Securitization, Non-Recourse Loans and House Prices

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August, 2017

Abstract

We study the effects of securitization and recourse (limited liability) laws on housing markets. Securitization allows originators to pass on the risk of loans they originate. When loans are non-recourse, originators stop screening due to the absence of credible signalling to securitizers. This allows speculator borrowers to start receiving loans and the put option of non-recourse loans pushes up house prices during a demand boom. We predict that the interaction between securitization and non-recourse status should lead to higher house prices. We use heterogeneity in recourse laws in US states to test this. As predicted, non-recourse status roughly doubles the size of the positive relationship between securitization and house prices and can potentially explain 75% of the difference in prices between recourse and non-recourse states during the 00s housing boom. To address potential endogeneity concerns, we propose a new instrument for securitization, the distance of a housing market to the headquarters of 'originate and securitize' institutions, and find further empirical support for our prediction.

JEL Classification Numbers: E00, E44, G20, R31.

Keywords: House prices, securitization, screening, non-recourse loans.

*Address: Musashi University, 1-26-1 Toyotamakami, Nerima-ku, Tokyo, Japan, e-mail: p.franco@cc.musashi.ac.jp. The author is indebted to Kevin Sheedy for his supervision and to many others, including Michael Peters, Rachel Ngai, Shengxing Zhang, Paolo Surico, Steve Pischke, Ethan Ilzetzki, Wouter den Haan, Alex Clymo, Fabian Winkler, Markus Riegler, Svetlana Bryzgalova, Oriol Anguera-Torrell, Yan Liang, Thomas Drechsel, Joao Paulo Pessoa, Andreas Ek, Victor Westrupp, Stefanie Huber, Michel Azulai, Thomas Carr and Galina Shyndriayeva for their suggestions, and to the seminar participants at numerous institutions and conferences, including the LSE, York/BoE PhD Workshop, Midwest Macro, TADC, UNLV, Riksbank, Insper, U Tokyo and SWET-2017 for their helpful comments. The author acknowledges and thanks the LSE and the estate of Sho-Chieh Tsiang for its financial support. A previous version of this paper was presented under the title of 'Securitization, Screening and Housing Bubbles'.

1 Introduction

The national rise and fall of house prices experienced in the US during the 2000s was unparalleled in the last 70 years, and the literature is still grappling with trying to explain the cause of this boom and bust. Given that many prominent economists, including Bernanke (2010) and Mian and Sufi (2014), have argued that the financial crisis and Great Recession that followed were a direct consequence of what happened in the US housing market in that period, the importance of trying to understand this phenomenon cannot be understated.

Many explanations have been put forward to try to explain the pattern in house prices. Amongst others, it has been proposed that moral hazard in mortgage originations caused an increase in supply of loans (Mian and Sufi, 2009); that a decline in lending standards by originators led to an increase in demand for housing (Duca, Muellbauer and Murphy, 2011, and Dell'Ariccia, Igan and Laeven, 2012); that there was a large degree of misrepresentation of the quality of mortgages (Piskorski, Seru and Witkin, 2013); and that house buyers experienced overoptimism about the future trajectory of house prices (Case and Shiller, 2003, and Case, Shiller and Thompson, 2012).

All these papers, with the exception of Case, et al., emphasize the importance that private securitization products, such as CDOs and MBOs, had in affecting prices; this is not surprising, as private securitization also reached unprecedented levels in the 2000s. We seek to add to this literature by proposing a mechanism by which private securitization, when combined with non-recourse laws, can affect house prices, and proceed to test this mechanism empirically, finding evidence of its effects during the boom period.

Our model follows the approach pioneered in Allen and Gorton (1993), where asymmetries of information and agency problems result in a mechanism which affect assets prices[1], resulting in prices being higher than they would otherwise be[2]. Their results have been extended to many different areas, such as between different sectors of the economy in Allen and Gale (2000) and Barlevy (2011), and there is experimental evidence that this mechanism can affect asset prices (Holmen, Kirchler and Kleinlercher, 2014). In particular, Barlevy and Fisher (2010), hereafter B&F, extend this mechanism to the housing sector; we use their framework to build our model.

In B&F's model, there exist two types of borrowers, those that value owning a house (high types) who can be interpreted as 'traditional' owner-occupiers, and those who do not (low types) who can be thought as speculators[3], with lenders unable to tell them apart. They find that under certain conditions, house prices can be higher than

[1] This literature denotes the effects of such mechanisms as rational bubbles.

