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Housing Wealth Reallocation between Subprime and Prime Borrowers during Recessions

Ayse Sapci and Nam Vu*

September 4, 2017

Abstract

Prime borrowers are more likely to own investment homes during recessions than during recoveries, while subprime borrowers are less likely to do so. This contrasting pattern conforms with the observation that the homeownership rates of these two types of borrowers have followed opposite trends since the mid-1990s. We attribute such divergence in homeownership to the better credit access of the prime borrowers and show that this asymmetry is amplified when subprime borrowers are previously subjected to lax credit conditions and have high debt-to-value ratios. An expansionary monetary policy can bridge this gap in housing wealth.

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1 Introduction

The Great Recession reminded us how integrated the housing market and the rest of the economy are. As the United States slipped into the worst recession since World War II, many homeowners, particularly subprime borrowers, defaulted on their mortgages. This wave of defaults, combined with massive fire sales from banks and other homeowners, put a significant downward pressure on house prices. Despite considerable losses in the overall housing wealth, such declines in house prices might have opened up ample investment opportunities for prime borrowers who still had relatively easy access to credit. In this paper, we study the effects of credit access - or the lack thereof - on the reallocation of housing wealth among subprime and prime borrowers during recessions.

Using data from the *U.S. Census* and the *Survey of Consumer Finances* (SCF, henceforth), we show that prime borrowers are more likely to own investment homes during recessions than during recoveries. In stark contrast, subprime borrowers are less likely to invest in housing during an economic downturn. We differentiate the two types of borrowers using a variety of criteria, including their first mortgage loan rates and income. Under our baseline specification, subprimers are borrowers whose first mortgage loan rates are among the top one-third of the distribution, whereas primers are those who have lower mortgage rates than the bank prime loan rate. Our empirical results are robust to various demographic and financial characteristics of the homeowners, and to different classifications of prime and subprime borrowers.

To understand the asymmetry in investment homeownership observed in the data, we study a dynamic setting in which borrowers are exposed to different levels of credit access. In particular, we construct two dynamic models - with and without nominal rigidity - that feature collateral constraints, debt accumulation, and an occasionally binding zero lower bound (ZLB). Analogous to our empirical setup, we classify borrowers into “subprimers” and “primers,” whose upper borrowing limits are constrained by the value of their homes. These two types of borrowers differ by the loan rate at which they have to incur when taking out mortgage on their first home. 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. We show that this asymmetry in housing investment patterns is significantly amplified in a model with nominal rigidity and that collateral constraints play an important role in the interplay of housing market and business cycles. We further demonstrate that the asymmetry in housing wealth across borrowers grows when the financial shock follows a period in which the subprimers

are previously subjected to lax credit conditions and have high debt-to-value ratios. We also find that the ZLB amplifies the negative effects of financial frictions on aggregate housing demand compared to the case in which the ZLB does not bind, while having a limited effect on housing wealth distribution. Turning to the policy implication of our results, we show that an expansionary monetary policy shock can decrease the asymmetry in home purchases, thereby ameliorating the undesired effects of increases in financial frictions as a result of recessions.

Along with the vast literature on the interplay between financial frictions, business cycles, and the housing market, our paper highlights the importance of house prices and collateral constraints. In a series of seminal works, [Iacoviello \(2005\)](#) and ([Iacoviello and Pavan, 2013a,b](#)) 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. Similarly, [Liu et al. \(2013\)](#) study the amplification effect on macroeconomic fluctuations generated from the positive correlation between land prices and business investment. [Favilukis et al. \(2013\)](#) 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 et al. \(2013\)](#) and [Kaplan et al. \(2016\)](#) find that the plunge in house prices was the main driving force in generating the Great Recession. We complement this literature by documenting the contrasting responses in investment homeownership across prime and subprime borrowers during recessions.

Similar to [Mian and Sufi \(2009\)](#), we show that when subprimers are subject to lax credit conditions, a subsequent financial shock creates a larger asymmetry in housing wealth distribution. As subprimers gain better access to credit, they accrue larger losses during recessions. This result closely resembles the credit environment before the Great Recession. [Justiniano et al. \(2016\)](#) further show that a drop in interest rates helps subprimers to afford larger mortgages. As subprimers ramp up their demand for houses and accumulate debt, they cause larger increases in house prices. Along these lines, we find that debt-to-value ratio is an important factor influencing mortgage rates for borrowers and demonstrate that introducing this ratio as a determinant of loan rates help create the asymmetry in housing wealth reallocation across prime and subprime borrowers.

While not the first to study the role of heterogeneity in credit access across borrowers, our paper complements the literature by underlining the channel through which high debt-to-value ratios can create a wedge in housing wealth distribution across the two types of borrowers. As ([Mian and Sufi, 2009, 2016](#)) demonstrate, the heterogeneity of borrowers plays an important yet underappreciated role in understanding macroeconomic fluctuations. By allowing for a risk premium between primers and subprimers that can change with their debt-to-value ratios, we focus on the asymmetry of housing wealth rather than the magnifi-

cation mechanism that stays at the core of many papers in the literature.¹ 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 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. Because we analyze the reallocation of housing wealth when the nominal interest rate is constrained by an occasionally binding ZLB, our paper also borders a large literature that focuses on the ZLB and its implications.

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 investment homeownership rates across prime and subprime borrowers using U.S. data from the mid-1990s. Complementing this empirical result, Section 3 introduces a simple model to explain the extent to which an increase in risk premium can lead to a significant asymmetry in housing investment decisions across borrowers. Section 4 presents an extended model with a more realistic production sector, nominal rigidity and zero lower bound, followed by a discussion on the role of collateral constraints. Section 5 discusses our results and their implications. Section 6 studies the importance of debt-to-value ratio in determining the risk premium that can lead to the asymmetry in housing investments across prime and subprime borrowers both in the model and in the data. Section 7 concludes the paper.

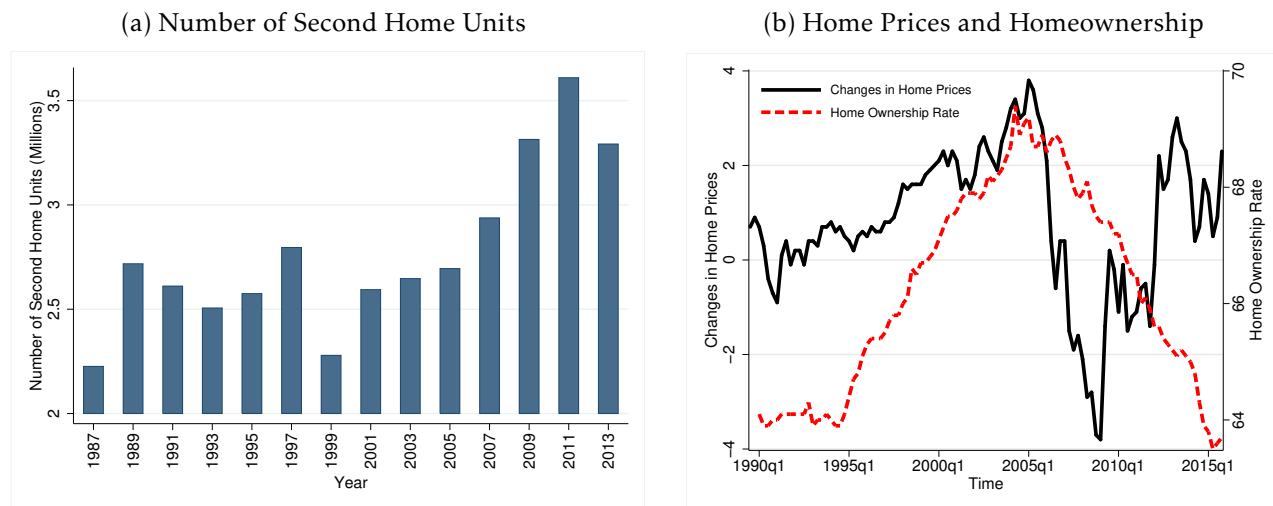
2 Homeownership and Credit Access in the Data

In this section, we present the empirical evidence that prime borrowers are more likely to own investment homes during recessions than during recoveries, while subprime borrowers are less likely to do so. Our starting point is to document that the number of second homes has been increasing over recessions. In particular, [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 key insight from this figure is that the number of second home units increases following the start of the three most recent recessions.²

¹For example, [Krueger et al. \(2016\)](#) 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 productivity across agents and find the drop in consumption to be larger for more constrained agents.

²We use the starting times of the contractions as designated by the National Bureau of Economic Research (NBER). We choose to study NBER recessions rather than periods when house prices are declining because we are interested in the effects of borrowing environment on house investment decisions. Low house prices do not necessarily indicate an economic environment with a limited access to credit. The theoretical part of the paper, however, generates low house prices during downturns.

Figure 1: Ownership and Home Prices over Time



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.

Building on these observations from the aggregate data in Figure 1, we next study the heterogeneity in housing wealth reallocation among subprime and prime borrowers using micro-level data from the *Survey of Consumer Finances* (SCF). 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 1995 to 2013.³ We differentiate between prime and subprime borrowers based on the loan rates that they pay on their primary home mortgages. For robustness checks, we also use income levels to classify borrowers and show that our narrative on the asymmetry in housing wealth distribution does not change (Table 3). We choose to use the loan rates instead of income levels for our baseline specification, because the loan rates are good ex-post indicators that can be used to understand who received favorable rates. Our regressions also control for income as well as other financial and domestic characteristics that can affect the credit access of a household.

While primers are classified as borrowers whose loan rates are less than the prime rate in the corresponding year, subprimers are those whose first mortgage loan rates fall into the highest one-third of the loan rate distribution.⁴ We pick the highest one-third of the loan rate distribution as our cutoff following Justiniano et al. (2016), who document that the ratio of to subprime borrowers is about 36 percent using micro-level data from the FRBNY Consumer Credit Panel/Equifax (CCP) and CoreLogic.

³We exclude survey data before 1995 in our regression analysis because standardized weights are not publicly available for earlier years.

⁴We use the series MPRIME from the St. Louis’ FRED as the prime rate.

