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Abstract

We study a general equilibrium model with a housing market to understand the role of credit access among borrowers and show that an adverse financial shock can increase the asymmetry in the housing wealth distribution of subprime and prime borrowers. Households with better credit access can take advantage of the low housing prices during recessions, especially when the subprimers are previously subjected to lax credit conditions. Our model is consistent with the data since the late 1980s, showing that the homeownership rates of the two groups move in opposite directions during turmoils as prime borrowers are more likely to invest in the housing market during recessions.

JEL Classification: E1, E32, E44, E52, G01, R21
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1 Introduction

The Great Recession reminded us how tightly connected the housing market and the financial sector are. As the U.S. economy slipped into the worst recession since World War II, the collapse of the housing market drove many homeowners, particularly subprime borrowers, to the brink of defaulting on their mortgages. As Gerardi, Shapiro, and Willen (2008) demonstrate, subprime borrowers are six times more likely to default than prime borrowers. The decline in house prices associated with this recession, however, might have created new investment opportunities for many prime borrowers who still had relatively easy access to credit. This paper studies the effects of the housing market and the heterogeneity in credit access on the reallocation of housing wealth among subprime and prime borrowers.

Using data from the *U.S. Census* and the *Survey of Consumer Finances* (SCF, henceforth), we first present evidence on the differential housing wealth distribution among borrowers during recessions. While prime borrowers tend to buy more investment homes during recessions, subprime borrowers are often unable to keep even their primary residences. We next show that prime borrowers are more likely to invest in the housing market during recessions than during recovery periods. While the overall homeownership rate tends to decline during recessions, this change is rather asymmetric among borrowers with different levels of credit access.

To understand the observed asymmetry in the housing market, we develop and estimate a general equilibrium model with borrowers who have varying levels of credit access. We classify these borrowers into two types, "subprimers" and "primers", whose maximum borrowing limits are constrained by the value of their homes. In the presence of an adverse financial shock, borrowing becomes disproportionately more costly for subprimers who have a higher risk premium compared to primers. Since primers can sustain better access to credit than subprimers during recessions, they are better positioned to capitalize on the declining house prices.

Our model is able to capture salient features of the data, notably the fact that since the late 1980s, while the homeownership rate among subprimers has been decreasing during recessions, this number has been increasing among primers. In fact, prime borrowers are more likely to invest in the housing market during recessions than during recovery periods. Building on these observations, we further demonstrate that when the financial shock follows a period in which the subprimers have lax credit conditions, the asymmetry between prime and subprime borrowers in their housing wealth distribution grows.

Our paper contributes to the vast literature on housing market and business cycle along several key dimensions. Our first source of novelty is that we use the *Survey of Consumer Finances* survey to document the contrasting responses in housing demand across prime and subprime borrowers during recessions and that we construct a dynamic model to help explain such patterns. Our paper, therefore, complements a strand of literature that studies the interplay among financial frictions, the housing sector, and the macroeconomy. In a series of seminal works, Iacoviello (2005) and Iacoviello and Pavan (2013 and 2013b) demonstrate that house price declines play a significant role not only in promoting recessions but also in magnifying the effects of ongoing recessions by tightening the collateral constraints of borrowers. Along these lines, Favilukis, Kohn, Ludvigson, and Van Nieuwerburgh (2013) show that the relaxation of collateral constraints and the decline in risk premia were the major reasons for the boom periods before 2007, while Mian, Rao, and Sufi (2013) and Kaplan, Mitman, and Violante (2016) find that the plunge in house prices was the main driving force in generating the Great Recession. Similarly, Liu, Wang, and Zha (2013) study the amplification effects on macroeconomic fluctuations generated from the positive correlation between land prices and business investment.

As another source of novelty, our paper analyzes the role of heterogeneity in credit access across borrowers. In particular, we introduce a risk premium between primers and subprimers and focus on the differential distribution of the housing wealth rather than the magnification mechanism that many in the literature have carefully documented. As Mian and Sufi (2009 and 2016) demonstrate, the heterogeneity of borrowers plays an important yet underappreciated role in understanding macroeconomic fluctuations. Krueger, Mitman, and Perri (2016) show that including wealth heterogeneity across borrowers into standard models amplifies the aggregate consumption drop during recessions. Guerrieri and Lorenzoni (2011) and Philippon and Midrigan (2011) introduce heterogeneity in the productivity of agents and find the drop in consumption to be larger for more constrained agents. By focusing on the heterogeneity in credit access, similar to the spirit of our paper, Huo and Rios-Rull (2016) argue that adverse financial shocks can generate large decreases in house prices. When the decreases in house prices are combined with the reduction in credit access, however, adverse shocks can depress consumption dramatically, especially for the more constrained agents.

Complementing the findings of Mian, Sufi, and Verner (2015) and Justiniano, Primiceri, and Tambalotti (2016), we show that when the financial shock follows a period in which the subprimers have lax credit conditions, the asymmetry of the housing wealth distribution between prime and subprime borrowers grows. As subprimers gain better access to credit, they accrue larger losses during recessions. This result closely resembles the credit environment before the Great Recession. For instance, Justiniano et al. (2016) show that a drop in interest rates helps subprimers to afford larger mortgages. While subprimers increase their demand for houses, they accumulate debt. The increase in demand causes larger spikes in housing prices and a more severe effect on the economy when subprimers default. Our paper departs from Justiniano et al. (2016) by focusing on the housing wealth reallocation rather than debt accumulation among borrowers.

Because the Great Recession is characterized not only by a housing market collapse but also by a near-zero nominal interest rate, we analyze the asymmetry between the two types of borrowers in an environment with an occasionally binding zero lower bound. Intuitively, when there is a decline in nominal interest rates, borrowing becomes cheaper, increasing housing demand and prices. However, when the nominal interest rate is constrained by the zero lower bound, there is a surge in the opportunity cost of savings and, hence, a decrease in available funds in the economy. The zero lower bound constraint, therefore, can help amplify the negative effects from a housing collapse and make borrowing harder for particularly more credit constraint borrowers. We find that when the zero-lower bound binds subprimers become worse off, which further increases the asymmetry between the two types of borrowers. Given this aspect, our paper also adds another dimension to the large literature that focuses on the effects of the zero lower bound. To the best of our knowledge, our paper is the first that studies the housing wealth distribution in the presence of an occasionally binding zero lower bound.

The rest of the paper is organized as follows. Section 2 lays out the empirical motivation of this paper by documenting the contrasting movements of homeownership rates across prime and subprime borrowers using U.S. data from 1989. Section 3 presents the model, followed by our calibration and estimation strategies presented in Section 4. Section 5 discusses our results and their implications. Section 6 concludes the paper.

2 Empirical Motivation

In this section, we present the empirical evidence that prime borrowers increase their residential investment during recessions to take advantage of the low house prices across the country. We start by documenting the descriptive statistics of homeownership over the business cycle. One key insight from this analysis is that the number of second homes, as measured by the number of "units whose residence is elsewhere," have been decreasing over recessions. Using micro-level data from the *Survey of Consumer Finances*, we next study the factors influencing homeownership during recessionary and non-recessionary periods

2.1 Homeownership over the Business Cycle

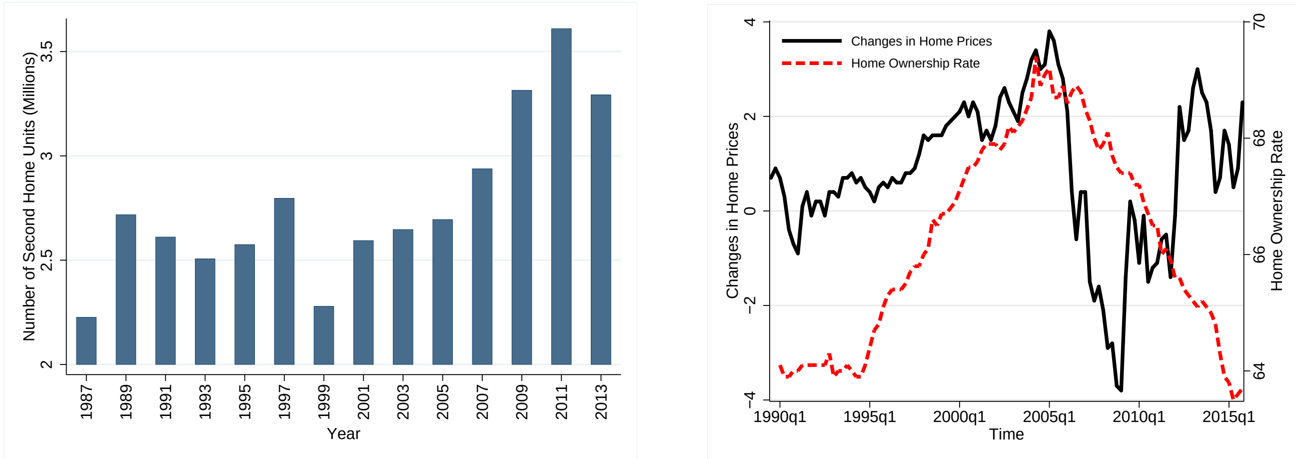
Figure 1a shows the total number of second home units since the late 1980s, as measured by the number of "units whose residence is elsewhere" from the *American Housing Survey* by the *U.S. Census*. The figure shows that the number of second home units increases following the advent of the three most recent recessions. Such increases in the number of second homes, however, do not seem to have much connection with the overall homeownership rate (Figure 1b). This observation suggests that there is a disconnection in the trends of homeownership between prime and subprime borrowers. Moreover, the overall homeownership rate has been gradually decreasing, yet house prices have been declining since 2006. As a result, while the majority of homeowners suffer from low house prices during recessions, another group of homeowners was able to turn these low prices into investment opportunities.

