on my estimates, I remove observations in the top and bottom one percent of real earnings. Finally, the filtering procedure yields 2150 individuals with a total of 6930 observations across the sample period.

First, I estimate the life-cycle profile g_j by regressing log-earnings on a cubic polynomial in age, conditional on sample year dummies, and dummies for the number of years of education. This yields the polynomial coefficients: $\{\beta_{age}, \beta_{age^2}, \beta_{age^3}\} = \{0.27007, -0.00484, 0.00028\}$. Second, I take the residuals from the previous regression and compute several cross-sectional statistics to provide moment conditions for the GMM estimation. Specifically, I compute the cross-sectional variance of log-income, as well as the two-, four-, and six-year auto-covariances of log-income. These moments are reported in Table D.6.

The model for the income process generates the following variance and auto-covariance statistics:

$$\text{var}(\log m_j) = \frac{\sigma_y^2}{1-\rho^2} + \sigma_z^2, \qquad \text{cov}(\log m_j, \log m_j + n) = \rho^n \frac{\sigma_y^2}{1-\rho^2}$$

TABLE D.6

Cross-sectional moments of individual earnings in the PSID

Variance	2-Year Auto-cov	4-Year Auto-cov.	6-Year Auto-cov
0.3977	0.2808	0.2483	0.2273

Notes: *Cross-sectional moments computed using the residuals from a regression of log-income on a polynomial in age and dummies for sample year and years of education.*
Source: *Author's calculations using data from PSID waves 1999-2007.*

Thus, the structure of auto-covariances in the data help to disentangle the relative volatility of the persistent and transitory components of income. I estimate the parameters $\{\rho, \sigma_y, \sigma_z\}$ by minimizing the difference between the set of moments generated by the model and the moments in the data. This yields $\{\rho, \sigma_y, \sigma_z\} = \{0.9479, 0.1777, 0.2942\}$. These estimates are very similar to those used elsewhere in the literature.

General Equilibrium Definition

The solution of the model consists of general equilibrium in housing and rental markets. The households' state vector is $\mathrm{s} = \{a, h, i, b, y\} \in \mathcal{S}$. In what follows I drop the dependence of variables on the state vector. Let ι^X be an indicator function equal to one when a household makes the discrete choice $X \in \{R, N, A\}$. Let μ_j denote the the measure of households aged j, defined on the state space $\mathcal{S}$. The total population across all cohorts is measure one: $\sum_{j=1}^{J} \mu_j = 1$. Let $Q_{j,j+1}$ denote a matrix describing the transition of the distribution of households across states s and from age j to $j+1$.

A *stationary recursive competitive equilibrium* is a set of value functions $\left\{V_j^R, V_j^N, V_j^A\right\}_{j=1}^{J}$, decision rules $\left\{\iota_j^R, \iota_j^N, \iota_j^A, c_j, a_j', d_j, h_j', i_j', b_j'\right\}_{j=1}^{J}$, corporate rental demand I', a house price P_h, a rental rate P_r, the supply of houses $\bar{H}$, and stationary measures $\{\mu_j\}_{j=1}^{J}$ such that:

- Given prices, households optimize and $\left\{V_j^R, V_j^N, V_j^A\right\}_{j=1}^{J}$ and $\left\{\iota_j^R, \iota_j^N, \iota_j^A, c_j, a_j', d_j, h_j', i_j', b_j'\right\}_{j=1}^{J}$ are the value functions and decision rules associated with the solution to household Problems (4), (5), and (6),
- Given prices, corporate investment demand I' is given by the firm's first order condition, Equation (7).
- The rental rate P_r is consistent with rental market clearing:

$$\sum_{j=1}^{J} \left[\int \iota_j^D d_j d\mu_j \right] = \sum_{j=1}^{J} \left[\int \left(\iota_j^A + \iota_j^N\right) i_j' d\mu_j \right] + I'$$

where the expression on the left is household rental demand, and the expression on the right consists of the household and corporate investment properties supplied to the rental market.

- Given housing supply $\bar{H}$, the house price P_h is consistent with housing market clearing:

$$\sum_{j=1}^{J}\left[\int\left(\iota_j^A+\iota_j^N\right)h_j'd\mu_j\right]+\sum_{j=1}^{J}\left[\int\left(\iota_j^A+\iota_j^N\right)i_j'd\mu_j\right]+I'=\bar{H}$$

where the expression on the left consists of the total number of owner-occupied houses held by households, and the total number of investment properties held by households and the corporate rental sector.