Table 1: Descriptive Statistics

	Subprime	Prime	Full Sample
Primary Homeownership (%)	92.36 (0.27)	98.05 (0.14)	96.27 (0.19)
Investment Homeownership (%)	30.40 (0.46)	44.66 (0.50)	38.65 (0.49)
Credit Rejected (%)	31.17 (0.46)	15.55 (0.36)	21.19 (0.41)
Number of Credit Cards	2.453 (2.076)	2.796 (2.020)	2.682 (2.024)
Payment Schedule (On Time) (%)	79.21 (0.41)	90.82 (0.29)	87.35 (0.33)
Median Income (Log)	11.45 (1.014)	12.10 (1.329)	11.86 (1.237)
Economic Expectations (Most Optimistic=2)	1.155 (0.764)	1.051 (0.741)	1.167 (0.758)
Employed (%)	87.99 (0.33)	90.67 (0.29)	89.52 (0.31)
Male Household Head (%)	85.92 (0.35)	91.20 (0.28)	89.09 (0.31)
Education (Years)	13.95 (2.473)	14.98 (2.204)	14.65 (2.350)
Number of Households	22,730	29,202	70,412

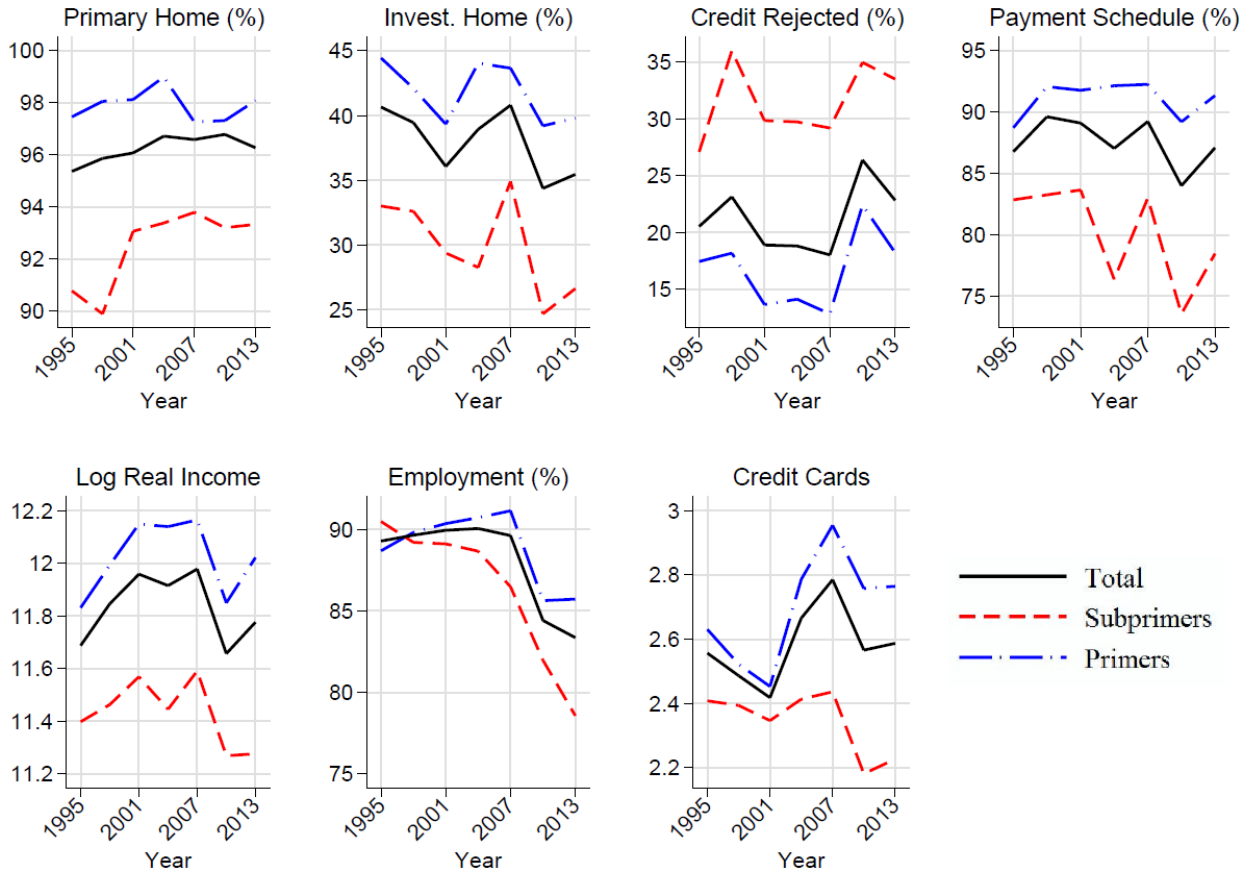
Note: The data are from the *Survey of Consumer Finances*. Standard deviations are in parenthesis. Prime and subprime borrowers are differentiated based on the loan rates of their first mortgages. A detailed description of some of these variables can be found in the Appendix.

Table 1 presents the first and second moments of selected variables from our dataset. As expected, subprimers are characterized by a higher rate of credit rejection, fewer credit cards, lower income, and a higher rate of unemployment. These borrowers are also less likely to be on time with their payments than prime borrowers. In addition, subprime borrowers are more likely to have a female household head and are relatively less educated. In terms of economic expectations, these borrowers are only slightly more optimistic about the current state of the economy than their prime counterparts. Given that only about 2 percent of primers and about 8 percent of subprimers do not own a primary home, we focus on the investment homeownership for both types of borrowers.⁵

Similar to Table 1, Figure 2 plots the means of all variables over time. Prime borrowers are more likely to own primary and investment homes, are less likely to have their credit applications rejected, are more likely to be on time with their mortgage payments, and have more credit cards any time during our sample period. Primers also have higher income and higher employment rate throughout the sample period.

⁵Unlike the data from *American Housing Survey* by the *U.S. Census*, SCF allows us to focus on investment

Figure 2: Descriptive Statistics Over Time



Note: This figure plots the descriptive statistics for selected variables over time. Prime and Subprime Borrowers are classified based on their primary home mortgage rates.

To better illustrate the dynamics of housing wealth distribution, Figure 3a plots the percentage of prime and subprime borrowers who own a primary home over time. Since the SCF does not follow individuals over time, we interpret these numbers as the average homeownership rates.

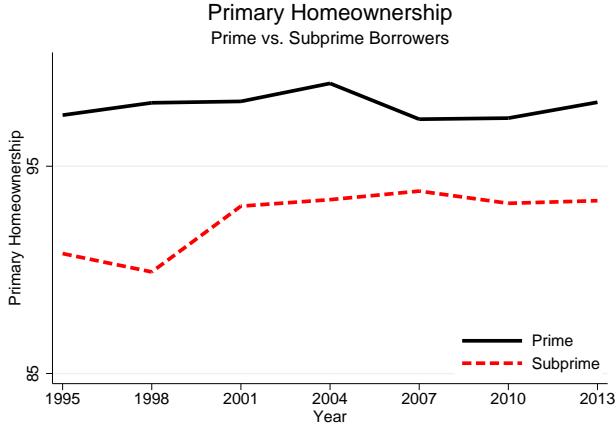
While prime borrowers have consistently higher primary homeownership rates over the sample period, this difference is not significant because of our baseline cutoff definition. Specifically, since we use primary home mortgage rates to differentiate borrowers, everyone in the sample has owned at least one house at a point in time. Some households do not own a primary home (about 2 and 8 percent for primers and subprimers, respectively) because their primary homes are either under foreclosure or on the market for sale.⁶ Even

homes specifically, rather than on any type of second homes.

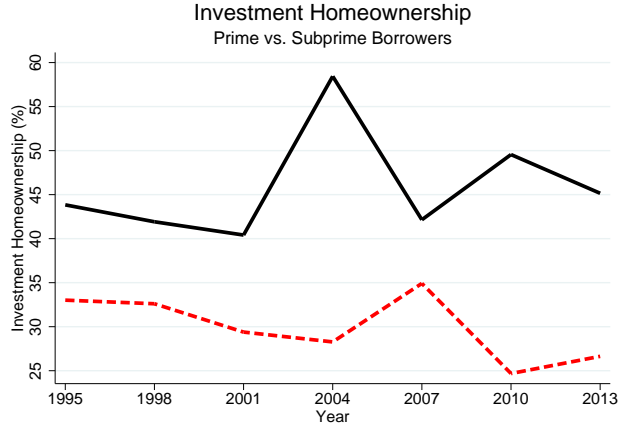
⁶These numbers do not represent foreclosures fairly as we cannot separate them from regular sales. [Adelino et al. \(2017\)](#), [Foote et al. \(2016\)](#), [Ferreira and Gyourko \(2015\)](#), and [Albanesi \(2016\)](#) show that foreclosures by prime borrowers were at least as important as those by subprime borrowers in causing the Great Recession. Our paper can only refer to foreclosures in a very restricted way. However, the focus of this paper is the investment homeownership across borrowers rather than foreclosures.

Figure 3: Homeownership for Prime and Subprime Borrowers

(a) Residence Homeownership among Borrowers



(b) Investment Homeownership among Borrowers



Note: Figure 3a plots the primary homeownership rate over time for both subprime and prime borrowers, per participants' survey responses. Figure 3b plots the investment homeownership rate for subprime and prime borrowers in the survey. Here we classify prime and subprime borrowers based on the rate of their first mortgages. Subprimers are the borrowers who are in the highest 30% of the loan rate distribution, whereas primers are borrowers whose loan rates are less than the prime rate of that year.

though this paper focuses on investment homeownership, primary homeownership also shows some asymmetry during recessions. Particularly during the Great Recession, more borrowers owned a primary home, whereas this rate decreased for subprime borrowers.

Turning to investment homes, Figure 3b presents the percentage of subprime and prime borrowers that own at least one investment home during the sample period. A significantly higher percentage of prime borrowers own an investment home during the recent two recessions compared to recoveries. On the other hand, a lower fraction of subprimers own an investment home during the downturns than expansions.

2.1 Investment Homeownership over the Business Cycle

To further analyze the asymmetry in investment homeownership between prime and subprime borrowers over the business cycle, we estimate the following Probit regression:

$$\begin{aligned}
 Investment\ Homeownership_{i,t} = & \beta_0 + \beta_1 Year\ Fixed\ Effects_t & (1) \\
 & + \beta_2 Demographic\ Controls_{i,t} \\
 & + \beta_3 Financial\ Controls_{i,t} + v_{i,t}
 \end{aligned}$$

Here *Investment Homeownership* is the binary dependent variable indicating whether household *i* owns an investment home in year *t*. *Demographic Controls* include gender, age, and education level of the household head. The set of *Financial Controls* includes whether a household's credit application was rejected, whether the household's payments of loans had

Table 2: Probit Regression Results: The Asymmetry in Homeownership Rates

	Subprime Borrowers		Prime Borrowers	
	(1)	(2)	(1)	(2)
1998	0.012*** (0.004)	0.008*** (0.002)	0.006*** (0.002)	0.009*** (0.002)
2001 Recession	-0.006 (0.004)	-0.023*** (0.003)	0.007*** (0.003)	0.001 (0.001)
2004	0.006** (0.003)	0.037*** (0.002)	0.082*** (0.004)	0.085*** (0.005)
2007	0.015*** (0.004)	0.039*** (0.003)	0.010*** (0.001)	0.053*** (0.001)
Great Recession	-0.0004 (0.003)	0.037*** (0.002)	0.063*** (0.004)	0.084*** (0.006)
2013	0.001 (0.003)	0.051*** (0.003)	0.017*** (0.0025)	0.053*** (0.003)
Demographic Controls	No	Yes	No	Yes
Financial Controls	No	Yes	No	Yes
Number of Observations	22,730	18,233	29,202	25,148

Note: We estimate the following specification: $Investment\ Homeownership_{i,t} = \beta_0 + \beta_1 Fixed\ Year\ Effects_t + \beta_2 Demographic\ Controls_{i,t} + \beta_3 Financial\ Controls_{i,t} + v_{i,t}$. Values in parentheses show the standard errors. We report the marginal effects at the means using 1995 as the base year. We classify prime and subprime borrowers based on their first loan rate: subprimers are the borrowers who are in the top 30% of the loan rate distribution and primers are borrowers whose loan rates are less than the prime rate of the corresponding year. 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). Here ***, **, and * denote the 1%, 5%, and 10 % levels of significance, respectively.

typically been on time or behind the payment schedule, whether the household is unemployed or employed, the number of credit cards the responding household had, and a measure of 5-year economic expectations of the household. We control for variations in income across different borrowers by including the log of real income reported by the survey respondents. Additionally, we restrict the sample to exclude households whose total income is below the Federal poverty level (i.e., \$19,530 in 2013 U.S. Dollars), because these households would be highly unlikely to make a housing investment decision.⁷

Table 2 presents the results of the Probit regression specified in Equation 1. Based on the observations drawn from the aggregate data (Figures 1 and 3), we expect the micro-level data from the SCF to show that households with better credit access can take advantage of depressed house prices while others cannot due to adverse economic conditions. With the exception of the Great Recession, we use the data surveyed from the same year as denoted in the first column. For the Great Recession results, we use the 2010 survey.