2.2 Homeownership and Credit Access During Recessions

Using micro-level data from the *Survey of Consumer Finances* (SCF), here we document the heterogeneity in the housing wealth reallocation among subprime and prime borrowers as observed in the aggregate data. The SCF consists of a triennial set of detailed questions about family income, real estate assets, and financial and demographic characteristics of the respondents for the period from 1989 to 2013.[1] We differentiate between the prime and subprime borrowers based on the loan rates they pay on their primary home mortgages. In particular, if the current loan rates of the borrowers are less than the prime rate of that year then these borrowers are listed as primers. Unlike prime rates, mortgage rates are long-term indicators, and thus, tend to be lower. Therefore,

Figure 1: Homeownership over Time

(a) Number of Second Home Units (b) Home Prices and Homeownership



Note: The figure on the left plots the total number of second home units (in millions). Data are from the American Housing Survey by the U.S. Census. Here we use the number of "units whose residence is elsewhere" (URE) as the number of total second-home units in the economy. The figure on the right plots the evolution of home prices and the overall rate of homeownership. Data for the right figure are from the St. Louis FRED database.

a relatively high cutoff ensures that we study a representative sample of primers. As Justiniano et al. (2016) documented, the ratio of prime borrowers to subprime borrowers is about 33 percent in the data, and our cutoff can generate about 25 percent. We define subprimers as the borrowers in the highest quartile of the loan rate distribution.[2]

Table 1 presents the first and second moments of selected variables from our dataset. Only about 3 percent of prime borrowers do not own a primary home and only about 29 percent of the subprimers own at least one investment home. Therefore, we cannot compare the two groups using a common type of homeownership since one group would be underpresented. Instead, we focus on the primary home purchase decisions by subprimers and on the investment home purchase decisions by primers.[3] As expected, subprimers have a higher rate of credit rejection, fewer credit cards, lower credit limit and income, and are less likely to be employed and be on time with their payments compared to primers. In addition, subprimers are more likely to have a female household head and a smaller sized family, and are relatively less educated. Primers and subprimers, however, do not show significant differences in terms of their economic expectations.

Figure 2a plots the rate of investment home ownership for prime borrowers and the rate of primary home ownership for the subprime borrowers over the past three recessions. While primers exhibit sharp increases in their investment homeownership during the recent three recessions,

Table 1: Descriptive Statistics

	Subprimers	**Primers**	**Full Sample**
Primary Homeownership	51.54%	97.31%	66.15%
	(0.50)	(0.16)	(0.47)
Investment Homeownership	29.44%	42.66%	32.45%
	(0.46)	(0.49)	(0.47)
Credit Rejected	29.62%	16.74%	25.55%
	(0.46)	(0.37)	(0.44)
Number of Credit Cards	1.59	2.56	1.90
	(1.80)	(1.99)	(1.92)
Payment Schedule (on time)	75.53%	89.54%	81.21%
	(0.43)	(0.31)	(0.39)
Median Income (log)	10.57	11.39	10.86
	(1.70)	(1.40)	(1.64)
Economic Expectations	1.12	1.04	1.14
	(0.77)	(0.74)	(0.77)
Employed	67.09%	88.15%	73.31%
	(0.47)	(0.32)	(0.44)
Retired	19.85%	7.60%	16.16%
	(0.40)	(0.26)	(0.37)
Male Household Head	73.65%	89.08%	78.07%
	(0.44)	(0.31)	(0.41)
Education (years)	13.41	14.72	13.80
	(2.99)	(2.42)	(2.89)
Household Size	2.48	3.06	2.66
	(1.41)	(1.42)	(1.45)
Number of Observations	145,122	35,534	207,640

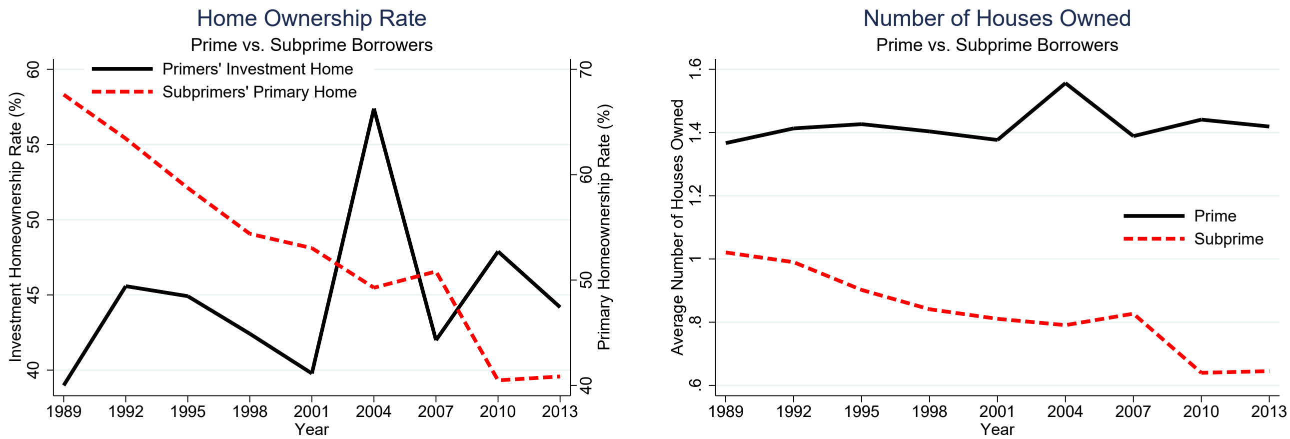
Note: The data are from the *Survey of Consumer Finances*. Standard deviations are in parenthesis. Prime and subprime borrowers are differentiated based on the loan rates of their first mortgages. A detailed description of some of these variables can be found in the appendix.

subprimers lose their primary residences at a steep rate. With similar tokens, Figure 2b shows the average number of houses owned by subprime and prime borrowers. While the average number of houses owned by primers has been steady over time, it has been declining for subprimers (from 1 in 1989 to less than 0.7 in 2013, on average). This observation dovetails with the contrasting patterns in the number of investment homes for prime borrowers and in the number of primary residence for the subprime borrowers (as in Figure 2a).

In order to analyze the trend in house investment decisions, we develop a formal structure taking demographic and financial differences among households into account. Specifically, we es-

Figure 2: Homeownership for Prime and Subprime Borrowers

(a) Homeownership Rate among Borrowers | (b) Number of Homes



Note: Figure 2a plots the primers' investment homeownership rate and subprimers' primary homeownership rate over time, per participants' survey responses. Figure 2b plots the average number of total houses for subprime and prime borrowers in the survey. Here we classify prime and subprime borrowers based on the rate on their first mortgages. Subprimers are the borrowers who are in the highest quartile of the loan rate distribution, whereas primers are borrowers whose current loan rates are less than the prime rate of that year.

timate the following Probit regression:

$$\begin{aligned} \textit{Home Ownership}_{i,t} &= \beta_0 + \beta_1 \textit{Year Fixed Effects}_t + \beta_2\, \textit{Demographic Controls}_{i,t} \\ &\quad + \beta_3\, \textit{Financial Controls}_{i,t} + \nu_{i,t} \end{aligned} \tag{1}$$

Here *Primary Home Ownership* and *Investment Home Ownership* are the two binary dependent variables we use in the analysis. In particular, *Primary Home Ownership* indicates whether the household owns a primary residence, and *Investment Home Ownership* shows whether the household owns an investment home. *Demographic Controls* include gender, age, and education level. The set of *Financial Controls* consists of variables that denote whether a household's credit application was rejected, whether the household's payments of loans have typically been on time or behind the schedule, whether the household head is retired, whether the household is unemployed or employed, the number of credit cards the responding household has, and a measure of 5-year economic expectations of the households. We also control for variations in income across different borrowers by including the log of incomes reported by the survey respondents. Additionally, we restrict the sample to exclude households whose total income is below the Federal poverty level

Table 2: Probit Regression Results: Impacts on Homeownership Rates

	Subprime Borrowers			**Prime Borrowers**		
1998 Recovery	-0.086***	0.017***	-0.027***	0.006	0.050***	0.005
	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.003)
2001 Recession	-0.116***	0.023***	-0.052***	0.007***	0.070***	-0.014***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
2004 Recovery	-0.169***	-0.013***	-0.124***	0.081***	0.152***	0.064***
	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)	(0.005)
2007 Recovery	-0.181***	0.014***	-0.096***	0.009***	0.106***	0.017***
	(0.001)	(0.0013)	(0.002)	(0.003)	(0.003)	(0.003)
Great Recession	-0.201***	0.024***	-0.112***	0.063***	0.144***	0.046***
	(0.001)	(0.001)	(0.001)	(0.006)	(0.007)	(0.006)
Demographic Controls	No	Yes	Yes	No	Yes	Yes
Financial Controls	No	No	Yes	No	No	Yes
Number of Observations	116,621	116,621	60,914	34,558	34,558	30,446

Note: Here ***, **, and * denote the 5%, 1%, and 0.1 % levels of significance, respectively. We report the marginal effects at the means. We classify prime and subprime borrowers based on their first loan rate: subprimers are the borrowers who are in the highest quartile of the loan rate distribution and primers are borrowers whose current loan rates are less than the prime rate of that year. We use Primary Home Ownership and Investment Home Ownership for subprimers and primers' homeownership rates, respectively. We also restrict the sample to exclude households whose total income is below the poverty line (i.e., $19,530 in 2013 U.S. Dollars). We estimate the following specification : $\textit{Home Ownership}_{i,t} = \beta_0 + \beta_1 \textit{Fixed Year Effects}_t + \beta_2\, \textit{Demographic Controls}_{i,t} + \beta_3\, \textit{Financial Controls}_{i,t} + \beta_4\, \textit{Log Income}_{i,t} + \nu_{i,t}$.

(i.e., $19,530 in 2013 U.S. Dollars), because these households would be highly unlikely to make a housing investment decision.