[2] This increase happens within the context of an agent-principal problem, where there are asymmetric payoffs for a risky investment, such that the upside rewards the agent, but the downside is born mainly or completely by the principal; this incentivizes the agent to over-invest in the risky asset

[3] As we discuss in the Appendix, there is substantial evidence that speculators were a significant part of house buyers during the 2000s housing boom in the US.

their fundamental value[4], arising during a housing boom triggered by an increase in housing demand.

This appreciation in prices is mainly due to these loans being non-recourse, that is, of limited liability, where in the case of a default, lenders can only recover the asset securing the loan; US state are heterogeneous when it comes to recourse status[5]. This creates a put option value for speculators, as they can default cheaply/costlessly should prices fall. When speculators subsequently become marginal sellers, this pushes house prices up. B&F predicts that either demand keeps increasing for long enough such that a new, permanent high level of house prices becomes the equilibrium price, or, if housing demand stops rising before that, that prices immediately drop and defaults happen.

We use B&F's framework, but introduce two novel elements to this literature: a screening technology that allows originators to costly screen borrowers, and a securitization market for loans. We choose to add these elements for several reasons, most saliently because there is empirical evidence that securitization interacted in important ways with screening by lenders during the 2000s boom in the US; Mian and Sufi (2009), Keys, Mukherjee, Seru and Vig (2010) and Elul (2011) all find that more securitization of loans led to less screening by lenders. Both Elul and Keys et al. find that this caused an increase in default rates in subprime mortgages, whilst the former also finds an increase in privately held, securitized prime loans, suggesting that this decrease in screening happened in all types of mortgages. Our addition of screening and securitization may also help explain why this mechanism may have not played a significant role prior to the 2000s, as we discuss below.

With these two new elements, we find that, under some parameter restriction, in housing markets where loans are non-recourse there are two possible equilibrium. In one, borrowers are screened and speculators are denied loans, however, counterfactually, no loans are securitized. In the other, no screening happens and loans are securitized. This is due to loan originators being unable to credibly signal to the securitization market whether a loan has been made to a speculator type or not combined with the non-recourse nature of loans.

As a consequence, in the absence of securitization, house prices follow fundamentals during a housing boom, but when securitization occurs, speculators' access to loans pushes up house prices as in B&F. Furthermore, if the boom stops, house prices fall further and defaults can take place when loans are being securitized. If loans are recourse, however, there is never a option value for borrowers, and prices always follow the fundamentals, independently of whether there is securitization or not.

[4]As per Allen, Morris, and Postlewaite (1993): 'Value of an asset in normal use as opposed to (...) as speculative instrument.'

[5]Few countries outside of the US offer non-recourse mortgages, but Brazil became a important exception in 1997, when 'alienacao fiduciaria' loans (article 27 of law 9.514) were established, which are not only non-recourse, but in the case of defaults, if the market value of the asset is greater than the contractual value, borrowers are entitled to the value in excess of the contract, after costs; such loans may be sold via a 'cessao de credito' operation.

We thus predict that the combination of both factors, securitization and the presence of non-recourse laws, should have a positive effect on house prices in US states, compared to states where either or both factors are missing. Depending on originators' size, this equilibrium can exist when we introduce down-payments.

Some tentative evidence for this mechanism can be seen in Figure 1, which plots house house prices in recourse and non-recourse states from 1991; the latter experiences higher house price growth starting at a similar period to when the private securitization market 'took-off', around 2003. In the Appendix D, a identical plot starting from 1975 but with lower quality data, shows a similar pattern[6].