One key takeaway from Table 2 is that prime borrowers are more likely to own invest-

⁷The results hold even stronger when we include households whose income are under the poverty line.

ment homes during recessions than recoveries, while subprime borrowers are less likely to do so. For example, in specification (2) of Table 2, prime borrowers are more likely to own investment homes during the Great Recession (8.4%) than during the previous (5.3%) or the following (5.3%) recoveries. Due to the backward-looking nature of the data collection process, the 2007 survey is highly unlikely to have documented substantial negative effects of the Great Recession, given that the recession started on December of 2007. Therefore, the results from the 2007 survey should be interpreted as reflecting on the preceding recovery period. Similarly, the 2004 survey is likely to reflect some of the effects from 2001 Recession because of the lag it takes to collect data and the short span of the recession. Therefore, the results from the 2001 and 2004 surveys must be taken into account together.

Unlike prime borrowers, subprime borrowers are less likely to own a primary home during recessions.⁸ For instance, in specification (2) of Table 2, subprime borrowers are less likely to own investment homes during the Great Recession (3.7%) than during the previous (3.9%) or the following (5.1%) recoveries. Such asymmetry in housing investment decisions between prime and subprime borrowers is robust to various demographic and financial characteristics of the households.⁹

While not reported in Table 2, households who are more educated, have male household head, and are older are more likely to be homeowners.¹⁰ 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, are employed, and have high income are also more likely to own a house throughout the sample period.

2.2 Robustness Checks

The results in Section 2.1 on the divergence in homeownership between the two types of borrowers remain consistent after a number of robustness checks. For instance, Table 3 columns (1) estimate the Probit regression in Equation 1 with a 5% decrease in the loan rate cutoffs for subprime and prime borrowers. To illustrate, suppose that the prime rate - namely, the cutoff in the baseline model for primers - is 600 basis points. A decrease of 5% means that 570 basis points would be the new cutoff for the prime borrowers. This change in the cutoff rates results in a 43% increase in the number of subprimers, and a 16% decrease in primers. The results on the asymmetry in housing investment ownership across borrowers

⁸It is important to note that since the SCF does not follow individuals over time, all of our empirical results pertain to the *average* borrower who falls into our prime-subprime subgroups.

⁹We also control for house prices (for the first investment home) as a measure of wealth and find that our main results do not change.

¹⁰The education variable is classified so that it captures people who could not complete high school, who are high school graduates, who have college degree, and who have higher education degree (masters or doctorate) rather than years of education.

Table 3: Robustness Checks

	Subprime Borrowers			Prime Borrowers			
	(1)	(2)	(3)	(1)	(2)	(3)	(4)
1998	0.003 (0.002)	-0.009** (0.003)	0.051*** (0.002)	0.020*** (0.002)	-0.003 (0.002)	0.120*** (0.009)	-0.005 (0.004)
2001 Recession	-0.016*** (0.002)	-0.026*** (0.004)	0.042*** (0.005)	0.025*** (0.005)	0.007*** (0.002)	0.255*** (0.006)	0.017*** (0.003)
2004	0.009*** (0.001)	0.039*** (0.003)	0.088*** (0.002)	0.144*** (0.005)	0.075*** (0.005)	0.256*** (0.013)	0.055 (0.003)
2007	0.040*** (0.002)	0.020*** (0.005)	0.074*** (0.002)	0.056*** (0.002)	0.045*** (0.001)	0.212*** (0.009)	0.075*** (0.003)
Great Recession	0.029*** (0.002)	0.034*** (0.004)	0.065*** (0.003)	0.085*** (0.009)	0.132*** (0.008)	0.214*** (0.013)	0.090*** (0.004)
2013	0.040*** (0.002)	0.049*** (0.003)	0.030*** (0.003)	0.082*** (0.005)	0.066*** (0.002)	0.206*** (0.010)	0.077*** (0.003)
Dem. Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fin. Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	25,988	13,386	8,250	21,101	20,509	9,588	22,337

Note: Table 3 estimates the Probit regressions in Equation 1 with (1) a decrease of 5% in the cutoffs of subprime and prime borrowers (columns 1), (2) the exclusion of the mortgages from government sponsored enterprises (columns 2), (3) the use of income to differentiate prime and subprime borrowers (columns 3), and (4) the cutoff for prime borrowers being the first quartile of loan rate distribution, i.e., households with the lowest 25% of loan rates (column 4). We estimate the Equation 1 with demographic and financial controls, and report the marginal effects at the means. ***, **, and * denote the 1%, 5%, and 10 % levels of significance, respectively.

are robust to these new cutoffs.

Since a significant number of subprime mortgages are Federally guaranteed with fixed low interest rates, one natural robustness check is to account for these mortgages as borrowers might be self-selected into their categories and therefore could bias our results. In Table 3 columns (2), we exclude mortgages from government sponsored enterprises such as the Federal Housing Administration, the Veteran’s Administration, various state housing programs, and first-time buyer programs, etc. in our regressions.¹¹ Given these restrictions, about 27 percents of subprime mortgages and 20 percents of prime mortgages were backed by Federal programs. Again, our results on the asymmetry in the housing wealth are robust to excluding these Federally guaranteed loans.

In columns (3) in Table 3, we use income levels as the alternative criterion to differentiate between subprime and prime borrowers. In particular, here the subprime borrowers constitute the bottom 15% of the income distribution and the prime borrowers fall in the top 15%. Lastly, in column (4), we allow prime borrowers to populate the top quartile of the loan rate distribution, i.e., households with the lowest 25% loan rates. Once again, our

¹¹The government sponsored enterprises exclude Fannie Mae and Freddie Mac. However, including Fannie Mae and Freddie Mac does not change the results.

main result is robust that prime borrowers are more likely to own investment homes during recessions than during recoveries, while subprime borrowers are far less likely to do so.

3 A Simple Model with Asymmetry in Credit Access

To understand the main source of the heterogeneity in housing wealth distribution as presented in Section 2, we develop a simple model with collateralized borrowing in the spirit of Iacoviello (2005). This stylized economy is populated by households, entrepreneurs, and house producers. Unlike in Iacoviello (2005), households are divided into patient households (savers), prime borrowers (primers) and subprime borrowers (subprimers).

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 there is a positive wedge between the risk-free rate and the loan rate. 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. In the US, the homeownership rate averages about 65% since the end of the Great Recession. Thus, patient households can be interpreted as the remaining 35%.¹²

3.1.1 Patient Households

Denoted with the subscript h , patient households optimize 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 Walrasian budget constraint that equates household's spending to their income as follows.

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

¹²Homeownership rate for the United States is obtained from the *U.S. Bureau of Economic Analysis* (BEA).

where w_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.

$$\frac{1}{\beta_h C_{h,t} R_t} = E_t \left\{ \frac{1}{C_{h,t+1}} \right\} \quad (3)$$

$$l_{h,t}^\xi = \frac{w_t}{C_{h,t}} \quad (4)$$

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 . They 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:

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

subject to

$$C_{p,t} + q_t^h (H_{p,t+1} - H_{p,t}) + Z_{p,t-1} B_{p,t-1} = B_{p,t} + w_t l_{p,t} \quad (5)$$

$$B_{p,t} Z_{p,t} \leq m_p E_t \{ q_{t+1}^h H_{p,t+1} \} \quad (6)$$

where Γ governs the weight of housing services in the utility function, $Z_{p,t}$ denotes the gross lending rate, and m_p represents the loan-to-value ratio for the primers. Prime borrowers can use the amount borrowed from banks, $B_{p,t}$, and their labor income, $w_t l_{p,t}$, to finance their consumption, new housing investment, and repayment of their debt, as shown in Equation 5. The bank, however, requires some of their assets to be collateralized, which restrains the available credit to borrowers. Equation 6 shows that the repayment of household's debt cannot exceed the expected future value of the real estate bought at time t .¹³ Equations 7 and 8 represent the first order conditions for primers that show labor supply and housing demand decisions, respectively.

$$l_{p,t}^\xi = \frac{w_t}{C_{p,t}} \quad (7)$$

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

¹³For the borrowing constraint of prime borrowers to be constrained, their discount factor must be lower than the inverse of the gross loan rate.

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, on the other hand, 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.

$$Z_s = Z_p + f_t \quad (9)$$

where f_t follows a mean reverting process as follows:

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

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

$$C_{s,t} + q_t^h H_{s,t+1} = q_t^h H_{s,t} - Z_{s,t-1} B_{s,t-1} + B_{s,t} + w_t l_{s,t} \quad (11)$$

$$B_{s,t} Z_{s,t} \leq m_s E_t \left\{ q_{t+1}^h H_{s,t+1} \right\} \quad (12)$$

The optimal decisions of subprimers for labor supply and housing demand are presented below, respectively.

$$l_{s,t}^\xi = \frac{w_t}{C_{s,t}} \quad (13)$$

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

3.2 Entrepreneurs

Entrepreneurs produce a homogeneous good, Y_t using labor through the following aggregate production function.

$$Y_t = A_t L_{e,t} \quad (15)$$

where

$$L_{e,t} = \nu \left(\rho L_{p,t} + (1 - \rho) L_{s,t} \right) + (1 - \nu) L_{h,t} \quad (16)$$

Here $L_{e,t}$ represents the total labor demand in the economy, ν denotes the relative size of borrowers to patient households, ρ shows the relative mass of prime borrowers to subprime

borrowers. A_t is the total factor productivity (TFP) that follows the AR (1) process in Equation 17.