Table 2 presents the results of the Probit regression specified in Equation 1. Based on the observations drawn from the aggregate data (Figures 2a and 2b), we expect this micro-level analysis to show that households with better access to credit can take advantage of low house prices while others cannot due to adverse economic conditions. Table 2 demonstrates this heterogeneity in housing purchase decisions among borrowers during recessions. One key result is that primers are more likely to invest in the housing market during the last two recessions, compared to the recovery periods.[4] Subprimers, on the other hand, is less likely to invest during the recessions. This result is robust after controlling for the demographic and financial characteristics of the households. Financial controls decrease the magnitude of time fixed effect coefficients since they are tightly connected to credit access of borrowers. All in all, our findings support the conclusion that while the majority of homeowners seemed to suffer from low house prices during recessions, another group of homeowners had been able to capitalize on these low prices.

While not reported in the regression table, households who are more educated, have male household head, and are older are more likely to be homeowners.[5] As expected, households who are not credit rejected, obtain more credit cards, are on time with their payments, expect worse economic conditions in the next 5 years, and have high income are also more likely to own a house during any period.

3 Model

To understand the sources of the heterogeneity in housing wealth distribution as presented in Section 2, we develop a model with collateralized borrowing in the spirit of Iacoviello (2005). The economy is populated by six types of agents: households, entrepreneurs, retailers, capital producers, house producers and the Central Bank. Households are divided into patient households (savers), prime borrowers (primers) and subprime borrowers (subprimers). While patient households are assumed to own retailers, entrepreneurs own goods producers (firms). The model features a Taylor-rule monetary policy with an occasionally binding zero lower bound constraint to account for the near zero interest rates during the Great Recession.

3.1 Households

There are two fundamental differences across the households in the model. First, patient households (savers) give greater value to the future than both borrowers. Specifically, the discount factor of patient households is larger than that of subprime and prime borrowers. This assumption guarantees an equilibrium in which the borrowing constraints for primers and subprimers always bind. The second difference among the households is that only borrowers engage in housing market activities. This difference helps to account for individuals who do not want to buy (or are not capable of buying) real estate.

3.1.1 Patient Households (Savers)

Denoted with subscript h, savers make their consumption, $C_{h,t}$, and leisure, $1 - l_{h,t}$, decisions at time t. They also decide how much to save, D_t, for a return at the gross deposit rate, R_t. The patient households use the following objective function to maximize their lifetime utility from consumption and leisure:

$$\max_{C_{h,t},l_{h,t},D_t} E_t \left\{ \sum_{k=0}^{\infty} \beta_h^k \left[\ln(C_{h,t+k}) - \frac{l_{h,t+k}^{1+\xi}}{1+\xi} \right] \right\}$$

The maximization is subject to the following Walrasian budget constraint that equates household's spending to their income.

$$C_{h,t} + D_t = \frac{R_{t-1} D_{t-1}}{\pi_t} + w_t l_{h,t} + F_t \tag{2}$$

where π_t denotes the gross inflation rate as follows $\pi_t = (P_t / P_{t-1})$, and F_t represents the lump-sum profits from retailers (as detailed in Section 3.2.2), $w_t = W/P_t$ denotes the real wage. The first-order conditions to the problem of patient households are given by the following standard consumption Euler equation and the labor supply decision, respectively.

$$\frac{1}{\beta_h C_{h,t} R_t} = E_t \left\{ \frac{1}{\pi_{t+1} C_{h,t+1}} \right\} \tag{3}$$

$$l_{h,t}^{\xi} = \frac{w_t}{C_{h,t}} \tag{4}$$

3.1.2 Prime Borrowers

Prime borrowers engage in housing market activities by making a debt contract with the bank. Represented with the subscript p, primers buy real estate, $H_{p,t+1}$, at the price q_t^h at time t. The bank, however, requires some of their assets to be collateralized, which restrains the available credit to borrowers.

Prime borrowers maximize their utility from consumption and leisure as well as the utility that they get from housing services. They use the following objective function to maximize their utility subject to the flow of funds constraint in Equation 5 and the collateral constraint in Equation 6:

$$\max_{C_{p,t},H_{p,t+1},l_{p,t},B_{p,t+1}} E_t \left\{ \sum_{k=0}^{\infty} \beta_p^k \left[\ln(C_{p,t+k}) + \Gamma_p \ln(H_{p,t+k}) - \frac{l_{p,t+k}^{1+\xi}}{1+\xi} \right] \right\}$$

where Γ_p governs the weight of housing services in the utility function. Prime borrowers can use the amount borrowed from banks, $B_{p,t}$, their labor income, $w_t l_{p,t}$, and the return from their previous investment, $q_t^h H_{p,t}$, to finance their consumption, new housing investment, and repayment of their debt, as shown in Equation 5, where $Z_{p,t}$ denotes the gross lending rate.

$$C_{p,t} + q_t^h H_{p,t+1} = q_t^h H_{p,t} - \frac{Z_{p,t-1} B_{p,t-1}}{\pi_t} + B_{p,t} + w_t l_{p,t} \tag{5}$$

where q_t^h denotes the real house price as $q_t^h = Q_t^H / P_t$. Banks require some of the real estate to be used as collateral. With the collateral constraint denoted in Equation 6, households can borrow up to a limit.

$$B_{p,t} \leq m_p E_t \left\{ q_{t+1}^H H_{p,t+1} \frac{\pi_{t+1}}{Z_{p,t}} \right\} \tag{6}$$

Here m_p represents the loan-to-value ratio for the primers and has an important role in setting up the trade-off between consumption and housing as is discussed in Section 5.4. Equation 6 shows that the repayment of household's debt cannot exceed the expected future value of the real estate bought at time t. Equations 7 and 8 give the first order conditions to impatient household's problem that show labor supply and housing demand decisions, respectively.

$$l_{p,t}^{\xi} = \frac{w_t}{C_{p,t}} \tag{7}$$

$$\frac{\beta_p \Gamma_p}{H_{p,t+1}} = E_t \left\{ \frac{q_t^h}{C_{p,t}} + (m_p - 1) \frac{\beta_p q_{t+1}^h}{C_{p,t+1}} - \frac{m_p q_{t+1}^h}{\frac{Z_{p,t}}{\pi_{t+1}} C_{p,t}} \right\} \tag{8}$$

3.1.3 Subprime Borrowers

Similar to prime borrowers, subprime borrowers engage in the housing market through obtaining funds while using their houses as collateral. The difference between prime and subprime borrowers is that primers are charged a favorable (prime) rate by banks because they are expected to be more reliable borrowers. Subprimers, however, have to pay a higher rate due to their risk. The risk premium f_t between the gross loan rate of the prime and subprime borrowers is given by the following equation:

$$Z_s = Z_p + f_t \tag{9}$$

where f_t follows a mean reverting process as follows

$$f_t = (1 - \rho_f)\bar{f} + \rho_f f_{t-1} + \varepsilon_t^f \tag{10}$$

Here ρ_f denotes the level of persistence and ε_t^f is assumed to follow $N(0, \sigma_f)$. Subprimers maximize their consumption and leisure subject to the budget constraint in Equation 11 and the borrowing constraint in Equation 12.

$$C_{s,t} + q_t^h H_{s,t+1} = q_t^h H_{s,t} - \frac{Z_{s,t-1} B_{s,t-1}}{\pi_t} + B_{s,t} + w_t l_{s,t} \tag{11}$$

$$B_{s,t} \leq m_s E_t \left\{ q_{t+1}^h H_{s,t+1} \frac{\pi_{t+1}}{Z_{st}} \right\} \tag{12}$$

The subprimers' optimal decisions for labor supply and housing demand are as follows:

$$l_{s,t}^{\xi} = \frac{w_t}{C_{s,t}} \tag{13}$$

$$\frac{\beta_s \Gamma_s}{H_{s,t+1}} = E_t \left\{ \frac{q_t^h}{C_{s,t}} + (m_s - 1) \frac{\beta_s q_{t+1}^h}{C_{s,t+1}} - \frac{m_s q_{t+1}^h}{\frac{Z_{s,t}}{\pi_{t+1}} C_{s,t}} \right\} \tag{14}$$

3.2 Entrepreneurs

Entrepreneurs are assumed to own the good producers (firms). They rent capital from capital producers and provide it to the firms.

3.2.1 Good Producers (Firms)

Firms produce a homogeneous good, Y_t, using capital, labor, and commercial real estate through the following aggregate Cobb-Douglas production function.

$$Y_t = A_t K_t^{\alpha} H_{e,t}^{\kappa} (L_{e,t})^{(1-\alpha-\kappa)} \tag{15}$$

where $\alpha \geq 0$ and $\kappa \geq 0$ denote the capital and commercial estate shares in production, respectively.[6] A_t is the total factor productivity (TFP) that follows the AR (1) process in Equation 16.