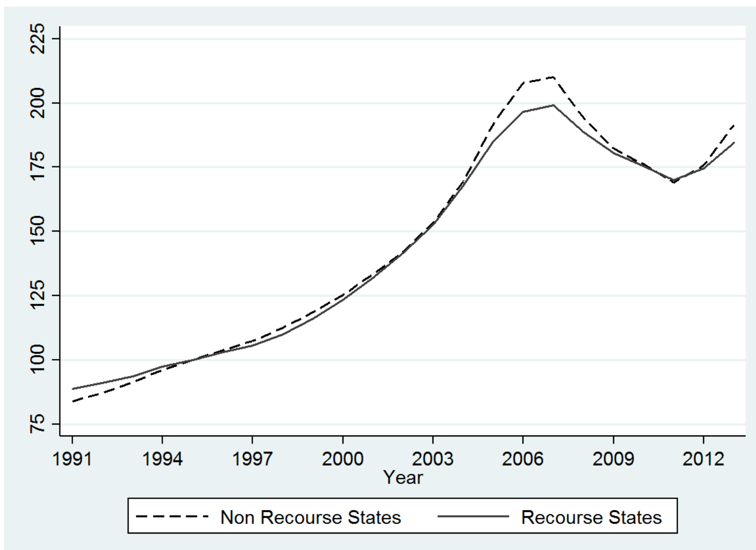

Figure 1: House Prices in recourse and non-recourse states, from 1991

We test our model predictions using US state and MSA (Metropolitan Statistical Area, that is, cities) level data from 2004-2006, making use of heterogeneity in US states' recourse laws. We do this by regressing house prices on a measure of the percentage of securitized new loans and interact this with non-recourse status of a state/MSA (and controls). We find evidence that securitization is positively correlated with house prices, wherein for every extra 1 p.p. of new mortgages that were securitized, house prices increased by around 1% in the period. Moreover, this effect was roughly doubled when laws are non-recourse. This result survives a number of robustness checks. We conclude that the interaction between securitization and non-recourse can potentially explain around 75% of the difference in house prices in the average recourse and non-recourse states from 2004-2006.

Due to possible endogeneity/reverse-causality issues between house prices and securitization, we instrument for securitization by using the weighted distance of a given

[6]However it also shows two other detachments, one from around 1985 to 1992, wherein recourse states experienced higher house growth compared to non-recourse states, and one since around 2012 with non-recourse states growing faster; we discuss this issue more in Section 5

MSA to the two closest headquarters of 'originate and securitize' mortgage institutions. We find similar results to our main regressions, but we note that there may be first stage problems with our instrument, in particular our first stage coefficients are inconsistent in recourse states. We take this result as more evidence, but not conclusive evidence, that our mechanism played a role in the US housing boom.

We also test our model predictions for the bust period, that house prices should fall more and there should be more defaults due to the interaction effect stemming from the boom period. Using a similar strategy to the boom period but with boom-period a measure of securitization, we find weak evidence for our house price prediction, and no evidence of increased defaults due to the interaction effect. We also find some evidence that securitization as whole played an role in determining house prices in both boom and bust, and for defaults in the bust.

Our paper and results are closely related to the growing literature on the effects of recourse law in the United States, which exploits the heterogeneity of state' laws, which stems mainly from the Great Depression. Ghent and Kudlyak (2011)'s paper, by providing a benchmark classification for recourse status and showing its effects on defaults, has proven very influential, with Dobbie and Goldsmith-Pinkham (2014), Westrupp (2015) and Chan, Haughwout, Hayashi, and Van der Klaauw (2016) being recent papers that explore the effects of recourse status in housing markets.

In particular, Nam and Oh (2014) propose a similar hypothesis to the one our paper explores, that is, that non-recourse laws may have affected house prices. They investigate this possibility empirically by looking at the effects of recourse laws on house prices during the boom period, using state border discontinuities. They find that non-recourse states experienced greater house price increases during the boom, and that borrowers were actively taking advantage of non-recourse status by taking on greater leverage and investing more in housing, and that lenders were aware of the added risks, which largely conform to our model predictions; unlike our paper, they do not control for levels of securitization. Our paper chooses to not follow their empirical strategy, however, following some of the concerns raised by Westrupp (2015).

This paper is organized as follows. The next section presents a two period version of the model with static prices to illustrate our basic model mechanism of how securitization and screening interact in our general equilibrium model. We then present in Section 3 our general equilibrium model with endogenous prices. We discuss our data in Section 4 and present our empirical strategy and results in Section 5. Section 6 concludes.

2 Partial equilibrium with exogenous prices

There are two periods in this version of the model. In the first period, firstly transactions between borrowers (B) and originators (O) happen. Borrowers consist of two types, owner-occupiers/high types (denoted by H) and speculators/low types (denoted by L). This is followed by a securitization period, where originators can sell mortgages to securitizers (S). In the second period, a exogenous house price increase/decrease happens and borrowers must decide whether to default or repay.

Houses initially cost 1 in period 1, and in period 2 will be $1 + \Pi$. Π is a random variable that equals π with probability q and $-\pi$ with probability $(1-q)$. All loans are of size 1 with total repayment in period 2 equal to $1 + r$, and we restrict interest rates to be positive for all cases. As we only have one repayment period, any default is for 100% of the loan. If a loan is in default, the house is immediately taken as collateral and sold for the prevailing market price.

We discuss the in depth the assumptions we make for each agent, including borrowers, and for each market of our model in Appendix A.

2.1 Borrowers

Borrowers derive a stock utility from owning a house. They are required to take on a loan to purchase a house and can only acquire one house. If they receive a loan in the first period, in period two they can either repay the loan from their income or from selling their house, or the can default on the loan. Borrowers can choose which originator to approach for a loan in period one.