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_t^A \quad (17)$$

where ρ_A is the persistence of the TFP shock, and $E(\varepsilon_t^A) = 0$. The first order condition to profit maximization yields:

$$\frac{Y_t}{L_{e,t}} = w_t \quad (18)$$

3.3 House Construction

House producers maximize their own profits subject to the quadratic housing adjustment cost, $\frac{\chi_h}{2} \left(\frac{\Delta H_t}{H_t}\right)^2 H_t$. In particular, the house producers maximize the following problem:

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

where ΔH_t denotes the housing investment at time t as below.¹⁴

$$\Delta H_t = H_{t+1} - H_t \quad (19)$$

and $H_t = H_{p,t} + H_{s,t}$.¹⁵ The optimal condition to the house producers' profit maximization provides the following house price rule, which is equal to 1 at the steady state.

$$E_t \left\{ q_t^h - 1 - \chi_h \left(\frac{\Delta H_t}{H_t}\right) \right\} = 0 \quad (20)$$

3.4 Market Clearing Conditions

The economy-wide resource constraint is shown below.

$$Y_t = C_t + \Delta H_t \quad (21)$$

In Equation 21, C_t represents the aggregate consumption, which can be written as $C_t = C_{h,t} + C_{p,t} + C_{s,t}$. The following labor market clearing condition guarantees that the demand for and supply of labor will be equal.

$$L_{e,t} = l_{h,t} + l_{s,t} + l_{p,t} \quad (22)$$

¹⁴The theoretical model does not distinguish between the *intensive* and *extensive* margins of home investment. We leave this topic for future research.

¹⁵The housing depreciation is assumed to be equal to zero to match the findings in [Iacoviello \(2005\)](#)

Lastly, Equation 23 shows that the loans market clears when the supply of deposits is equal to the demand for funds by subprimers and primers as follows.

$$D_t = B_{p,t} + B_{s,t} \quad (23)$$

3.5 Parametrization

The values for all the parameters are presented in Table 4. We set the discount rates of patient households, primers, and subprimers to be 0.970, 0.965, and 0.950, respectively. These values are in line with the values found by Lawrance (1991) and Samwick (1998). The order of the discount factors (i.e., $\beta_h > \beta_p \geq \beta_s$) guarantees that there is a positive wedge between risk-free rate and the loan rate. We pick the weights of housing in utility functions, Γ , to ensure that the steady state level of prime rate matches the data (i.e., 6.3% annually from the St. Louis FRED database) for the periods from 1984:Q1 to 2016:Q2. Following the literature using micro-level data (e.g., Krause et al. (2008) and Aaronson and French (2009)), we set the inverse of the Frisch elasticity equal to 3. The relative size of primers to subprimers, ρ , is set to 0.64 following Justiniano et al. (2016), and the relative size of borrowers to patient households, ν , is set to 0.65 using the homeownership data from the U.S. Bureau of Economic Analysis (BEA). Similar to Ngo (2015), the housing adjustment cost is equal to 0.1. We choose the loan to value ratio to be 0.765 which is the average found in the public database for Fannie Mae and Freddie Mac by the *Federal Housing Finance Agency* for 2014. The steady state level of risk premium is calculated from the SCF dataset using long run mortgage rates for prime and subprime borrowers and is equal to 2% in the steady state.¹⁶

3.6 Results: Implications for the Housing Market under the Real Model

Figure 4 plots the impulse responses of housing investments to (1) an adverse financial shock and (2) an adverse TFP shock. Here prime borrowers take advantage of low house prices when the subprimers' risk premium increases. In particular, while prime borrowers are able to increase their housing investment during times of an adverse financial shock their subprime counterparts cannot. Intuitively, when there is an increase in the risk premium f_t , subprime borrowers are further constrained in their ability to borrow and therefore have to reduce their housing investment. The prime borrowers, however, are not constrained by this premium and thus can take advantage of the low house prices.

¹⁶Since 2% is the lowest value in the United States experienced at the peak of the economy, we underestimate the effects of the risk premium.

Table 4: Calibrated Parameters: Real Model

Parameters	Description	Value
β_h	Discount rate for Savers	0.99
β_p	Discount rate for Primers	0.97
β_s	Discount rate for Subprimers	0.95
Γ	Weight of housing in the utility function	0.83
ξ	Inverse of Frisch elasticity	3
ν	Relative size of borrowers to patient households	0.65
ρ	Relative size of primers to subprimers	0.64
χ_h	Housing adjustment cost	0.10
$m_s = m_p$	Loan-to-value ratios	0.765
\bar{f}	SS level risk premium (annualized)	2%
ρ_f	Persistence for financial friction	0.96
σ_f	Std. deviation for financial shock	0.01
ρ_A	TFP shock persistence	0.90
σ_A	Std. deviation for TFP shock	0.01

A negative TFP shock affects the two types of borrowers in a similar way even though subprimers pay about 2% (annualized) more on their loan rates in equilibrium. Thus the TFP shock does not cause the asymmetry observed with the financial shock. Because of the inherent differences in the steady state levels of loan rates, subprimers become significantly worse off compared to primes in the housing market as a result of adverse shocks.

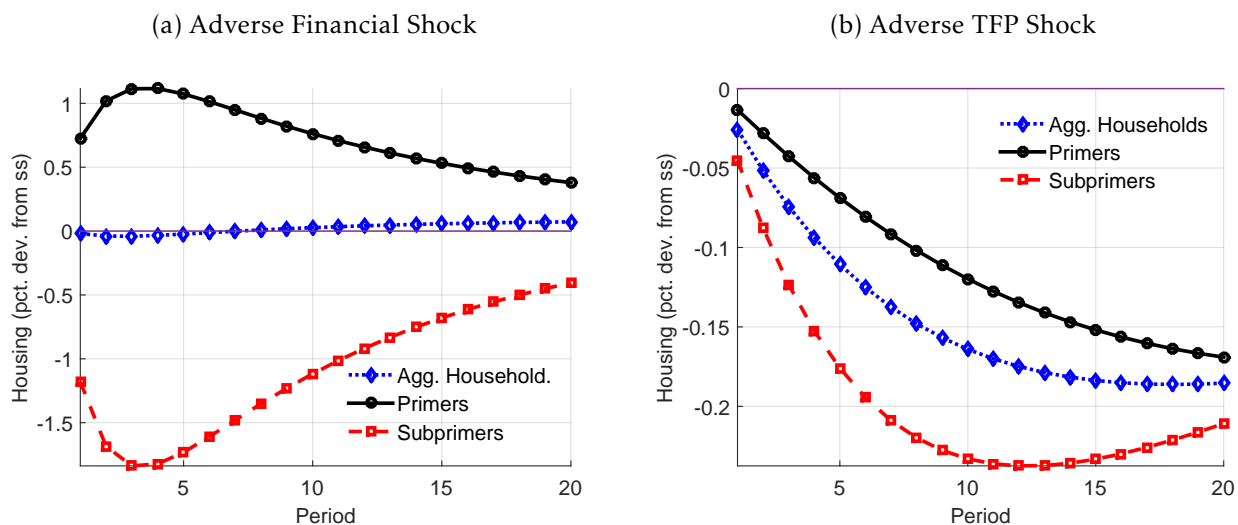
Despite its simplicity, the real model presented in this section shows that the financial friction f_t is an important factor that determines the wedge in the housing wealth distribution across prime and subprime borrowers.

4 An Extended Model with Nominal Rigidity

Our real model in Section 3 shows that, even in a stylized economy without any nominal rigidity, the differences in access to credit among borrowers can lead to asymmetric responses in house purchase decisions during recessions. While helpful in providing the basic intuition, this model lacks some features necessary to resemble the U.S. economy. In this section, we augment the real model in Section 3 with a more realistic production sector, nominal rigidity, a Taylor-rule monetary policy, and an occasionally binding ZLB to better represent the salient features of the period in study. We also allow for firms to borrow, subject to their collateral constraints.

In this extended framework, the economy is populated by six types of agents: house-

Figure 4: Responses of the Housing Market under the Real Model



Note: This figure plots the impulse responses of housing investment of prime and subprime borrowers to a one standard deviation change in the innovation of the financial friction, ε_t^f and TFP. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

holds, entrepreneurs, retailers, capital producers, house producers and the central bank. Similar to the model in Section 3 households are divided into patient households (savers), prime borrowers (primers) and subprime borrowers (subprimers). Entrepreneurs are assumed to own goods producers (firms) and the retailers. The model features a Taylor-style monetary policy rule with an occasionally binding ZLB constraint to account for the near zero interest rates during the Great Recession.

4.1 Households

We keep all types of households same with the model in Section 3 except the implications coming from the nominal rigidity. We also relax the assumption that subprime and prime borrowers receive the same utility from housing services. We further add a preference shock to the patient households. In particular, the preference shock takes the form of the following mean reverting process where $\varepsilon_t^{\beta_h}$ is normally distributed with mean zero and standard deviation σ_{β_h} .

$$\log(\beta_{h,t}) = (1 - \rho_{\beta_h})\beta_h + \rho_{\beta_h}\log(\beta_{h,t-1}) + \varepsilon_t^{\beta_h} \quad (24)$$

4.2 Entrepreneurs

Entrepreneurs are assumed to own the good producers (firms). They rent capital from capital producers and provide it to the firms. Firms produce a homogeneous good, Y_t , using capital, labor, and commercial real estate through the following aggregate Cobb-Douglas

production function.

$$Y_t = A_t K_t^\alpha H_{e,t}^\kappa (L_{e,t})^{(1-\alpha-\kappa)} \quad (25)$$

where $\alpha \geq 0$ and $\kappa \geq 0$ denote the capital and commercial estate shares in production, respectively. Here $H_{e,t}$ can also be interpreted as land. Firms maximize their consumption with respect to Equations 25 and 17, as well as their flow of funds in Equation 26, and borrowing constraint in Equation 28.

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

$$C_{e,t} + q_t^h H_{e,t+1} = \frac{Y_t}{X_t} + q_t^h H_{e,t} - w_t L_{e,t} - q_t I_t + B_{e,t} - \frac{Z_{e,t-1} B_{e,t-1}}{\pi_t} + F_t \quad (26)$$

where

$$L_{e,t} = \nu (\rho L_{p,t} + (1-\rho) L_{s,t}) + (1-\nu) L_{h,t} \quad (27)$$

Here π_t denotes the gross inflation rate, $\pi_t = (P_t/P_{t-1})$, and F_t represents the lump-sum profits from retailers. X_t shows the markups in period t , q_t^h denotes the real house price as $q_t^h = Q_t^h/P_t$, and $q_t = Q_t/P_t$ is the real capital price. Similar to subprimers and primers, firms can only borrow up to the expected future value of their total assets which includes their physical capital as well as their commercial estate. The borrowing constraint of the entrepreneurs is given by

$$B_{e,t} \leq m_e E_t \left\{ \left(q_{t+1}^h H_{e,t+1} + q_{t+1} K_{t+1} \right) \frac{\pi_{t+1}}{Z_{e,t}} \right\}, \quad (28)$$

where m_e is the loan-to-value ratio for firms. The solution of firm's maximization problem is given by the following three equations. They represent the demand for capital, housing, and labor, respectively.

$$\frac{\beta_e q_{t+1}}{C_{e,t+1}} \left(\frac{\alpha Y_{t+1}}{q_{t+1} X_{t+1} K_{t+1}} + (1-\delta) - m_e \right) + \frac{1}{C_{e,t}} \left(\frac{m_e q_{t+1}}{\frac{Z_{e,t}}{\pi_{t+1}}} - q_t \right) = 0 \quad (29)$$

$$\frac{\beta_e q_{t+1}^h}{C_{e,t+1}} \left(\frac{\kappa Y_{t+1}}{q_{t+1}^h X_{t+1} H_{e,t+1}} + (1-m_e) \right) + \frac{1}{C_{e,t}} \left(\frac{m_e q_{t+1}^h}{\frac{Z_{e,t}}{\pi_{t+1}}} - q_t^h \right) = 0 \quad (30)$$

$$(1-\alpha-\kappa) \frac{Y_t}{L_{e,t}} = w_t \quad (31)$$

4.2.1 Retailers

Following [Iacoviello \(2005\)](#), we assume that there is a continuum of monopolistically competitive retailers owned by entrepreneurs who are the source of the 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 of $\theta \in (0, 1)$ that the prices will not change; hence, each period retailers have a probability of $(1 - \theta)$ to reset their price. Since optimally each retailer selects the same price, it follows that

$$\pi_t = \left[(1 - \theta)(\pi_t^c)^{1-\varepsilon} + \theta \right]^{\frac{1}{1-\varepsilon}} \quad (32)$$

The optimal price for each retailer is $\pi_t^c \equiv \frac{P_t^c}{P_{t-1}}$, and the retailers' profit is $F_t = \left(1 - \frac{1}{\chi_t}\right) Y_t$. Given that the entrepreneurs own the retailers, the profits are distributed back to them.