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_t^A \tag{16}$$

where ρ_A is the persistence of the TFP shock, and $E(\varepsilon_t^A) = 0$. Firms maximize their consumption with respect to Equations 15 and 16, as well as their flow of funds in Equation 17, and borrowing constraint in Equation 19.

$$\max_{C_{e,t},K_{t+1},H_{e,t+1},L_{e,t},B_{e,t+1}} E_t \left\{ \sum_{k=0}^{\infty} \beta_e^k \ln(C_{e,t+k}) \right\}$$

$$C_{e,t} + q_t^h H_{e,t+1} = \frac{Y_t}{X_t} + q_t^h H_{e,t} - w_t L_{e,t} - q_t I_t + B_{e,t} - \frac{Z_{e,t-1} B_{e,t-1}}{\pi_t} \tag{17}$$

where

$$L_{e,t} = \nu \left(\varrho L_{p,t} + (1-\varrho) L_{s,t} \right) + (1-\nu) L_{h,t} \tag{18}$$

Here $L_{e,t}$ represents the total labor demand in the economy, ν gives the relative size of borrowers to patient households and ϱ shows the relative mass of prime borrowers to subprime borrowers. Similar to subprimers and primers, firms can only borrow up to the expected future value of their total assets. The borrowing constraint of the entrepreneurs is given by

$$B_{e,t} \leq m_e E_t \left\{ \left(q_{t+1}^h H_{e,t+1} + q_{t+1} K_{t+1} \right) \frac{\pi_{t+1}}{Z_{e,t}} \right\}, \tag{19}$$

where m_e is the loan-to-value ratio for firms and $q_t = \dfrac{Q_t}{P_t}$ is the real capital price. The solution of firm's maximization problem is given by the following three equations. They represent the demand for capital, housing, and labor, respectively.

$$\frac{\beta_e q_{t+1}}{C_{e,t+1}} \left(\frac{\alpha Y_{t+1}}{q_{t+1} X_{t+1} K_{t+1}} + (1-\delta) - m_e \right) + \frac{1}{C_{e,t}} \left(\frac{m_e q_{t+1}}{\frac{Z_{e,t}}{\pi_{t+1}}} - q_t \right) = 0 \tag{20}$$

$$\frac{\beta_e q_{t+1}^h}{C_{e,t+1}} \left(\frac{\kappa Y_{t+1}}{q_{t+1}^h X_{t+1} H_{e,t+1}} + (1-m_e) \right) + \frac{1}{C_{e,t}} \left(\frac{m_e q_{t+1}^h}{\frac{Z_{e,t}}{\pi_{t+1}}} - q_t^h \right) = 0 \tag{21}$$

$$(1-\alpha-\kappa) \frac{Y_t}{L_{e,t}} = w_t \tag{22}$$

3.2.2 Retailers

Following Iacoviello (2005), we assume that there is a continuum of monopolistically competitive retailers who are the source of nominal rigidity. They buy intermediate goods from the firms at the wholesale price P_t^w in a competitive market. The final goods are distributed from the bundle $Y_t = \left(\int_0^1 Y_t(z)^{(\varepsilon-1)/\varepsilon} dz \right)^{\varepsilon/(\varepsilon-1)}$. We assume that in each period there is a probability $\theta \in (0,1)$ that the prices will not change; hence, each period retailers have a probability $1-\theta$ to reset their price. Since optimally each retailer selects the same price, it follows that

$$\pi_t = \left[(1-\theta)\left(\pi_t^c\right)^{1-\varepsilon} + \theta\right]^{\frac{1}{1-\varepsilon}} \tag{23}$$

Here the optimal price that each retailer changes to is $\pi_t^c \equiv \frac{P_t^c}{P_{t-1}}$, and the retailers' profit is $F_t = \left(1 - \frac{1}{X_t}\right) Y_t$, where X_t denotes the markups in period t. Given that the patient households own the retailers, the profits are distributed back to the households.

3.3 Capital Producers

Capital producers produce new capital goods, which replace the depreciated capital and contribute to the capital stock. Capital producers maximize their own profit subject to the quadratic capital adjustment cost, $\frac{\chi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t$.

$$\max_{I_t} E_t \left\{ q_t x_t^i I_t - I_t - \frac{\chi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t \right\}$$

Here x_t^i is the investment specific technology shock which follows the auto-regressive process in Equation 24 where $\varepsilon_t^{x^i}$ is normally distributed with mean zero and standard deviation σ_{x^i}.

$$\log(x_t^i) = \rho_{x^i} \log(x_{t-1}^i) + \varepsilon_t^{x^i} \tag{24}$$

The optimal condition to capital producers' profit maximization provides the following capital price rule, which is equal to 1 at the steady state.

$$E_t \left\{ q_t x_t^i - 1 - \chi\left(\frac{I_t}{K_t} - \delta\right) \right\} = 0 \tag{25}$$

The law of capital motion is assumed to follow

$$x_t^i I_t = K_{t+1} - (1-\delta) K_t \tag{26}$$

3.4 House Producers

Similar to capital producers, house producers maximize their own profits subject to the quadratic housing adjustment cost, $\frac{\chi_h}{2}\left(\frac{\Delta H_t}{H_t}\right)^2 H_t$, and housing supply shock, x_t^h, where

$$x_t^h \Delta H_t = H_{t+1} - H_t \tag{27}$$

and $H_t = H_{p,t} + H_{s,t} + H_{e,t}$.[7] The housing supply shock follows the auto-regressive process below:

$$\log(x_t^h) = \rho_{x^h} \log(x_{t-1}^h) + \varepsilon_t^{x^h} \tag{28}$$

The house producers maximize the following problem:

$$\max_{H_t} E_t \left\{ q_t^h x_t^h \Delta H_t - \Delta H_t - \frac{\chi_h}{2}\left(\frac{\Delta H_t}{H_t}\right)^2 H_t \right\}$$

The optimal condition to the house producers' profit maximization provides the following house price rule, which is equal to 1 at the steady state.

$$E_t \left\{ q_t^h x_t^h - 1 - \chi_h \left(\frac{\Delta H_t}{H_t}\right) \right\} = 0 \tag{29}$$

3.5 Risk-Free Rate and Monetary Policy

We posit that monetary policy follows a Taylor rule specification as in Equation 30, where b_1 and b_2 are the parameters that govern the central bank's weight on the output gap and inflation gap target. Here e_t^R denotes the monetary policy shock.

$$R_t = \bar{R}\left(\left[\frac{Y_t}{\bar{Y}}\right]^{b_1} \left[\frac{1+\pi_t}{1+\bar{\pi}}\right]^{b_2} \right) e_t^R \tag{30}$$

Here the monetary policy shock e_t^R follows an AR(1) process as follows:

$$\log\left(e_t^R\right) = \rho_e \log\left(e_{t-1}^R\right) + \varepsilon_t^R \tag{31}$$

in which ε_t^R is normally distributed around 0 with standard deviation σ_R. Additionally, the nominal interest rate is bounded by zero as expressed below.

$$R_t - 1 \geq 0 \tag{32}$$

3.6 Market Clearing Conditions

The economy-wide resource constraint is shown below, where I_t denotes the gross capital investment and ΔH_t denotes the total housing investment.

$$Y_t = C_t + I_t + \Delta H_t \tag{33}$$

In Equation 33, C_t represents the aggregate consumption and is the sum of households, borrowers, and entrepreneurs' consumption, as shown in Equation 34.

$$C_t = C_{h,t} + C_{p,t} + C_{s,t} + C_{e,t} \tag{34}$$

The following labor market clearing conditions guarantee that the demand for and supply of labor will be equal; namely, $L_{e,t} = l_{h,t} + l_{s,t} + l_{p,t}$. Lastly, Equation 35 shows that the loans market clears when the supply of deposits is equal to the demand for funds by subprimers, primers, and entrepreneurs as follows.

$$D_t = B_{p,t} + B_{s,t} + B_{e,t} \tag{35}$$

4 Calibration and Estimation

We estimate a number of important parameters while calibrating the rest to values that are either common in the literature or to values from the data. Table 3 presents the set of parameters that we calibrate. We choose standard values for the taste and technology parameters. The capital share in production and the depreciation rate are set to 0.33 and 0.025, respectively. The weight of leisure in the utility function for households is set so that the Frisch elasticity is equal to 1. We pick the commercial housing share in the production function of the firms so that the entrepreneurial loan rate matches the data for our time period.[8] The relative size of primers to subprimers is set to 0.64 following Justiniano et al. (2016), and the relative size of borrowers to patient households is set

Table 3: Calibrated Parameters

Parameters	**Description**	**Value**	
α	Share of capital in production	0.33	Standard Parameter
δ	Capital depreciation	0.025	Standard Parameter
ξ	Inverse of Frisch elasticity	1	Frisch elasticity=1
ϱ	Relative size of of primers to subprimers	0.64	Justiniano et al. (2016)
ν	Relative size of borrowers to patient households	0.65	U.S. Bureau of Economic Analysis (BEA)
$\bar{f}$	Steady-state level risk premium	2%	Our calculations from SCF
Γ_s	Weight of housing in the utility function of subprimers	is set so that annualized $\frac{Q^h H_s}{Y} = s$ matches the data	Our calculations from SCF
Γ_p	Weight of housing in the utility function of primers	is set so that annualized $\frac{Q^h H_p}{Y} = p$ matches the data	Our calculations from SCF
b_1	Taylor Rule Output Weight	0.5	Taylor (1993)
b_2	Taylor Rule Inflation Weight	1.5	Taylor (1993)

to 0.65 using the homeownership data from the *U.S. Bureau of Economic Analysis* (BEA).[9] The steady state level of risk premium is calculated from the SCF dataset using long run mortgage rates for prime and subprime borrowers. We pick the weights of housing in utility functions so that they match the housing stock of subprimers and primers to the data. Following Taylor (1993), we select neutral values of the weights on output (b_1) and inflation (b_2) targeting. In particular, the coefficients for the Taylor rule are set to be 0.5 for the output weight and 1.5 for the inflation weight.