Borrowers consist of two types, $\zeta_{.} \in \{H, L\}$, with γ low-types/speculators and $(1-\gamma)$ high types/owner-occupiers; we use these terms interchangeably. Both types have an income of y, realized in period two, and where y is large enough to fully cover any level of mortgage repayments.

Borrower' utility function is linear and separable between consumption goods and house ownership, such that for a borrower i:

$$U_i^B = c_i + \kappa_i B_i(1 - D_i)(1 - S_i)$$

where c_i is the consumption in period 2; κ_i is the stock utility from owning a house at the end of period 2, with $\kappa_i = 1 + \kappa$ for $\zeta_i = H$ and $\kappa_i = 0$[7] for $\zeta_i = L$; and B_i, D_i and S_i are indicator functions, where a 1 indicates whether a borrower has bought a house, defaulted on a loan and sold a house, respectively.

The budget constraint of a borrower i is:

$$c_i + B_i(1 - D_i)(1 + r_{i,j}) = y + B_i(1 - D_i)S_i(1 + \Pi)$$

where $r_{i,j}$ is the interest rate on a loan from originator j and y is the income of borrowers, high enough such that $1 + r_i < y$ for any $r_{i,j}$. Although borrowers are risk neutral, we can make borrowers of both types be risk averse and find that our equilibrium results can hold, depending on the level of risk aversion; the Appendix A provides a further discussion.

Borrowers have a set of 3 actions, $S_{\zeta,B}$. In the first period, they decide which originator they approach for a loan, choosing j_i^B in J (where J is the set of originators).

[7] Although assuming that speculators derive zero utility from owning a house may seem extreme, we could re-normalize this to some positive number without loss of generality.

They do so taking into account that each originators post a set of information Λ_j. In the second period, borrowers decide whether to default on a loan (D_i), and whether to sell a house (S_i).

The information set $\Lambda_j = (SC(j), BO(j), \{r(.)\})$ consists of the following. $SC(j)$ is a indicator function which takes value 1 if j screens borrowers. $BO(j)$ is a indicator function which takes value 1 if loans will be given to both types (as opposed to only high types). $\{r(.)\}$ is the set of interest rates on the loans being offered, which we divide into different cases, depending on $SC(j)$ and $BO(j)$. If $SC(j) = 0$, this is a non-screening Originator, so there will be a single interest rate $r^{P,j}$ (where P stands for pooled). If $SC(j) = BO = 1$, this is a screening Originator who gives loans to both types, so the set of rates will be $r^{H,j}$ and $r^{L,j}$. If $SC(j) = 1$ and $BO = 1$, the set will consist of $r^{H,j}$. Note that we use the notation $r^{\cdot,j}$ to denote posted interest rates, as opposed to $r_{i,j}$ to denote interest rates in originated loans.

2.1.1 Borrowers' optimal behaviour

We assume that $\pi \leq \kappa$, as the equivalent condition always holds when we endogenize prices, that is, house prices never exceed their value by owner-occupiers.

Borrower's optimal behaviour can be determined through a standard dominated action analysis. The resulting set of optimal strategies is very similar to the set that buyers have when playing a Bertrand competition, so we deem this as 'Bertrand-like' competition.

As borrowers have the option to costlessly default in the second period, both types are always at least weakly better off borrowing and buying a house; buying a house is a weakly-dominating strategy. Note that as low types have zero utility from owning a house, they only benefit from buying if they can sell the house at a profit.

To decide which j_i^B, high types will choose the Originator with lowest posted interest rate, $j_i^H = \arg\min_j r^{\cdot,j}, j \in J$. Low types will first find the subset $J' \in J$, such that $\Lambda_{J'}$ indicates they will receive a loan, and then choose $j_i^L = \arg\min_j r^{\cdot,j}, j \in J'$. As Λ_j is common knowledge for borrowers, in equilibrium we must have that all borrowers of a given type must have receive the same interest rate in loans. A proof for this in is shown in Appendix B.

Owner-occupiers never wish to sell the house as $\pi \leq \kappa$. As long as $r_{\cdot} \leq \kappa$, they never wish to default in the second period and, as $\pi \leq \kappa < r_{\cdot}$, if $r_{\cdot} > \kappa$, they default on the loans in period 2, irrespective of what happens to house prices.

For speculators, if house prices decrease, their best action is to default as house prices are now worth less than loans $\pi < 0$. If house prices increase, then if $\pi \geq r_{\cdot}$, they can make a profit not defaulting and then selling the house; otherwise the cost of repaying is greater and they default.