4.3 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 33 where $\varepsilon_t^{x_t^i}$ is normally distributed with mean zero and standard deviation σ_{x^i} .

$$\log(x_t^i) = \rho_{x^i} \log(x_{t-1}^i) + \varepsilon_t^{x^i} \quad (33)$$

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

$$E_t \left\{ q_t x_t^i - 1 - \chi \left(\frac{I_t}{K_t} - \delta \right) \right\} = 0 \quad (34)$$

The law of capital motion is assumed to follow

$$x_t^i I_t = K_{t+1} - (1 - \delta) K_t \quad (35)$$

4.4 House Construction

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

$$x_t^h \Delta H_t = H_{t+1} - H_t \quad (36)$$

and $H_t = H_{p,t} + H_{s,t} + H_{e,t}$. The housing supply shock follows the auto-regressive process below.¹⁷

$$\log(x_t^h) = \rho_{x^h} \log(x_{t-1}^h) + \varepsilon_t^{x^h} \quad (37)$$

The house producers maximize their profits as follows.

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

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

$$E_t \left\{ q_t^h x_t^h - 1 - \chi_h \left(\frac{\Delta H_t}{H_t}\right) \right\} = 0 \quad (38)$$

4.5 Monetary Policy

We posit that monetary policy follows a Taylor rule specified in Equation 39, where b_1 and b_2 are the parameters that govern the central bank's weights on the output gap and inflation gap target.

$$R_t = \bar{R} \left(\left[\frac{Y_t}{\bar{Y}} \right]^{b_1} \left[\frac{1 + \pi_t}{1 + \bar{\pi}} \right]^{b_2} \right) e_t^R \quad (39)$$

The monetary policy shock, e_t^R , follows the AR(1) process below.

$$\log(e_t^R) = \rho_e \log(e_{t-1}^R) + \varepsilon_t^R \quad (40)$$

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

$$R_t - 1 \geq 0 \quad (41)$$

¹⁷Housing is a predetermined variable. Therefore, the housing supply shock should be interpreted similarly with the investment specific technology shock.

Table 5: Calibrated Parameters: Extended Model

Par.	Description	Value	Source
ξ	Inverse of Frisch elasticity	3	Aaronson and French (2009)
ρ	Relative size 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% (annualized)	Our calculations from SCF
α	Share of capital in production	0.33	Standard Parameter
δ	Capital depreciation	0.025	Standard Parameter
Γ_s	Weight of housing in the utility function of subprimers	1	Our calculations from SCF
Γ_p	Weight of housing in the utility function of primers	1	Our calculations from SCF
b_1	Taylor Rule Output Weight	0.5	Taylor (1993)
b_2	Taylor Rule Inflation Weight	1.5	Taylor (1993)

4.6 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.

$$Y_t = C_t + I_t + \Delta H_t \quad (42)$$

In Equation 42, C_t represents the aggregate consumption and is the sum of households, borrowers, and entrepreneurs' consumption. The labor market clearing condition is the same with the model in Section 3 and guarantees that the demand for and supply of labor will be equal. The loans market clears when the supply of deposits is equal to the demand for funds by subprimers, primers, and entrepreneurs as follows:

$$D_t = B_{p,t} + B_{s,t} + B_{e,t} \quad (43)$$

4.7 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 obtained from the data. Table 5 presents the set of parameters that we calibrate. Parameters for Frisch elasticity, the relative size of primers to subprimers, the relative size of borrowers to patient households, and the steady state level of risk premium are kept the same with the values used in the real model as explained in Section 3.5. These values generate a steady state level of prime rate that matches the long run average since the past 22 years (i.e., 6.3%, annually).

We choose standard values for the technology and policy parameters. In particular, the capital share in production and the depreciation rate are set to 0.33 and 0.025, respectively. 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.¹⁸ Following [Taylor \(1993\)](#), we select neutral values for 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. While erring on the side of having priors that are as non-informative as possible, we based many of our guesses on the current literature. For the choices of prior distributions, we draw heavily from [Iacoviello \(2015a\)](#), wherever appropriate. Given the values of the capital and housing adjustment costs are taken from [Christensen and Dib \(2008\)](#) and [Ngo \(2015\)](#), we set the starting guesses for these two parameters to be 0.59 and 0.1, respectively. Our initial guesses for the weights of housing in utility functions are set so that in the steady state subprimers' housing is 40% of the GDP, whereas the ratio of primers' housing to GDP is equal to 2.4. We obtain these values using the SCF, FRED and BEA databases.

Table 6 presents the sets of estimated parameters, along with our choices of prior and posterior information. For estimation, we attempt to match the extended model to five series: real output growth, real consumption growth, growth rate of the private residential investment, growth rate of house prices, and bank prime loan rate. We obtain data after the *Great Moderation* (1984:Q1 to 2016:Q2) from the Federal Reserve Bank of 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 ergodic distribution. As Table 6 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 0.99, 0.95, 0.97 and 0.98 to be the means of the discount rates of patient households, subprimers, primers, and entrepreneurs, respectively.

5 Results: An Extended Model with Nominal Rigidity

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,

¹⁸In equilibrium, the share of housing in production is $\kappa = (((1 - (m_e/Z_e))(1/\beta_e)) - (1 - m_e))(qH_e X/Y)$. Therefore, κ can be calculated using the estimations of $(q^h H_e/Y) = e$ and Z_e as shown in Table 6.

Table 6: Priors and Posteriors of Estimated Parameters

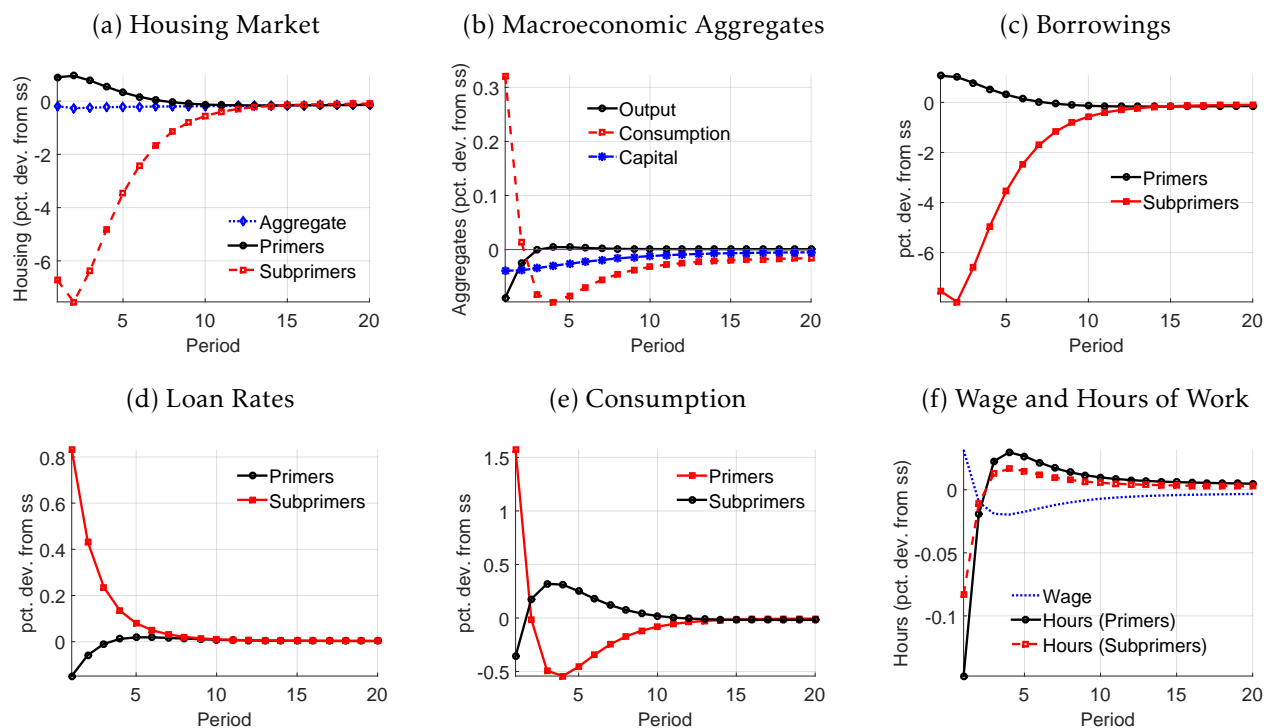
Parameters	Prior Mean	Posterior Mean	90% HPD interval	Prior	Post. Std.	
β_H	0.99	0.9879	0.9798	0.996	beta	0.005
β_S	0.95	0.9507	0.9432	0.9593	beta	0.005
β_P	0.97	0.9699	0.9624	0.9774	beta	0.005
β_e	0.98	0.9804	0.9741	0.9886	beta	0.005
ρ_A	0.9	0.8991	0.8669	0.9291	beta	0.02
χ_K	0.59	0.5902	0.5853	0.5948	beta	0.003
χ_H	0.1	0.1003	0.0948	0.1046	beta	0.003
m_e	0.8	0.8016	0.7442	0.8442	norm	0.03
m_s	0.8	0.8014	0.7525	0.8504	norm	0.03
m_p	0.8	0.7984	0.7487	0.8436	norm	0.03
θ	0.75	0.7482	0.7145	0.7805	norm	0.02
e	0.6	0.6001	0.5528	0.6516	norm	0.03
s	0.4	0.4023	0.3496	0.4514	norm	0.03
p	2.5	2.5034	2.4508	2.551	norm	0.03
ρ_f	0.5	0.5364	0.4108	0.6686	beta	0.1
ρ_X	0.5	0.505	0.3174	0.696	beta	0.1
ρ_{XI}	0.5	0.5218	0.3572	0.675	beta	0.1
Standard Deviation of Shocks						
Shocks	Prior Mean	Posterior Mean	90% HPD interval	Prior	Post. Std.	
ε_A	0.01	0.0364	0.0328	0.0398	invg	Inf
ε_e	0.01	0.0417	0.0383	0.045	invg	Inf
ε_f	0.02	0.0078	0.0051	0.0107	invg	Inf
ε_X	0.01	0.0382	0.0334	0.041	invg	Inf
ε_{XI}	0.01	0.0265	0.0241	0.0293	invg	Inf
ε_P	0.01	0.0094	0.0085	0.0103	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) from the Federal Reserve Bank of St. Louis (FRED) database. 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.

or equivalently an increase in the risk premium that subprime borrowers pay, can significantly affect housing wealth reallocation 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 housing wealth distribution. As expected, the non-financial shocks have little effect on the housing wealth distribution due to similar effects on borrowers.