We estimate the rest of the parameters using a variety of sources as guesses for prior information. The prior information for capital and housing adjustment costs are taken from Christensen and Dib (2008) and Ngo (2015) and are guessed to be around 0.59 and 0.1, respectively.[10] Following our calculations from the SCF, the premium between the subprime and prime loan rates is chosen to be around 2% in the steady state.[11] Our initial guess for the weights of housing in utility functions are set so that in the steady state the housing stock of subprimers is 76% of the GDP, whereas the ratio of housing stock of primers to GDP is equal to 2.8. These values are calculated using the data from Amromin and Paulson (2010) as well as the FRED and BEA databases. In line with the data presented in Ferreira and Gyourko (2015), we guess the loan-to-value ratio for

Table 4: Priors and Posteriors of Estimated Parameters

Parameters	Prior Mean	Posterior Mean	90% HPD	interval	Prior	Posterior Std.
β_H	0.97	0.9701	0.9667	0.9733	beta	0.002
β_S	0.95	0.9501	0.9472	0.9537	beta	0.002
β_P	0.965	0.965	0.9615	0.9683	beta	0.002
β_e	0.96	0.9599	0.9566	0.9632	beta	0.002
ρ_A	0.5	0.656	0.6558	0.6562	beta	0.02
χ_K	0.3	0.5872	0.5871	0.5873	beta	0.003
χ_H	0.3	0.586	0.586	0.586	beta	0.003
m_e	0.5	0.8182	0.8175	0.8187	norm	0.03
m_s	0.5	0.7423	0.741	0.7432	norm	0.03
m_p	0.5	0.6647	0.6629	0.6664	norm	0.03
ϱ	0.4	0.399	0.3549	0.4429	beta	0.03
θ	0.75	0.7701	0.7692	0.7709	norm	0.02
e	0.6	0.6761	0.6758	0.6766	norm	0.03
s	0.6	0.7913	0.7895	0.7921	norm	0.03
p	2.5	2.8618	2.8606	2.8624	norm	0.03
ρ_f	0.5	0.6206	0.6151	0.625	beta	0.1
ρ_X	0.5	0.6848	0.6839	0.6857	beta	0.1
ρ_{XI}	0.5	0.7886	0.7863	0.7908	beta	0.1
$Z_{e,ss}$	1.051	1.074	1.0738	1.0742	norm	0.01

Standard Deviation of Shocks

Shocks	Prior Mean	Posterior Mean	90% HPD	interval	Prior	Posterior Std.
ε_A	0.01	0.0416	0.0372	0.0459	invg	Inf
ε_e	0.01	0.0745	0.068	0.0803	invg	Inf
ε_f	0.02	0.0232	0.0213	0.0248	invg	Inf
ε_X	0.01	0.0386	0.0343	0.0431	invg	Inf
ε_{XI}	0.01	0.0038	0.0024	0.0052	invg	Inf
ε_P	0.01	0.0099	0.009	0.0107	invg	Inf

Note: We estimate the model to fit five series: real output growth (GDPC96), bank prime loan rate (MPRIME), growth rate of the private residential investment (PRFI), the growth rate of house prices (MSPUS), and real consumption growth (PCECC96). Data are all seasonally adjusted, HP filtered, and transformed in a way such that the variable definitions match ours in the model. Please see the appendix for more details. Here $e = Qh \times He/Y$ denotes the steady state level of commercial real estate relative to output. m_s, m_p, and m_e denote the loan-to-value ratio for sub-primers, primers, and entrepreneurs, respectively.

primers, subprimers, and entrepreneurs to be 90%.

Table 4 presents our sets of estimated parameters, along with our choices of prior and posterior information. For estimation, we attempt to match the baseline model to five series: real output growth (GDPC96), bank prime loan rate (MPRIME), growth rate of the private residential investment (PRFI), the growth rate of house prices (MSPUS), and real consumption growth (PCECC96). We obtain data after the *Great Moderation* (1984:Q1 to 2016:Q2) from the St. Louis' (FRED) database, where all data series are seasonally adjusted and filtered using Hodrick-Prescott filter (HP). We estimate the model using Bayesian methods with Metropolis-Hastings algorithm and make sure the Markov Chain Monte Carlo (MCMC) converges to its egordic distribution.

As Table 4 shows, the estimated discount factors match the findings in Lawrance (1991) and Samwick (1998). In particular, while Lawrance (1991) estimates the quarterly discount rate of borrowers (or the less patient households) to be between 0.95 and 0.98, Samwick (1998) finds the discount factors for all agents to be between 0.91 and 0.99. In line with these findings, we estimated 0.97, 0.96, 0.965 and 0.96 to be the mode of the discount rates of patient households, subprimers, primers, and entrepreneurs, respectively.

5 Results

This section demonstrates that an adverse financial shock can lead to asymmetric housing wealth distribution among primers and subprimers. An increase in the financial friction, or equivalently an increase in the risk premium that subprime borrowers pay, can significantly affect the asymmetry in housing wealth across borrowers. Besides the financial shock, we examine the effects of non-financial shocks such as TFP, capital and housing supply shocks, and the monetary policy shock to the asymmetry of housing wealth distribution. Except the housing supply shock, the non-financial shocks have little impact on the housing wealth distribution as they tend to affect borrowers similarly.

Since the recent financial crisis coincide with a period of near zero interest rates and lax borrowing conditions, we examine the effects of an adverse financial shock at the zero lower bound and study the role of collateral constraints. We show that the zero lower bound amplifies the macroeconomic aggregates compared to the case in which the zero lower bound does not bind, yet has a limited effect on housing wealth distribution. To examine the role of lax credit constraints, we study how variations in the loan-to-value (LTV) ratio of subprimers can amplify the effects of an adverse financial shock on the housing wealth across borrowers.

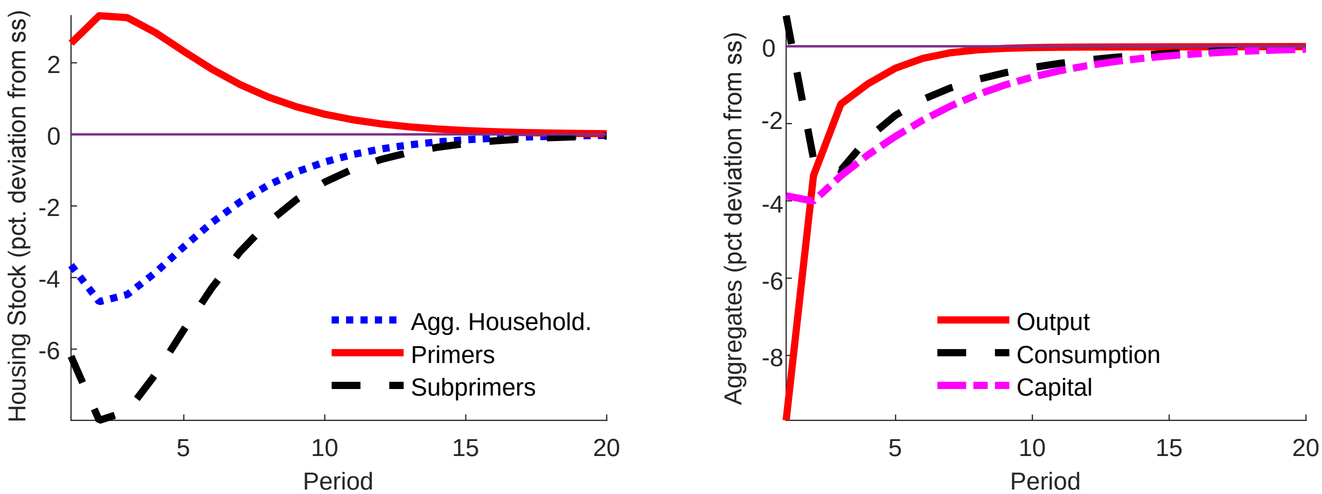
5.1 The Effects of the Financial Shock

Here we document the responses of the housing market and other macroeconomic aggregates to an adverse financial shock. To do so, we solve the model in Section 3 under the baseline calibration presented in Section 4 and account for the occasionally binding zero lower bound by using piecewise approximation.[12] We generate the impulse responses by initiating a one standard deviation adverse shock to the financial friction. Figure 3 demonstrates the responses to this financial

Figure 3: Responses to an Adverse Financial Shock

(a) Housing Market

(b) Macroeconomic Aggregates



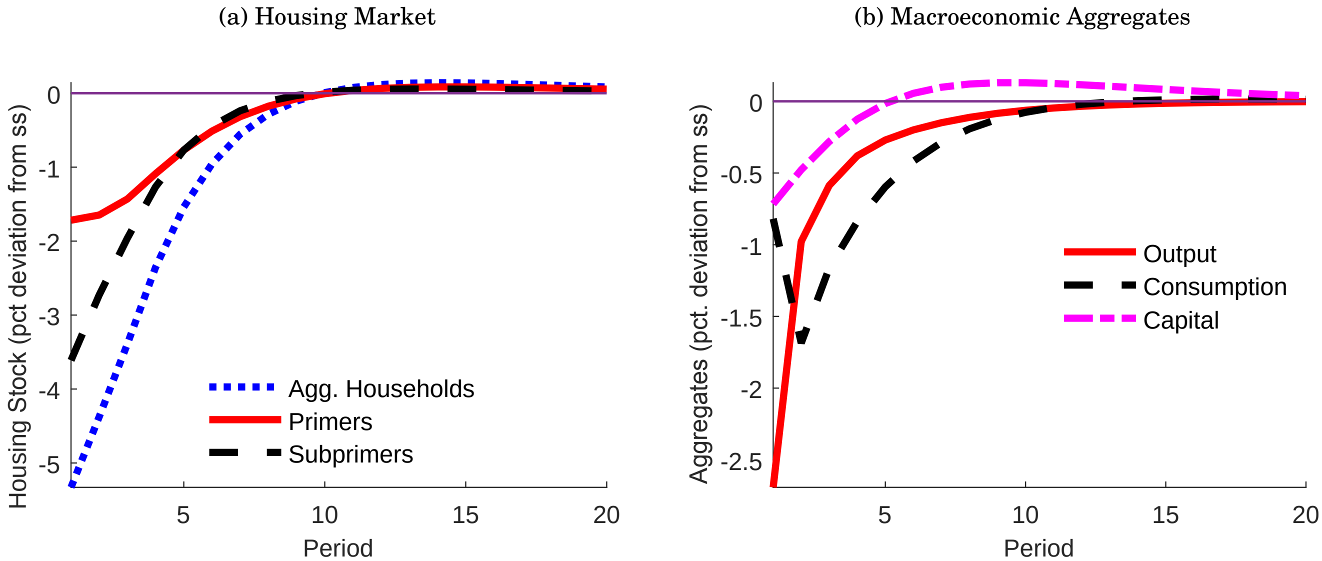
Note: This figure plots the impulse responses of selected variables to a standard deviation increase in the innovation of the financial friction, ε_t^f. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

shock which are normalized such that they represent percentage deviations from their respective steady-state values.