As we show ahead, in equilibrium originators will set interest rates $\pi \geq r_{i,j}$, such that the set of optimal actions for borrowers, $S^*_{i,B}$ will consist of the following, which resembles the set of actions they will take in the general equilibrium model:

Conclusion 1 *Owner-occupiers choose a originator* $j^H_.$*, which is offering the lowest interest rate from set* J *of all originators. They never default or sell in the second period. Speculators choose originator* $j^L_.$*, with the lowest interest rate from set* J' *of originators offering loans to speculators. In the second period, they default when prices fall, otherwise they do not default and sell the house.*

2.2 Originators

Originators should be understood as the banks and other financial agents that create mortgages. As such, they have two separate, but intertwined roles in our model. They decide whether to extend loans to borrowers and at what interest rates, and they choose whether to sell loans to securitizers.

We assume that originators are risk averse, with the following utility function:

$$U_j^O = E(W_j^O) - aV(W_j^O) - n_j * C$$

where W_j^O is the wealth they hold at the end of period two, E is the expectation operator, a is a parameter determining risk aversion, V is the variance operator, n_j is the number of borrowers screened and C is the cost of screening per borrower screened.

The assumption that originators are risk averse and securitizers are risk neutral is an integral part of our model; as we discuss in the next section, these two assumptions are required to model the securitization process[8].

As alternative to the Bertrand-like competition and generic set J of originators we use, we can model our originators as having deep pockets and there being free-entry into the origination market and focus on a representative originator.

Originators will take 2 sets of actions in the model. They begin by posting the set of information Λ_j, that is, whether they screen borrowers or not; if they screen, whether they grant loans to both types or just owner-occupiers; and choosing the interest rates on loans. After a borrower approach a originator, the originator acts according to their $\Lambda_.$. The set of information $\Lambda_.$ is only visible to borrowers, not securitizers.

The second set of actions of originators is choosing whether to sell loans originated on the securitization market. For each originator j' there is a set $I(j') = \{\forall i | j_i^B = j'\}$ of loans they originate, and we define $I(j', \zeta) = \{i | j_i^B = j' \& \zeta_i = \zeta\}$, of loans originates to ζ types. Furthermore, the number of screened borrowers is $n'_j(I(j')) = |I(j')| \times SC(j')$, that is, the number of loans originated times the decision to screen loans.

For all $i \in I(j)$, originator j will choose $q_{i,j}^O$, whether they sell loan i or not, where $q_{i,j}^O = 1$ indicates they will sell. They do so by seeing what is the price paid for loans by the representative securitizer, $P^*(r)$. We define $Q^O(j)$ to be the set of all $q_{i,j}^O$ for originator j.

To simplify notation, we define the following variables. $X_\zeta(r_{(.)})$ is a random variable that indicates the rate of return from a loan with interest rate $r_{i,j}$ made to type ζ.

[8] If originators are risk neutral, our results are very similar to that of B&F and securitization plays no significant role in determining house prices.

For high types, $X_H(r_{(.)}) = r_{(.)}$. For low types, when prices are high, they repay, so $X_L(r_{(.)}) = r_{(.)}$ with probability q; otherwise, $X_L(r_{(.)}) = -\pi$[9], with probability $(1-q)$, so $E(X_L(r_{(.)})) = qr_{(.)} - (1-q)\pi$.

Now we define $Y(Q_j^O, SC, BO, I(j))$ as the returns obtained for all 3 possible courses of action that a originator can take concerning loan origination, that is, not screening, screening and lending to both types, and screening and lending to owner-occupiers, in addition to their choices of selling/keeping a loan. We thus have that:

$$Y(Q_j^O, 1, 0, I(j)) = \sum_{i \in I(j)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) X_H(r_i)$$

$$\begin{aligned} Y(Q_j^O, 1, 1, I(j)) = \{ &\sum_{i \in I(j,H)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) X_H(r_i) \} \\ + \{ &\sum_{i \in I(j,L)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) E(X_L(r_i)) \} \end{aligned}$$

$$\begin{aligned} Y(Q_j^O, 0, \emptyset, I(j)) = \{ &\sum_{i \in I(j,H)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) X_H(r_i) \} \\ + \{ &\sum_{i \in I(j,L)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) E(X_L(r_i)) \} \end{aligned}$$

The wealth of a originator j at the end of period 2 will thus be:

$$\begin{aligned} W_j^O(I(j)) = &SC_j(1 - BO_j) Y(Q^0, 1, 0, I(j)) + SC_j BO_j Y(Q^0, 1, 1, I(j)) \\ &+ (1 - SC_j) Y(Q^0, 0, \emptyset, I(j)) \end{aligned}$$

Finally, note that the interest rates on loans can be used as signal of loan quality by originators to securitizers. Although this is the only signal we allow between originators and securitizers, in practice other characteristics of a loan, such as differentiated loan-to-value ratios/down-payments, might also be used as such; a further discussion of the results of our model with down-payments can be found in Appendix A. So the strategy set of a originator j, $S_{j,O}$, consists of choosing the set of Λ_j and of choosing whether to sell each loan, Q_j.