- The law of motion for the stationary distribution of households is

$$\mu_{j+1}=Q_{j,j+1}\mu_j$$

Computational Details

For computational convenience, I solve the model using a slightly modified set of state variables. The state space used in computations consists of cash on hand, primary property, secondary property, the current mortgage loan to value ratio, and the persistent component of income. In notation, $\mathrm{s}=[x,h,i,q,y]$, where $x=aR+m_j$ and $q=\frac{b}{P(h+i)}$. For this formulation, an adjusting household's problem becomes:

$$\begin{aligned}
V_j^A(\mathbf{s}) = &\max_{c,a',h',i',q'} u(c,h')+\beta\mathbb{E}\left(V_{j+1}(\mathbf{s}')\right)\\
\text{s.t.}\quad & c+a'+P_h(\mathbb{1}_{h'\neq h}h'+\mathbb{1}_{i'\neq i}i')+\delta P_h(h'+i')+bR_b\\
&\quad =x+(1-f_s)P_h(\mathbb{1}_{h'\neq h}h+\mathbb{1}_{i'\neq i}i)+(1-f_b)b'-\mathbb{1}_{b'>0}F_b+(P_r-f_i)i'\\
& q'\leq\theta\\
& q'\leq\frac{\theta_y m_j}{P_h(h'+i')\pi(1,r_b)}\\
& b\equiv qP_h(h+i),\quad b'\equiv q'P_h(h'+i')
\end{aligned}$$

Notice that the household chooses the mortgage loan-to-value ratio directly. A non-adjusting household's problem becomes:

$$\begin{aligned}
V_j^N(\mathbf{s}) = &\max_{c,a'}\quad u(c,h)+\beta\mathbb{E}\left(V_{j+1}(\mathbf{s}')\right)\\
\text{s.t.}\quad & c+a'+\delta_h P_h(h+i)+\pi(b,r_b)=x+(P_r-f_i)i\\
& q'=q(R_b-\pi(1,r_b))\\
& b\equiv qP_h(h+i)
\end{aligned}$$

A renting household's problem becomes:

$$\begin{aligned} V_j^R(\mathbf{s}) = \max_{c,a',d} \quad & u(c,d) + \beta \mathbb{E}\left(V_{j+1}(\mathbf{s}')\right) \\ \text{s.t.} \quad & c + a' + P_r d + bR_b = x + (1-f_s)P_h(h+i) \end{aligned}$$

The model solution is computed on a finite grid space that approximates the true state space. The accuracy of the solution is improved when the distribution of points within this grid space are chosen carefully. As is the case in any standard model of consumption under uncertainty with borrowing constraints, the consumption policy function is increasing and concave in x. Approximations to the consumption function, then, benefit from clustering points in the x grid near zero. I use 50 grid points, distributed on the interval $[0, 85]$ using an inverse-exponential scaling function. Households with large loan to value ratios also exhibit significant curvature in their policy functions, suggesting that points in the q grid should be clustered near the maximum LTV ratio. I use 25 grid points, distributed on the interval $[0, \theta_b]$ using an exponential scaling function. As discussed in Section 4.2, I only allow households to purchase one size of house and investment property. This means the grid space for each of these state variables is $0, \underline{h}$. I use five grid points for the Markov chain representing the persistent component of income y, and I use Gaussian quadrature with five nodes to approximate the IID component of income.

Computation of Equilibrium

In the stationary equilibrium, two market clearing conditions must be satisfied: rental demand equals rental supply, and housing demand equals housing supply. To find the equilibrium, first define the excess demand functions:

$$\begin{aligned} ERD(P_r, P_h) =& \sum_{j=1}^{J} \left[\int \iota_j^D(\mathbf{s}) s_j(\mathbf{s}) d\mu_j(\mathbf{s}) \right] - \sum_{j=1}^{J} \left[\int \left(\iota_j^A(\mathbf{s}) + \iota_j^N(\mathbf{s})\right) i_j'(\mathbf{s}) d\mu_j(\mathbf{s}) \right] - I' \\ EHD(P_r, P_h) =& I' + \sum_{j=1}^{J} \left[\int \left(\iota_j^A(\mathbf{s}) + \iota_j^N(\mathbf{s})\right) \left(h_j'(\mathbf{s}) + i_j'(\mathbf{s})\right) d\mu_j(\mathbf{s}) \right] - \overline{H} \end{aligned}$$

Then define the sum over the squared deviations from each market clearing condition: $Z(P_r, P_h) = ERD(P_r, P_h)^2 + EHD(P_r, P_h)^2$. Notice that a zero of the function Z corresponds to simultaneous zeros of the two excess demand functions, ERD and EHD. I can then use a nonlinear minimization routine over Z to find the market clearing prices P_r, and P_h.

Finally, to help with calibrating the model I employ a trick inspired by **boppart2018exploiting**. This involves replacing the housing market clearing conditions with one of the SMM moment conditions. Specifically, rather than calibrating the model by guessing values $\bar{H}$ to match the observed homeownership rate, I solve for equilibrium by varying the house price P_h to match the homeownership rate directly. The market clearing housing supply $\bar{H}$ is then backed out from the housing market clearing condition.