Figure 3 shows that a one standard deviation increase in the gap between primers and subprimers' loan rates can lead to an increase of over 2% in the housing investment for the primers and a decrease of around 6% for the subprimers. The intuition of the mechanism is as follows. The adverse financial shock significantly increases the relative cost of obtaining additional housing for the subprimers compared to the prime borrowers. Since subprimers have to pay disproportionately higher loan rates, their collateral constraints bind faster than that of primers. Because of the tightening of their collateral constraint together with the high loan rates, subprimers demand less housing. Given that subprimers account for about 65% of all borrowers, the overall demand for real estate investment in the economy decreases, diminishing house prices. Since primers still have relatively better access to credit compared to subprimers, they take advantage of low house prices and increase their investment.

Turning to the responses of macroeconomic aggregates, a one percent increase in the risk premium can have significant effects on the economy. Specifically, output, consumption, and capital decrease following a negative financial shock (i.e., an increase in the level of risk premium) as the

Figure 4: Responses to an Adverse TFP Shock



Note: This figure plots the impulse responses of selected variables to a one standard deviation decrease in the innovation of TFP ε_t^A. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

overall demand for real estate investments declines. While primers can take advantage of their relatively better access to credit, their gains are far from being able to make up for the decreases in the housing demand of subprime borrowers. Thus, the economy as a whole experience a further decrease in output, consumption, and capital as a result of an increase in risk premium for the subprime borrowers.

5.2 The Effects of Non-Financial Shocks

5.2.1 The Effects of the TFP Shock

Figure 4 shows the responses of housing market and other macroeconomic variables to a one standard deviation decrease to the TFP. As expected, a negative shock reduces capital investment, consumption, and output. However, the reallocation of housing wealth among primers and subprimers disappears as both borrowers are affected similarly. This result shows that the risk premium between borrowers is an important source of heterogeneity contributing to the asymmetry in housing wealth distribution observed in the data.

5.2.2 The Effects of Capital and Housing Supply Shocks

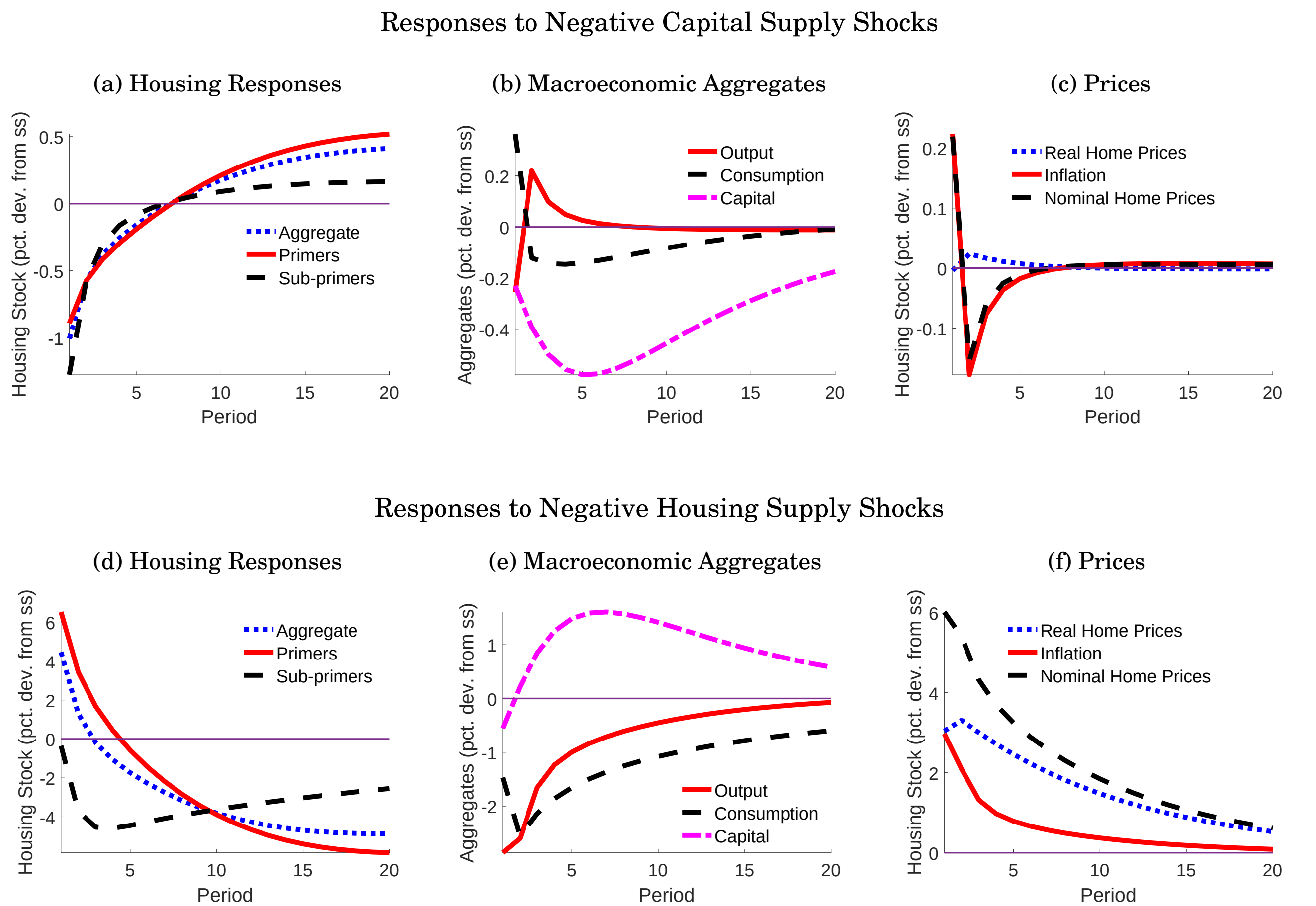
In this section, we investigate the effects of a negative capital supply shock (i.e., the investment specific technology shock x_t^i) and negative housing supply shock (i.e., the housing specific technology shock x_t^h). In particular, we initiate a one standard deviation decrease in the innovations of each shock, the results of which are plotted in Figure 5. As expected, a negative shock on capital supply causes the entrepreneurs to substitute away from capital. Thus, while the capital stock decreases in the economy, entrepreneurs demand more housing. Figure 5c shows that the increase in entrepreneurial demand on housing is not sufficiently large to push the nominal house prices up entirely. Thus, the borrowing constraints become tighter for both subprimers and primers, the combination of which prompts the two types of borrowers to consume more, rather than to ramp up their investments in housing. As the initial negative effect on output diminishes, the increase in consumption causes the economy to recover.

On the other hand, a negative housing supply shock increases the house prices while decreasing the available supply in the market. As seen in Figure 5f, increases in house prices relax the borrowing constraint by increasing the collateral value. The less constrained agents, i.e., the primers, enjoy the lax credit constraints more, while subprimers are further constrained by higher house prices. However, these contrasting patterns between the prime and subprime borrowers do not materialize in the case of a negative capital supply shock (x_t^i). In particular, the capital supply shock (in Figure 5a) cannot generate significant wealth reallocation between subprime and prime borrowers as both borrowers are similarly affected.

5.2.3 The Effects of Monetary Policy Shock

Figure 6 shows the responses of housing market and other macroeconomic variables to a one hundred basis point decrease in the nominal interest rate. In particular, here we initiate a negative 100-basis-point shock to the innovation of the interest rate process ε_t^R. As expected, an expansionary monetary shock implies a persistent increase in consumption. As the left panel shows, while housing investment for both primers and subprimers increase significantly, those of primers are more persistent. This result dovetails with the idea that primers are better positioned to take advantage of an expansionary monetary policy.

Figure 5: Impacts of Negative Supply Shocks



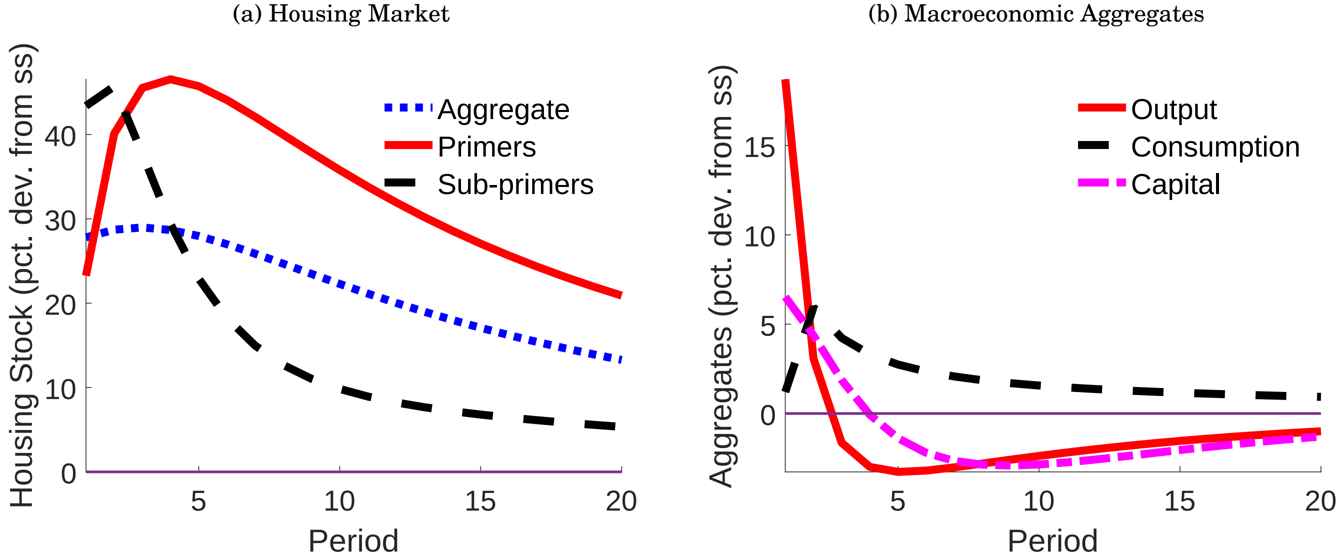
Note: This figure plots the impulse responses of selected variables to a one percent decrease in the innovation to the investment and housing specific technology shocks. Aggregate housing demand does not include that of entrepreneurs. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