2.3 Securitizers

The securitization market in our model refers to the private sector securitization exclusively, and we opt not to include securitization done by government sponsored enterprises (GSEs); a further discussion of GSE securitization may be found in Appendix A. Securitizers in our model consists of a single risk-neutral agent who buy loans from

[9] A fall leads to speculators defaulting, the house is then repossessed and immediately sold at the market price.

originators and hold on to them, and only cares about their expected wealth at the end of period 2, such that their utility function is:

$$U^S = E(W^S)$$

where W^S is the wealth they hold at the end of period two.

Note that securitizers in our model play both the role of the financial intermediates who securitize the loan and the financial agents who buy the loan. We opt to keep both roles in one agent to simplify our model. We use risk neutrality as a reduced form for the securitization process, in particular, as the reduction of uncertainty that stems from securitization. Appendix A provides a further discussion for both issues.

We assume that securitizers have deep pockets, so with free entry into the securitization market, this is why we can model our equilibrium results through a representative agent. The securitizer's only action will be to post the price P_r for which they be will willing to buy a loan of interest rate r. Securitizers cannot condition their purchase of loans to specific originators.

As we discuss in the Appendix A, due to the complexities of the securitization process, securitizers cannot distinguish between high and low-type loans. Due to asymmetry of information, the price securitizers are willing to pay depends on their beliefs, denoted by $\Omega(r)$ which is the probability that a loan of a given interest rate is of a low type.

The wealth of a securitizer at the end of period 2 will be:

$$W^S(Q_j) = \sum_{j \in J} \{ [\sum_{i \in I(j,H)} q^O_{i,j}(X_H(r_i) - P^*(r_i))] + [\sum_{i \in I(j,L)} q^O_{i,j}(E(X_L(r_i)) - P^*(r_i))] \}$$

So the strategy set S_S of securitizer consists of a set of P_r.

2.4 Timeline and definition of the equilibrium

To summarize the possible actions taken in our model, we now present the timeline of actions taken in Figure 2.

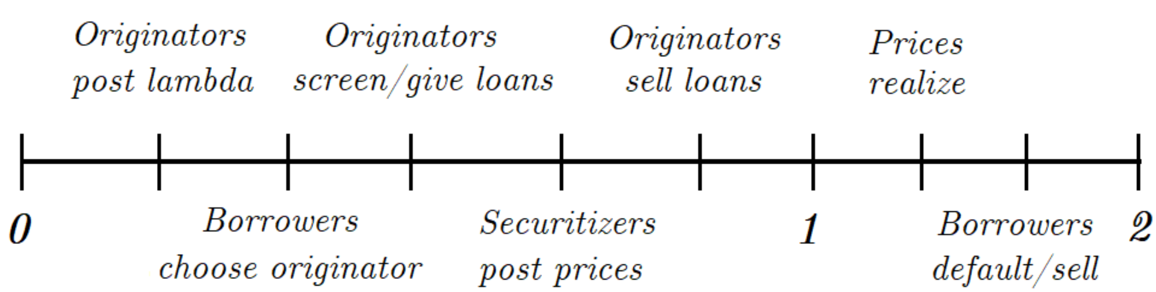

Figure 2: Partial Equilibrium Timeline

We now define the equilibrium of our model. As this is a signalling game, we focus our attention on a Perfect Bayesian Equilibrium (PBE), under which beliefs are consistent with Bayesian updating. This also means that we solve parts of the game via backwards induction.

A PBE in our model consists of a strategy profile ($S^*_{i,B}$, $S^*_{j,O}$ and S^*_S) and a set of beliefs (Ω_S) for for all agents, that is, for all $\forall i$ and $\forall j \in J$, we have that:

Borrowers:

$$S^*_{i,B} \in \arg\max c_i + \kappa B_i(1-D_i)(1-S_i)$$
$$s.t.$$
$$c_i + B_i(1-D_i)(1+r_i-(1+\Pi)S_i) = y$$

.

Originators:

$$S^*_{j,O} \in \arg\max E(W^O_j(I(j)^*)) - aV(W^O_j(I(j)^*)) - n_j(I(j)^*) * C$$

where their wealth W^O_j is defined above, $I(j)^* \in S^*_{i,B}$.