Since the recent financial crisis coincided with a period of near zero interest rates and lax borrowing conditions, we examine the effects of an adverse financial shock at the ZLB and study the role of collateral constraints. We also show that the ZLB amplifies the negative

Figure 5: Responses to an Adverse Financial Shock



Note: This figure plots the impulse responses of selected variables to a one standard deviation (one percent) 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.

effects of financial frictions on aggregate housing demand compared to the case in which the ZLB does not bind, yet has a limited effect on housing wealth distribution. To examine the role of 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 4 under the calibration presented in Section 4.7. We generate the impulse responses by initiating a one standard deviation adverse shock to the financial friction. Figure 5 demonstrates the responses to this financial shock which are normalized such that they represent percentage deviations from their respective steady-state values.

Figure 5 shows that a one standard deviation increase in the gap between primers and subprimers' loan rates can lead to an increase of over 1% in the housing investment for primers and a decrease of around 7% for subprimers. The intuition of the mechanism is as

follows. The adverse financial shock (i.e., an increase in the level of risk premium) significantly increases the relative cost of obtaining additional housing for the subprimers compared to the prime borrowers. Because 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. The stark decrease in subprimers' demand pushes the house prices down. Since primers still have relatively better access to credit and decreasing loan rates as preferred customers of banks, they can take advantage of low house prices and increase their investment. Indeed, as our variance decomposition exercise in Table B1 shows, financial shocks can account for approximately 25-28% of variation in housing investment for subprime borrowers.

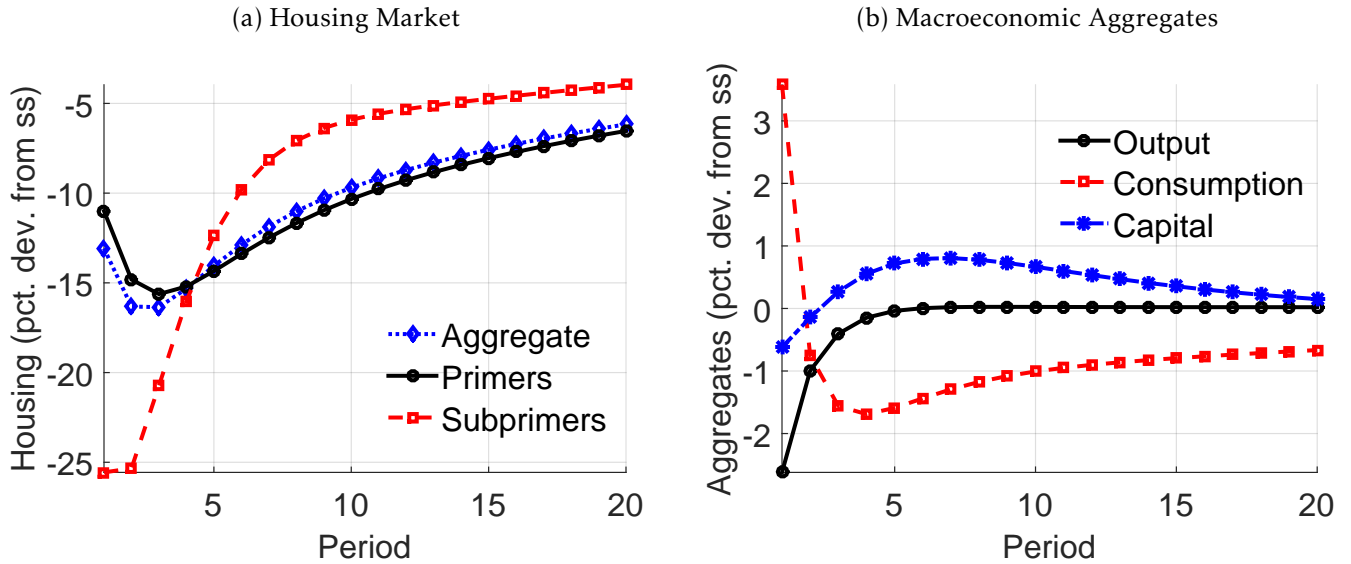
Turning to the responses of macroeconomic aggregates, an adverse financial shock (i.e., a one-percent increase in the innovation to the financial friction f_t) can have a significant ramifications on the economy. Specifically, output, consumption, and capital decrease following a negative financial shock as the 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

The Effects of the TFP Shock Figure 6 presents 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. The difference between the loan rates of borrowers cause subprimers to be significantly worse off in the housing market. 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.

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 7. As expected, a negative shock on capital supply causes the entrepreneurs to substitute away from capital. Thus, while the capital stock

Figure 6: 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.

decreases in the economy, entrepreneurs demand more housing.

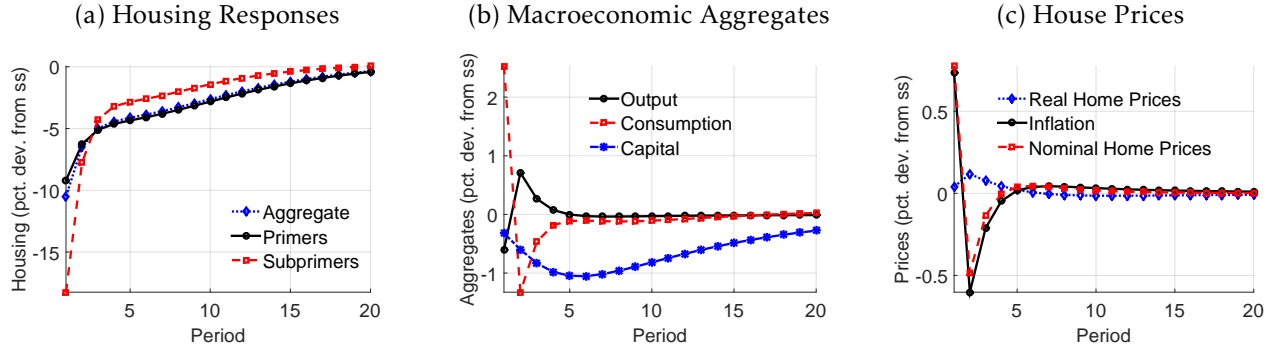
Figure 7c shows that the increase in entrepreneurial demand on housing is not sufficiently large to push the nominal house prices up entirely. As a result, the borrowing constraints become tighter for both subprimers and primers, the combination of which prompts the two types of borrowers to consume more, rather than to ramp up their investments in housing. The capital supply shock (Figure 7a), therefore, cannot generate a wealth reallocation between subprime and prime borrowers since both borrowers are similarly affected. 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 presented in Figure 7f, increases in house prices relax the borrowing constraint by increasing the collateral value. Even though subprimers initially enjoy the lax credit conditions more, the less constrained agents receive more persistent benefits.

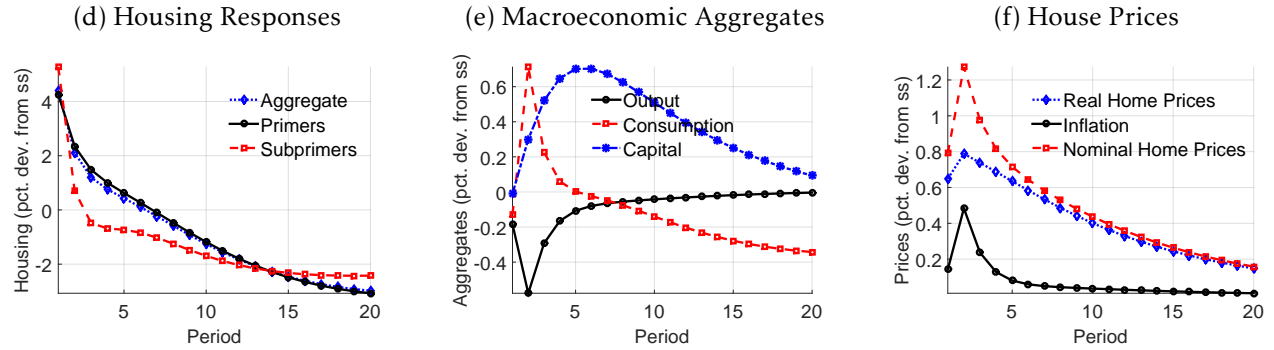
The Effects of Monetary Policy Shock Figure 8 presents the responses of housing market and other macroeconomic variables to a one hundred basis point decrease in the nominal interest rate. In particular, here we initiate a negative 100-basis-point shock to the innovation of the interest rate process, ε_t^R . While consumption decreases at first due to substitution with housing, it quickly increases as price responses to expansionary monetary policy and the real interest rate rises.

Figure 7: Effects of Negative Supply Shocks

Responses to Negative Capital Supply Shocks



Responses to Negative Housing Supply Shocks



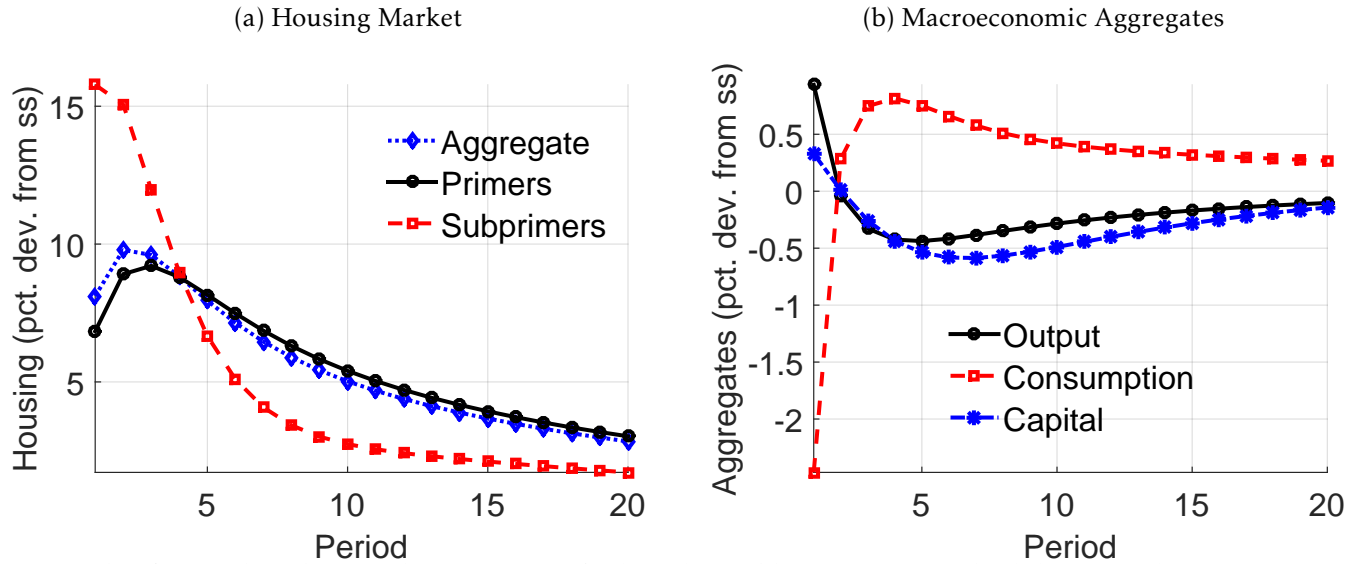
Note: This figure plots the impulse responses of selected variables to a one percent decrease in the innovation to the investment and housing specific technology shocks. Aggregate housing demand shows the total demand of subprime and prime borrowers. All responses are normalized so that the units of the vertical axes represent percentage deviations from the steady state.