5.3 The Role of the Zero Lower Bound

We also explore the effects of an adverse financial shock when the economy is at the zero lower bound. In particular, we initiate a negative preference shock to β_h so that the risk-free interest rate R_t is kept at the zero lower bound for four periods, and we then employ a one standard deviation adverse financial shock to the economy. We solve the model using piecewise approximation as in Iacoviello (2015). Figure 7 presents the impulse responses of housing demand, total output, house prices, and total savings for the case when the economy is kept at the zero lower bound against the case when the interest rate is allowed to follow the standard Taylor rule.[13]

An adverse financial shock significantly amplifies the effects on all the macroeconomic variables

Figure 6: Impacts of Expansionary Monetary Policy

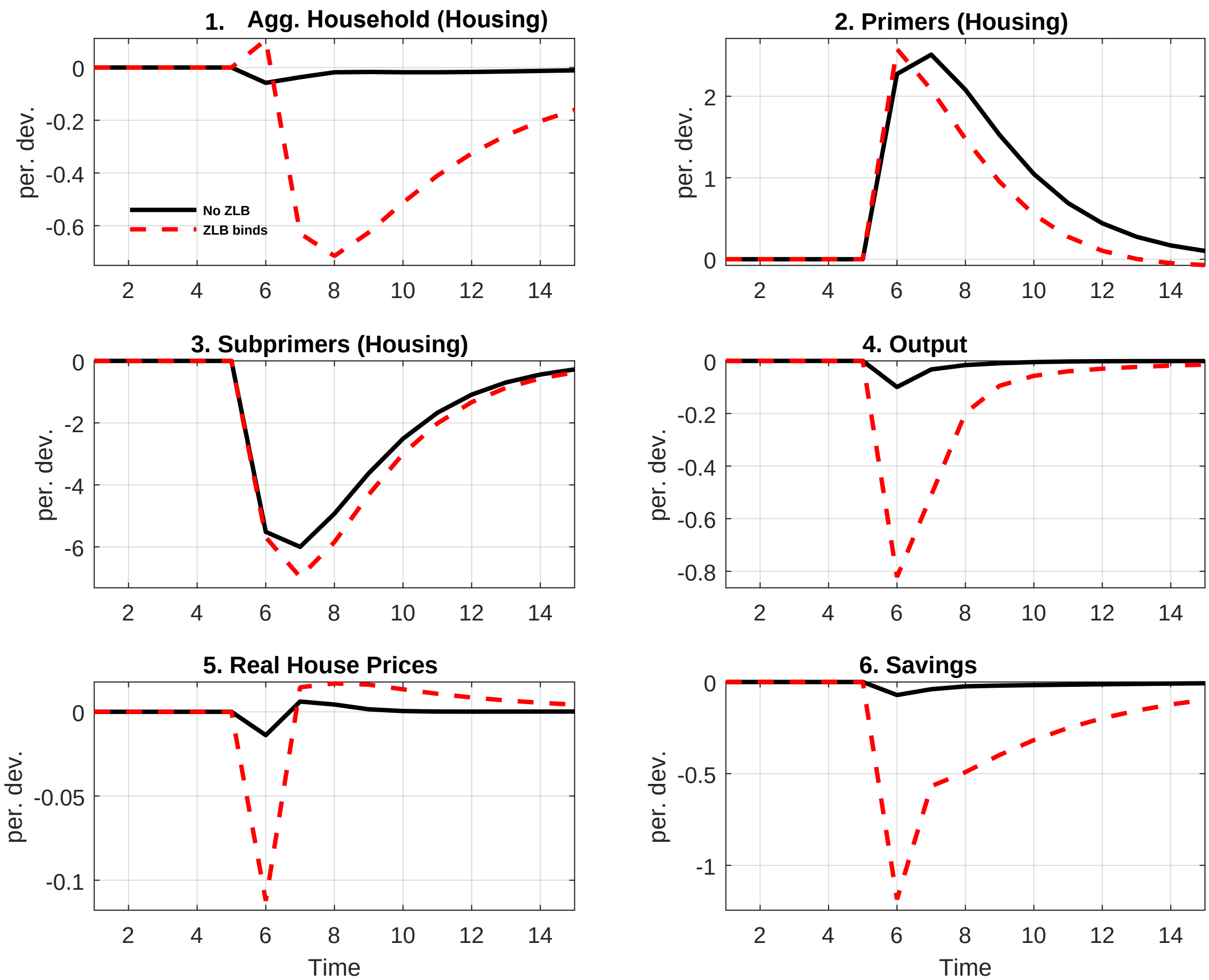


Note: This figure plots the impulse responses of selected variables to a one standard deviation decrease in the innovation to the nominal interest rate ε_t^R. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

when the economy is at the zero lower bound. The intuition for this result is as follows. When the economy reaches the zero lower bound under an adverse financial shock, it becomes increasingly costly to save using the risk-free bond with the presence of inflation. As a result, the amount of available funds in the economy decreases, making it harder to borrow for everyone and causing a decrease in aggregate housing demand. As a result, house prices decline further, leading to a vicious cycle in the economy by decreasing the output more than the case without the zero lower bound. Under the zero lower bound regime, primers do not have a significant change in housing investment behavior whereas subprimers become worse off. Therefore, the wealth reallocation between primers and subprimers exhibits small magnification effects in the case of a constrained nominal interest rate.

5.4 The Role of Collateral Constraints and the Loan-to-Value Ratio

Collateral constraint serves as an important channel in our model and the loan-to-value (LTV) ratio directly affects this constraint. Therefore, in this section we vary the LTV ratio to understand the role of collateral constraints in creating asymmetries across different types of borrowers. By not constraining the loan-to-value ratio, we took a conservative route to pin down the effects coming



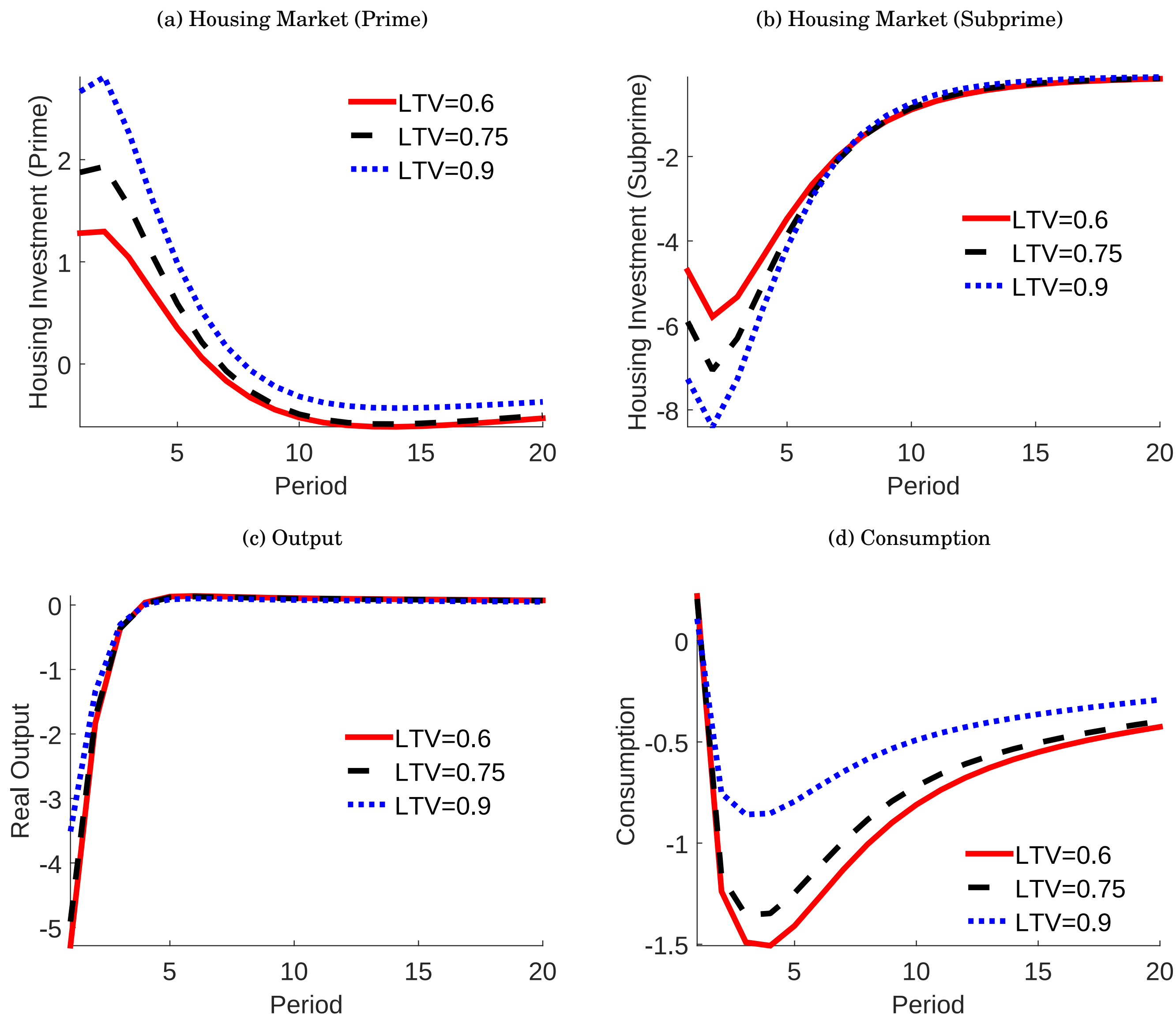
Note: This figure plots the impulse responses of selected variables to a one standard deviation increase in innovation to the financial friction, ε_t^f. All responses are normalized so that the units of the vertical axes are percentage deviations from the steady-state. Aggregate housing demand does not include that of the entrepreneurs. We solve the model using piecewise approximation, following Iacoviello (2015).