Securitizers:

$$S^*_S \in \arg\max E[(W^S(Q^*_j))/\Omega\}]$$

where their wealth is defined above and $\{Q^*_j\} \in S^*_{j,O}$, and securitizer's beliefs $\Omega(r)$, must satisfy Bayes' law.

In other words, our model consists of a signalling game played between originators and securitizers, where the interest rate for a loan put on sale is the signal, and where originators are constrained in their actions by the actions taken by borrowers, S^*_i.

2.5 Securitizers' optimal behaviour

The price paid by securitizers for a loan will depend on the interest rate and the beliefs that securitizers have about the composition of that loan, i.e., $P_r = f(\Omega(r), r)$. Securitizers buy and then hold-on to the loans until they pay off in the next period. The equilibrium price, conditional on beliefs, will be such that expected utility of securitizers will be equal to zero due to free entry; a proof of this can be found in Appendix B.

We now establish what is the expected utility of securitizers given their beliefs and establish necessary conditions on the prices. Let the belief structure of securitizers be such that any given loan of interest rate r_Ω has probability Ω, of being of a low type, noting again that we restrict ourselves to $r \leq \pi$:

$$EU^S_\Omega(X_H, X_L,) = (1-\Omega)(1+r_\Omega) - \Omega[(1+qr_\Omega - (1-q)(1-\pi)] - P_\Omega.$$

With free entry, $EU^S_\Omega = 0$, so $P_\Omega = (1-\Omega)(1+r_\Omega) - \Omega[(1+qr_\Omega) - (1-q)(1-\pi)]$. In particular, if $\Omega = 0$, a belief that a loan is to a of high type, we have that with free entry:

$$P^*_H = 1 + r_H$$

where we abuse notation. If $\Omega = 1$, a belief that loans consists only of low types, then with free entry:

$$P^*_L = 1 + qr_L - (1-q)\pi$$

with similar abuse of notation. With this, we have established the full set of optimal actions of securitizers with free entry, S^*_S, conditional on their beliefs.

Note that, as expected, $P_H \geq P_L$ for two loans with the same interest rate but different beliefs about their types and that the price paid is monotonically decreasing in Ω, and that all $P_\cdot$ are monotonically increasing in r.

2.5.1 Preview of results and strategy

To help the exposition that follows, we first show the equilibrium when originators are restricted from selling loans. We then proceed to find the equilibrium under two different set of actions for originators, whether they screen borrowers or not. To help the discussion that follows, we first state our results and the intuition behind it. Note that we make several assumptions about our model parameters to find our results, so we discuss what happens otherwise for each assumption.

In a screening equilibrium with 'low probabilities', because the price paid for low type loans is less than the cost of lending, if any selling of loans to securitizers were to happen, the only loans that could be sold to securitizers would be those consisting of owner-occupiers. But originators are capable of masquerading speculators as owner-occupiers by offering them the same equilibrium interest rates, which would be a profitable deviation. Securitizers are thus unwilling to pay a high enough price for any loan put on sale, so none are sold. Originators will screen loans and only lend to owner-occupiers. With 'high probabilities', a screening equilibrium where speculator loans are sold and owner-occupier loans are held on by originators can be sustained.

A no-screening equilibrium, which can only be sustained when costs are high enough to stop originators from 'skimming the cream', loans are sold to securitizers and both types receive loans. Thus if loans are securitized, speculators will receive loans.

2.5.2 Restricted selling equilibrium

As high types never default there is no uncertainty from them, thus when originators are restricted from selling, utility is additive.

As we show in Appendix B, if originators are sufficiently risk averse, satisfying $a \geq max\{\overline{\overline{a}}, \overline{a}\}$, will always suffer negative utility by lending to speculators; thus, if possible, they will screen and only give loans to owner-occupiers. This assumption is required for tractability, as if $a < max\{\overline{\overline{a}}, \overline{a}\}$, originator's set of optimal is very large and becomes conditional on our other parameters.

Furthermore, as originators are competing among each other via Bertrand-like pricing, we have to have that $EU^{O,H} = 0$[10]. In equilibrium, interest rates must be such that their utility is zero and the equilibrium interest rate will be $r_H = \frac{C}{(1-\gamma)}$. Note that this requires that $\frac{C}{(1-\gamma)} \leq \pi$, which implies that $\overline{\overline{a}} < 0$, making $\overline{\overline{a}}$ redundant. If $\frac{C}{(1-\gamma)} > \pi$, loans are too costly and no lending takes place.