While housing investment for both primers and subprimers increase significantly (more so for latter), those of primers are more persistent. The finding that subprimers enjoy the low interest rates more due to being able to afford larger mortgages supports the results in [Justiniano et al. \(2016\)](#). This result therefore suggests that an expansionary monetary policy can help ameliorate the asymmetry caused by housing wealth reallocation during recessions.

5.2.1 The Role of the Zero Lower Bound

We explore the effects of an adverse financial shock when the economy is at the ZLB. In particular, we initiate a negative preference shock to β_h so that the risk-free interest rate R_t is kept at the ZLB for two periods, and we then employ a one standard deviation adverse financial shock to the economy. We solve the model using piece-wise approximation as in [Iacoviello \(2015b\)](#). Figure 9 presents the impulse responses of housing demand, house

Figure 8: Effects 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.

prices, output, and consumption 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.¹⁹

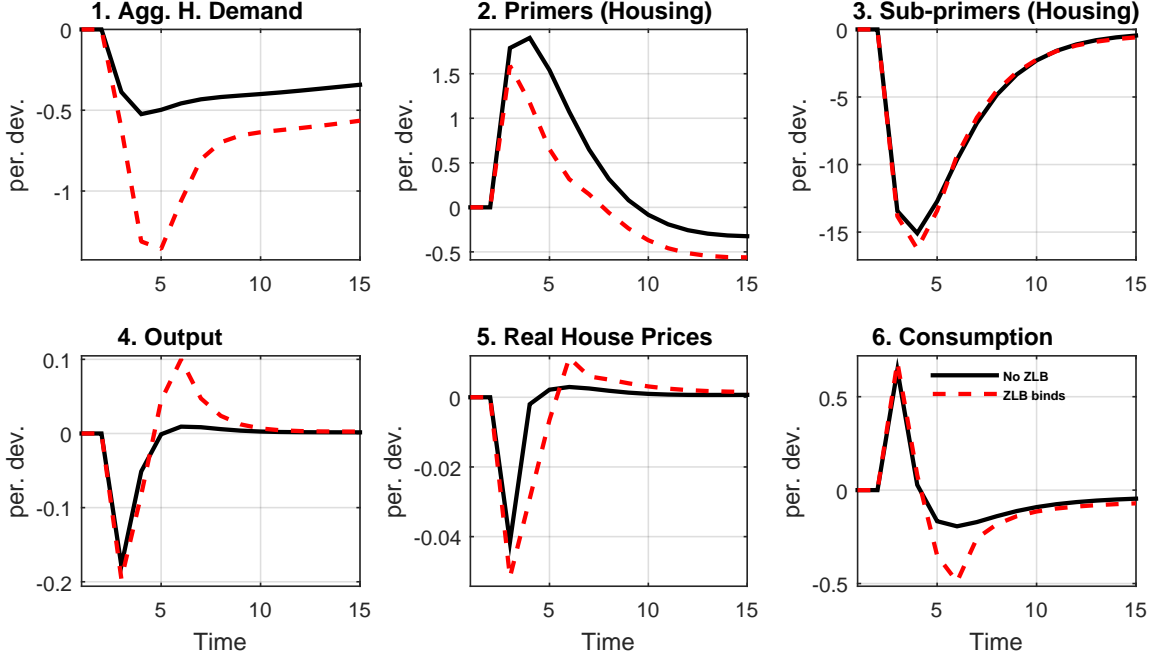
The effects of an increase in financial premium across the two types of borrowers on the aggregate housing are amplified when the economy is constrained at the ZLB. The intuition for this result is as follows. When the nominal interest rate is constrained by the ZLB under an adverse financial shock, 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. The ZLB amplifies the negative effects of financial frictions on aggregate housing demand compared to the case in which the ZLB does not bind, while having a limited effect (an increase of less than 0.5% in asymmetry) on housing wealth distribution.

5.2.2 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 housing wealth reallocation. By not constraining the loan-to-value ratio previously, we took a conservative route to pin down the effects coming only from the risk premium. However, a decrease in this ratio can cause tighter borrowing conditions for all borrowers. For instance, consider the following

¹⁹While we did not use a global method to solve for the policy function, the piece-wise method presented by [Iacoviello \(2015b\)](#) provides a reasonably close approximation of the policy function to the one that is solved using global methods.

Figure 9: Responses at the Zero Lower Bound



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 shows the total demand of subprime and prime borrowers. We solve the model using piecewise approximation, following [Iacoviello \(2015b\)](#).

borrowing constraint for the subprime borrowers.

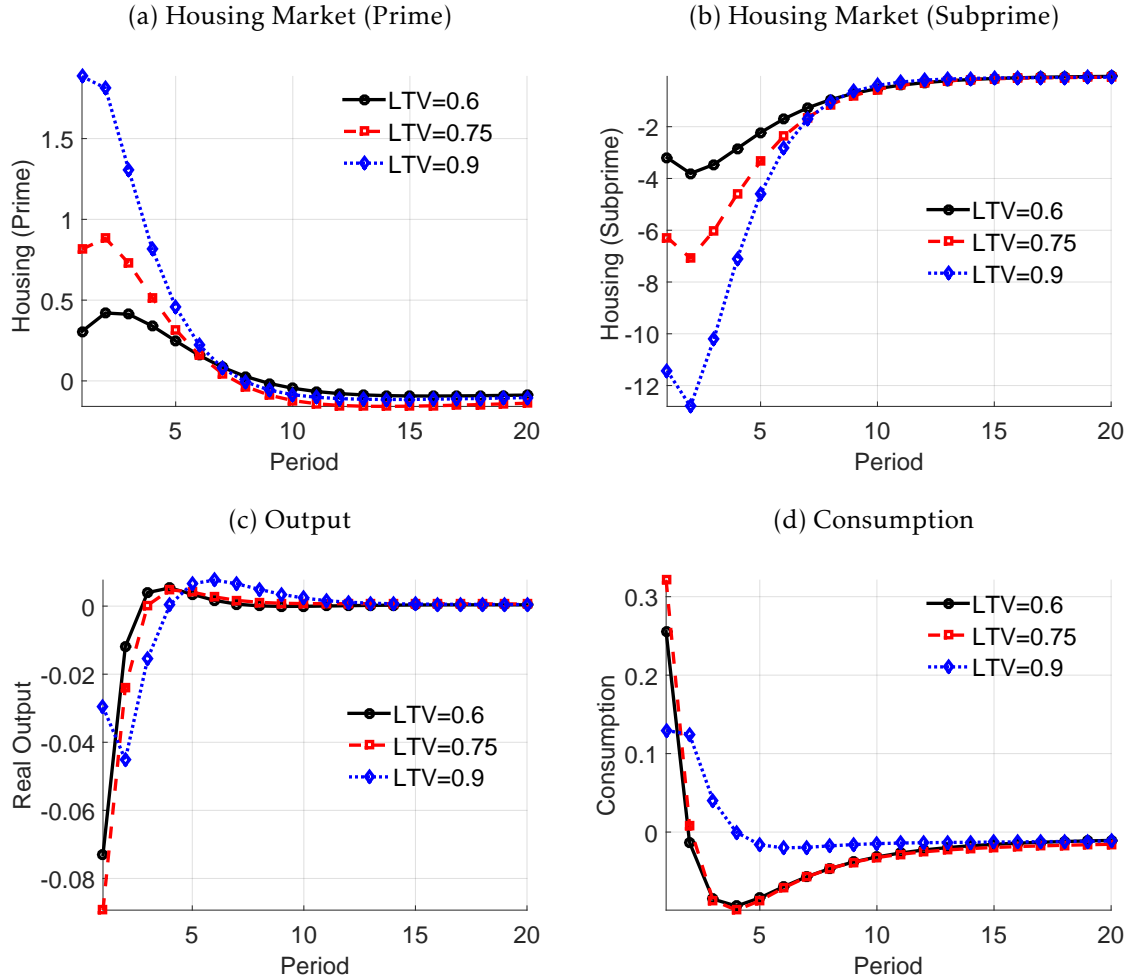
$$B_{s,t} \leq m_s E_t \left\{ q_{t+1}^H H_{s,t+1} \frac{\pi_{t+1}}{Z_{s,t}} \right\}$$

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 his 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 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 subject to an adverse financial shock, their loan rates will increase disproportionately more

Figure 10: Adverse Financial Shocks (Varying LTV Ratios for Subprimers)



Note: This figure plots the responses of selected variables to an adverse financial shock. In particular, we initiate a one standard deviation adverse 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 , while keeping everything else in line with the baseline calibration.

compared to prime borrowers. A higher value of Z_s will push subprimers into the case in which $Z_s > \frac{1}{\beta_s}$ holds. 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 10 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 10 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 cause subprimers to have excess leverage which yields higher losses in the housing market under a credit crunch supporting the findings in [Justiniano et al. \(2016\)](#) further.

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 Debt-to-Value Ratio and Risk Premium

We have shown that an increase in the financial friction f can help amplify the asymmetry in housing investment during recessions as observed in the data. While studying the model under a direct shock to the risk premium is important, a natural question arises as to which factors can help determine the premium between subprime and prime borrowers. Our starting point to answer this question is to understand the extent to which the borrowers' debt-to-value ratio has an effect on the borrowers' loan rate. To do so we return to the *Survey of Consumer Finances* and regress the individual loan rate (in basis points) on the debt-to-value ratio, while controlling for demographic characteristics and time fixed effects. In particular, we use the following specification:

$$\text{Loan Rate}_{it} = \beta_0 + \beta_1 \text{Debt-to-Value}_{it} + \beta_2 \text{Demographic Controls}_{it} + \varepsilon_{it} \quad (44)$$

Here the debt-to-value ratio is calculated as:

$$\text{Debt-to-Value} = \frac{\text{Borrowed Amount}}{\text{Total Value of the House}}$$

Table 7 presents the regression results for prime and subprime borrowers using Equation 44. While the first two columns of Table 7 uses the same classification for prime and subprime borrowers as in our baseline regressions in Section 2 (i.e., based on their loan rates), in the next two columns of the table we classify borrowers based on their income. One key insight from Table 7 is that debt-to-value ratios can have a significant and positive impact on the

Table 7: Debt-to-Value Ratio Regression Results

	By Loan Rate		By Real Income	
	Subprimers	Primers	Subprimers	Primers
Debt-to-Value Ratio	1.178** (0.153)	0.591 (0.265)	0.538*** (0.0263)	2.236*** (0.0833)
Constant	5,562.8*** (63.12)	-1,036.8* (249.7)	5,064.6*** (97.69)	10,214.3*** (112.6)
N	6,203	856	11,816	5,627
Demographic Controls	Yes	Yes	Yes	Yes

Note: In this table, we regress the loan rate of the first mortgage on the individual debt-to-value ratios for prime and subprime borrowers using the following specification: $\text{Loan Rate}_{it} = \beta_0 + \beta_1 \text{Debt-to-Value}_{it} + \beta_2 \text{Demographic Control}_{it} + \varepsilon_{it}$. We classify prime and subprime by both their loan rates and their real income. Values in parentheses show the standard errors. Here we control for time fixed effects as well as demographics of the households. Loan rates are expressed in basis points. ***, **, and * denote the 1%, 5%, and 10 % levels of significance, respectively.

rate at which the borrowers can borrow. In other words, the higher their debt-to-value ratios are, the higher loan rate the borrowers have to pay.