only from the risk premia. However, a decrease in this ratio can cause tighter borrowing conditions for all borrowers. For instance, consider the following borrowing constraint for the subprime borrowers.

$$B_{s,t} \leq m_s E_t \left\{ q_{t+1}^H H_{s,t+1} \frac{\pi_{t+1}}{Z_{s,t}} \right\}$$

Here the LTV ratio for the subprimers, m_s, creates a constraint on the value of assets and limits the amount that a subprime borrower can obtain using their housing as collateral. If LTV ratios differ across borrowers, then their housing investment decisions could vary as a result of their borrowing conditions. A static exercise on the housing and consumption trade-off can provide the

Figure 8: Responses to Adverse Financial Shocks (Varying Loan-to-Value Ratios for Subprimers)



Note: This figure plots the responses of selected variables to an adverse financial shock. In particular, we initiate a positive one standard deviation shock to the innovation of the risk premium between the prime and subprime borrowers, ε_t^f. We vary the loan to value ratio for subprime borrowers m_s, keeping everything else in line with the baseline calibration.

necessary intuition.

$$\frac{\beta_p \Gamma_s}{H_{s,t+1}} = E_t \left\{ \frac{q_t^h}{C_{s,t}} + (m_s - 1)\frac{\beta_s q_{t+1}^h}{C_{s,t+1}} - \frac{m_s q_{t+1}^h}{\frac{Z_{s,t}}{\pi_{t+1}} C_{s,t}} \right\}$$

Analyzing the consumption and housing trade-off, as shown above, yields that $\frac{\partial \frac{C_s}{q^h H_s}}{\partial m_s} > 0$ if $Z_s > \frac{1}{\beta_s}$ and $\frac{\partial \frac{C_s}{q^h H_s}}{\partial m_s} < 0$ if $Z_s < \frac{1}{\beta_s}$ in the steady state. In other words, when subprimers are subjected to an adverse financial shock, their loan rates will increase disproportionately more compared to prime borrowers. A higher value of Z_s will push subprimers into the case in which $Z_s > \frac{1}{\beta_s}$. Thus, an increase in subprimers' loan rates will make them prefer consumption over housing investment in the equilibrium.

To understand the role of collateral constraints in a dynamic setting, we collected micro-level evidence on plausible values of the LTV ratios using the public database for Fannie Mae and Freddie Mac by the *Federal Housing Finance Agency*. In 2014, across a total of 34,300 loans in the database, the average LTV ratio is 0.765 with the standard deviation of 0.16. Using the range of values obtained from this dataset, Figure 8 presents the responses of housing demand, output, and consumption to an adverse financial shock. In this analysis, while we set the LTV ratio of the prime borrowers following the benchmark parametrization, we use different values for the loan-to-value ratios of subprimers at 0.6, 0.75, and 0.9.

Figure 8 shows that higher LTV ratios for subprimers, or equivalently laxer credit constraints, magnify the asymmetry in housing wealth distribution between subprimers and primers. Despite this negative effect, laxer credit constraints cause a smaller decrease in consumption and output. This result is expected because when subprimers have better credit conditions (higher LTV ratios), they can better smooth out the adverse effects of financial shocks. As a result, the effects of these adverse shocks on consumption (and therefore output) would be more subdued. Moreover, lax credit conditions also cause subprimers to have excess leverage which yields higher losses in housing under a credit crunch.

This exercise shows that the LTV ratio plays an important role in amplifying the housing wealth distribution inequality across agents during recessions. In particular, tighter credit constraints for subprimers can dampen the effects on housing wealth distribution across borrowers at the cost of having larger decline in output and aggregate consumption.

6 Conclusion

In this paper, we investigate the effects of heterogeneity in terms of credit access among borrowers on the housing wealth distribution during recessions. Using macro-level data, we find that the secondary home purchases increase significantly during recessions, while overall homeownership and house prices decline steadily. To differentiate and control for the characteristics of borrowers, we use micro-level survey data from the *Survey of Consumer Finances*. We classify the borrowers as prime and subprime borrowers based on their mortgage loan rates and control for borrowers' demographic characteristics, such as gender, age, and education and financial characteristics such as whether the household's credit application was rejected, whether the household's loan payments have typically been on time, whether the household head is retired, whether the household head is employed, number of credit cards the household have, 5-year economic expectations of the household and the household's total income. Even after controlling for demographic and financial differences across groups, we find that prime borrowers are more likely to buy investment homes during recessions compared to recoveries, whereas subprimers are more likely to lose their primary homes. These results point to a dramatic difference between subprimers and primers: while subprimers are most harmed by the collapse of the housing market, primers can take advantage of lower house prices.

To explain the reallocation of housing wealth across borrowers, we develop a general equilibrium framework by introducing heterogeneity in terms of credit access among borrowers. As observed in data, subprimers have a risk premium that increases during recessions. This increase causes the more constrained agents, subprimers, to decrease their housing demand significantly. In stark contrast, borrowers who have relatively better access to credit benefit from lower house prices and thus increase their investment home purchases. Moreover, when a financial shock follows a period in which the subprimers experience lax credit conditions, as in Great Recession, the asymmetry between prime and subprime borrowers in their housing wealth distribution grows. We also analyze the reallocation of housing wealth when the nominal interest rates are constrained by the zero lower bound. We find that when the economy is at the zero lower bound, subprimers become worse off and the asymmetry among borrowers remains. Lastly, we estimate our model using Bayesian methods and find that our model is able to capture salient features of the U.S. data for the period from 1984 onward.

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A Data Appendix

We use data from the *Survey of Consumer Finances* and combine the surveys conducted in 1989, 1992, 1995, 1998, 2001, 2004, 2007, 2009, 2010, and 2013 into one single dataset. While data before 1989 are available, we exclude them from the combined dataset because standardized weighting files are not provided (analysis weights are only provided by the *Federal Reserve Board* from 1989 onward). Please refer to Table 5 for the details about derivations and definitions of the selected variables.

Table 5: **SCF Survey Questions for Selected Variables**

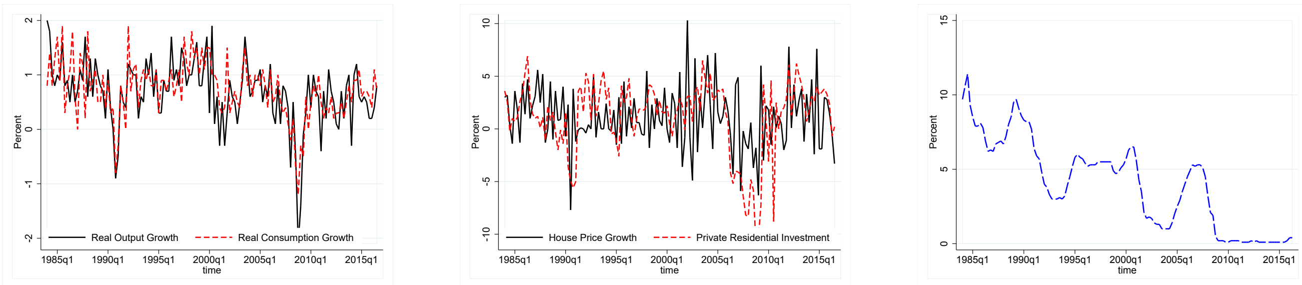
Variables:	**Definitions and Questions:**
Primary Home Ownership	Do you (and your family living here) own this house? 1. Yes 0.No
Investment Home Ownership	Own any investment real estate such as a lot, vacation home, timeshare, apartment building, commercial property, or other investment property, including properties owned in partnership with other people? 1. Yes 0. No
Income	How much was the total income you (and your family living here) received in previous year from all sources, before taxes and other deductions were made?
Payment Schedule	Thinking of all the various loan or mortgage payments you made during the last year, were all the payments made the way they were scheduled, or were payments on any of the loans sometimes made later or missed? 1. On time 0. Late
Credit Rejected	In the past five years, has a particular lender or creditor turned down any request you made for credit, or not given you as much credit as you applied for? 1. Yes 0. No
Expectations	Over the next five years, do you expect the U.S. economy as a whole to perform better, worse, or about the same as it has over the past five years? 0. Worse 1. Same 2. Better
Gender	Sex of the respondent 1. Male 2. Female
Education	What is the highest grade of school or year of college the household head completed? 0. No Grades, 1. Until 12th Grade, 2. College (1-4 years), 3. Masters and higher
Age	What is your year of birth?

B Estimation Appendix

We estimate the model to fit the following five series: real output growth (GDPC96), bank prime loan rate (MPRIME), growth rate of private residential investment (PRFI), the growth rate of house prices (MSPUS), and real consumption growth (PCECC96), in which the codes in the brack-

Figure 9: Series Used for Estimation

(a) Output and Consumption (b) Investment and House Prices (c) Prime Interest Rate



ets denote the corresponding codes from the St. Louis's FRED database. Data from 1984:Q1 to 2016:Q2 are retrieved from the St. Louis's FRED database, are in quarterly frequency, seasonally adjusted, and filtered using the Hodrick-Prescott filter. Here we abstract from periods with high volatility before the Great Moderation by focusing on post-1984 data only. We define a set of auxiliary variables in the model and then transform the data accordingly. In particular, we use the following four quantities $g^Y = \frac{Y' - Y}{Y}$; $g^C = \frac{C' - C}{C}$; $g^H = \frac{PRFI' - PRFI}{PRFI}$; $g^{PH} = \frac{P_H^{'} - P_H}{P_H}$, where P_H denotes the series "Median Sales Price of Houses Sold for the United States (MSPUS)" from the *U.S. Bureau of the Census*. To match with the growth rate of real house prices in the model, we deflate the variables using a common GDP deflator as in the case for output and consumption. For the growth rate of house prices and the borrowing rates for primers, we match the net rates with the ones obtained from the St. Louis's FRED. We plot the series used for estimation in Figure 9.