Decomposition of the Effects of the Mortgage Credit Shock

Figure D.1 compares the equilibrium effects of the mortgage credit shock discussed in Table 5 to separate shocks to mortgage constraints and mortgage costs. The red dashed lines illustrate a shock to mortgage borrowing constraints only (θ_b, θ_y), and the green circled line shows a shock to mortgage costs only (r_b, f_b). All experiments are conducted with $\varepsilon = 0$.

The main result is that the household investment ownership rate and share of house purchases rise significantly more when only mortgage constraints are affected, and are significantly dampened when only mortgage costs are affected. Recall that households choosing to invest are both wealthier and borrow with smaller LTV ratios than other homeowners (see Panel B of Table 4, and Figures 4 and 5). This means that potential household investors are further from the borrowing constraints when they tighten, and so are less exposed to that component of the mortgage credit shock than potential homeowners. In contrast, the shock to mortgage interest rates directly affects potential household investors since it reduces the returns to holding investment property while borrowing.

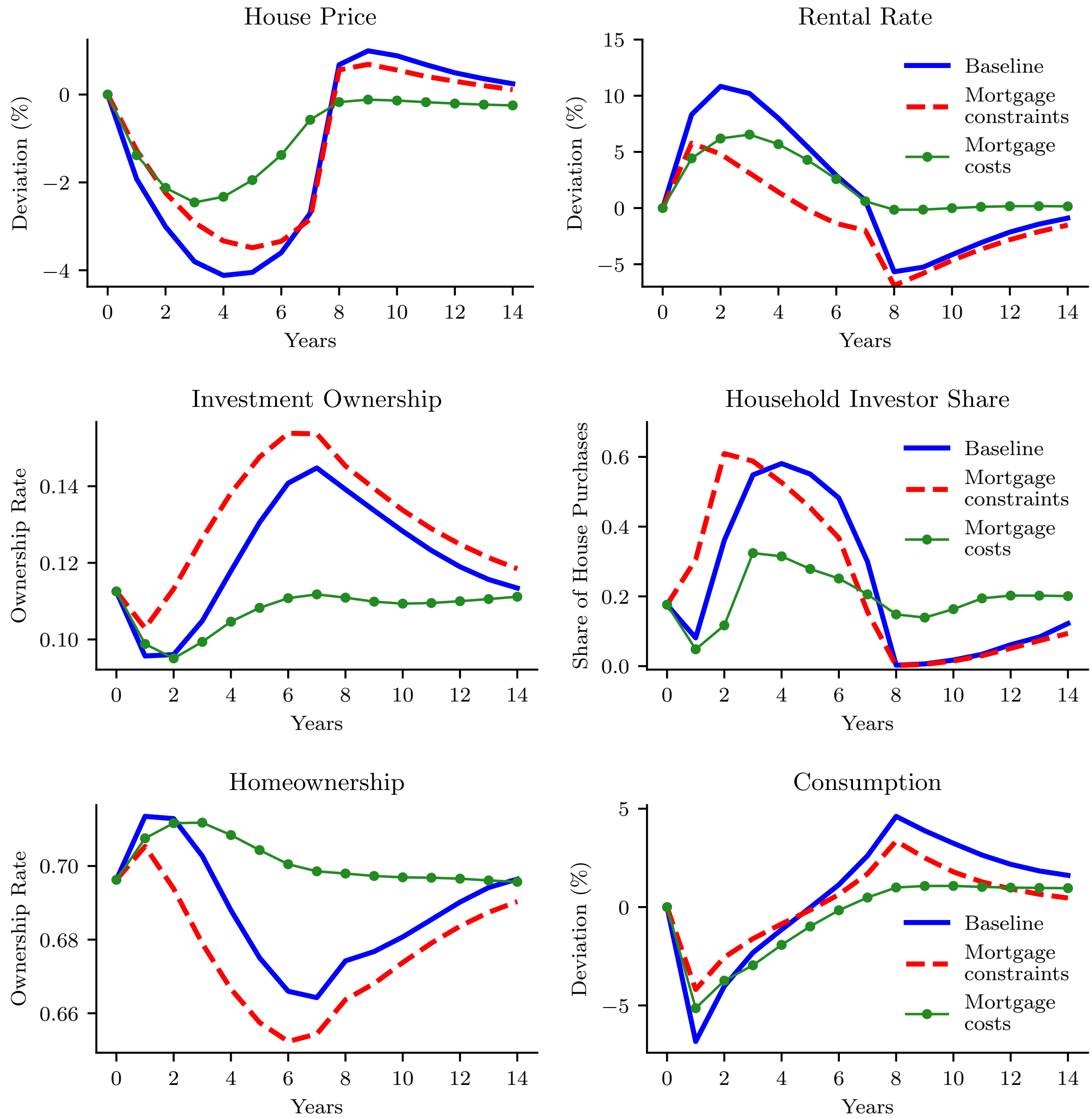


FIGURE D.1
Impulse Responses to Components of the Mortgage Credit Supply Shock

Notes: Impulse responses to different components of the mortgage credit shock. Responses plotted for the economy with $\varepsilon = 0$.