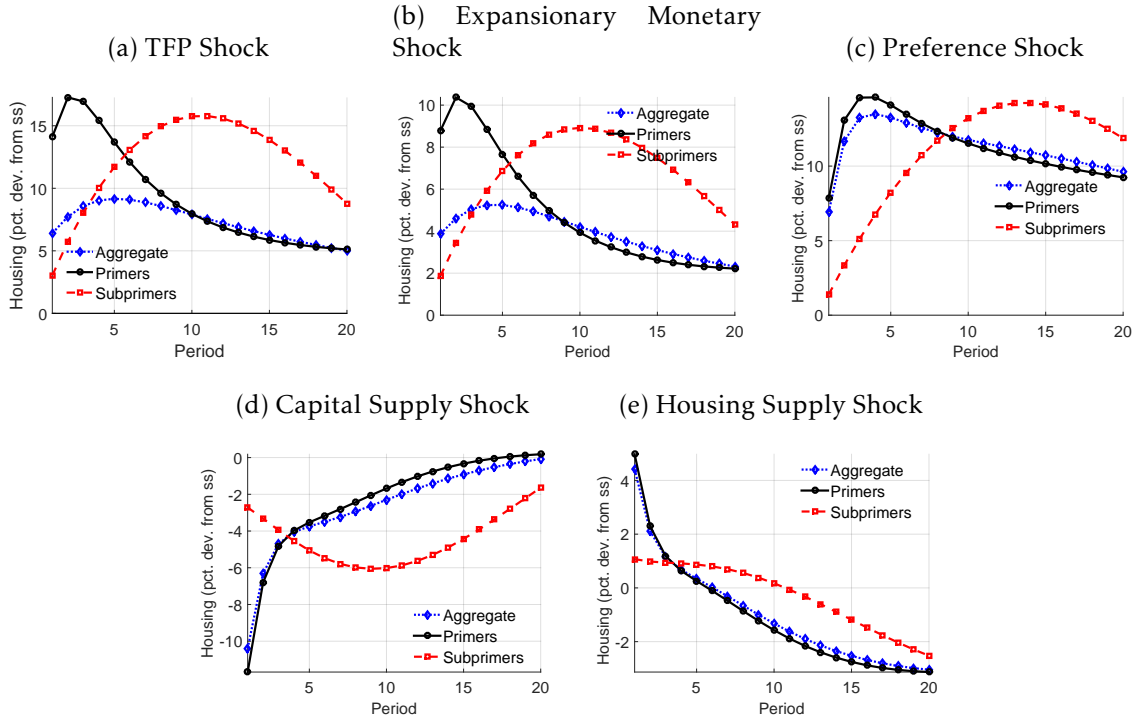
Given this positive relationship between loan rates and debt-to-value ratio in the data, we take this empirical result to the model, exploring the possibility that the financial institution does take into account the debt-to-value ratios of the subprime borrowers when setting their interest rate premium in our model. In particular, we solve for a model with nominal rigidity that is identical to our extended model in Section 4, with the exception of the equation for the financial friction as follows.

$$f_t = (1 - \rho_f) \bar{f} + \rho_f f_{t-1} + \Delta \left(\frac{\tilde{Z}_{s,t} \tilde{B}_{s,t}}{q_t^h \tilde{H}_{s,t}} \right) \quad (45)$$

Here the ρ_f denotes the level of persistence and $\frac{\tilde{Z}_{s,t} \tilde{B}_{s,t}}{q_t^h \tilde{H}_{s,t}}$ represents the average debt-to-value ratio across all subprime borrowers. We assume that individual borrowers do not observe the average debt-to-value ratio of their type. The expression $\Delta \left(\frac{\tilde{Z}_{s,t} \tilde{B}_{s,t}}{q_t^h \tilde{H}_{s,t}} \right)$ therefore represents the percent change in the debt-to-value ratio from the previous year, which is our equivalent of the debt-to-value ratio that we used in Table 7. Under this specification, as subprimers accumulate more leverage, their risk premium increases. In terms of parametrization, we follow all parameter values specified in Section 4.

Figure 11 plots the impulse responses of housing investment for prime and subprime borrowers with the financial friction f characterized as in Equation 45. While an increase in TFP leads to increases in housing investment as expected, we also observe a divergence in the responses across the prime and subprime borrowers. In a similar fashion, an expansionary monetary policy shock tend to benefit the primers more than their subprime counterparts

Figure 11: Responses of Housing Market with (Debt-to-value Specification)



Note: This figure plots the responses of housing investment to a TFP shock, an expansionary shock, a capital supply shock, a preference shock (for the patient households), and a housing supply shock. All shocks are initiated with a 1% magnitude.

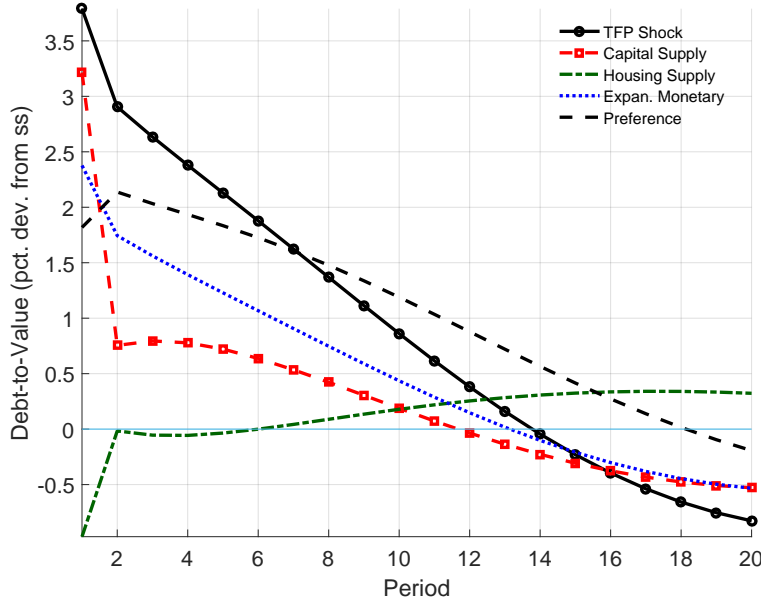
in the long run, because the shock can implicitly effect the premium that the subprimers have to incur by influencing the debt-to-value ratio. We also observe diverging responses of housing across these two types of borrowers to a negative capital supply shock.

To understand the mechanism behind these results, we plot the impulse responses of the debt-to-value ratio to all of the shocks in Figure 12. Since the risk premium is positively related to the debt-to-value ratio, a higher ratio implies an increase in the premium that the borrowers have to incur. An increase in TFP and capital supply, along with a decrease in the nominal interest rate amplify the debt-to-value ratio. Therefore, higher risk premium leads to stronger asymmetry between subprime and primer borrowers as observed in Figure 11.

7 Conclusion

In this paper, we investigate the effects of the heterogeneity in credit access among borrowers on the housing wealth distribution during recessions. We first document that second home purchases increase significantly during recessions, while overall homeownership and house prices decline steadily. To differentiate and control for different 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

Figure 12: Responses of Debt-to-value Ratio



Note: This figure plots the impulse responses of the debt-to-value ratio to a one-percent increase in TFP, capital supply, housing supply, and one percent decrease in the nominal interest rate.

for a rich set of demographic and financial characteristics. We find that prime borrowers are more likely to own investment homes during recessions compared to recoveries, whereas subprimers are less likely to do so. These results point to a dramatic difference between subprimers and primers: while subprimers are likely to be 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 study a general equilibrium framework with heterogeneity in terms of credit access across borrowers. As observed in the data, subprimers have a risk premium that increases with their debt-to-value ratios 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 ZLB and find that the ZLB amplifies the negative effects of financial frictions on aggregate housing demand compared to the case in which the zero lower bound does not bind, yet has a limited effect on housing wealth distribution. We find that debt-to-value ratios play an important role in propagating the risk premium across these two types of borrowers, both in the model and in the data. On the other hand, an expansionary

monetary policy can decrease the asymmetry in home purchases, ameliorating the undesired effects of increases in financial frictions during recessions.

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A Data Appendix

We use data from the *Survey of Consumer Finances* and combine the surveys conducted in 1995, 1998, 2001, 2004, 2007, 2010, and 2013 into one single dataset. While data before 1995 are available, we exclude them from the combined dataset because standardized weighting files are not provided. Please refer to Table A1 for the details about derivations and definitions of the selected variables.

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 brackets 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.

Table A1: SCF Survey Questions for Selected Variables

Variables:	Definitions and Questions:
<i>Primary Homeownership</i>	Do you (and your family living here) own this house? 1. Yes 0.No
<i>Investment Homeownership</i>	Do you 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
<i>Income</i>	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?
<i>Payment Schedule</i>	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
<i>Credit Rejected</i>	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
<i>Expectations</i>	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
<i>Gender</i>	Sex of the respondent 1. Male 2. Female
<i>Education</i>	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
<i>Age</i>	What is your year of birth?

Table B1: Variance Decomposition: Baseline Extended Model

	Shocks				
	Financial Friction	TFP	Monetary	Housing Supply	Capital Supply
B_p	1.03	75.98	17.73	2.55	2.65
B_s	24.54	56.65	15.54	0.90	2.37
$\Delta H_s/H_s$	28.37	48.44	15.71	0.37	7.13
$\Delta H_p/H_p$	9.81	58.30	18.32	4.92	8.65
C_p	0.62	69.49	23.96	2.55	3.38
C_s	8.24	61.53	20.97	5.08	4.17
L_p	0.67	72.38	21.73	3.15	2.05
L_s	7.62	66.07	20.25	3.45	2.62
H_p	1.04	76.06	17.51	2.77	2.57
H_s	25.26	55.52	14.83	2.21	2.18
q^h	0.05	8.71	2.58	88.49	0.16
q	0.17	20.93	5.63	0.60	72.67

Note: This table present the variance decomposition of selected variables to financial friction shock, TFP shock, expansionary monetary shock as well as housing and capital supply shocks. We exclude preference shock in this exercisce as it serves the purpose of keeping the economy at the ZLB.