Finally, borrowers will have utility $EU_H = \kappa + y - \frac{C}{(1-\gamma)} > y = EU_L$.

Conclusion 2 *If originators are restricted from selling loans to securitizers and we have* $a \geq \overline{a}$ *and* $\frac{C}{(1-\gamma)} \leq \pi$*, a unique screening equilibrium exists where only owner-occupiers receive loans,* $r_H = \frac{C}{(1-\gamma)}$.

2.6 Screening equilibrium

We begin by setting $\frac{q}{1-q} < 1$, as we are interested in cases with asymmetry in house price movements analogous to the general equilibrium version of our model. From W_j^O, the profit from selling a loan is $P_i(r_i) - 1$, so originators will want to sell only if, for any given loan with interest rate r_i, $P_i(r_i) \geq 1$. As $\frac{q}{1-q} < 1$, $P_L(r_L) < 1$[11], speculator loans are not profitable and not granting loans to speculators dominates.

A screening equilibrium where loans are extended only to owner-occupiers and are then sold to securitizers, and speculators are denied loans cannot be thus sustained. In such a case, first assume that the equilibrium posted interest rates $(\overline{r^L}, \overline{r^H})$ are different. A originator j' could then profitably deviate by posting a $\Lambda_{j'}$ where they offer to grant loans to speculators and set $r^{L,j'} = \overline{r^H}$, masking speculators as owner-occupiers. Speculators would then choose $j = j'$ and this originator would have higher payoff, as $P_H \geq 1$.

And originators will not wish to hold on to loans made to with $a \geq \overline{a}$ as we discussed in the previous subsection. So in a screening equilibrium, if $\frac{q}{1-q} < 1$, no equilibrium can exist where screening takes place and low types receive loans. We can sustain this equilibrium by setting the off the equilibrium path beliefs of securitizers such that any

[10] If the equilibrium interest rate r' was such that $EU' > 0$ for a originator making loans, a different originator could offer $0 < r'' < r'$ attracting those borrowers and increase their profits.

[11] The highest possible interest rate such low types do not default is $r_L = \pi$, and for that interest rate, $P_L = 1 + \pi(2q - 1) < 1$ for $\frac{q}{1-q} < 1$.

loan put on sale is a low type loan ($\Omega = 1$) for any interest rate, in which case no originator would want to deviate and sell a loan, making these beliefs consistent. If, alternatively, $\overline{r_L} = \overline{r_H}$, then the equilibrium would not be sustained as not screening would strictly dominate screening for originators due to the cost of screening.

If $\frac{q}{1-q} > 1$, then it is possible to sustain a equilibrium where speculator loans are sold and owner-occupiers receive loans which are not sold, which we discuss further in the Appendix.

Conclusion 3 *In a screening equilibrium, if speculators are a bad enough risk, only owner-occupiers receive loans and originators do not sell loans to securitizers. If speculators are not a bad risk, then their loans are sold and owner-occupiers loans are held on by originators.*

2.7 No screening equilibrium

From our results when originators are restricted from selling loans, if the cost of screening is not incurred, then originators would never want to extend loans to simply hold-on to them. As such, if there is no screening taking place, a equilibrium can only exist if originators sell loans to securitizers.

Conclusion 4 *In a no screening equilibrium, originators offer interest rates of* $\overline{r_P} = \frac{\gamma(1-q)\pi}{(1-\gamma)+q\gamma}$*, for any borrowers. Securitizers will set* $P_P^* = 1$ *for any loans with an interest rate of* $\overline{r_P}$ *(which implies* $\Omega(\overline{r_P}) = \gamma$*) and they have off-the-equilibrium path beliefs that* $\Omega(r \neq \overline{r_P}) = 1$*).*

We show that this is a equilibrium result in the Appendix B, under two additional parameter restrictions, that $\gamma \leq \frac{1}{2(1-q)}$, so that interest rates are not too high, and that $\frac{(1-\gamma)\gamma(1-q)}{(1-\gamma)+q\gamma} \leq C$, which guarantees that originators will not wish to 'skim the cream'. Otherwise, a no-screening equilibrium cannot be sustained.

2.8 Summary and discussion

Under the conditions that $a > \overline{a}$ (sufficient risk aversion), $\frac{q}{1-q} < 1$ (low-types present a bad risk), $\frac{C}{(1-\gamma)} \leq \pi$ (sufficiently low screening costs), $\gamma \leq \frac{1}{2(1-q)}$ (sufficiently low number of low types) and $\frac{(1-\gamma)\gamma(1-q)}{(1-\gamma)+q\gamma} \leq C$ (sufficiently high costs)[12] we find there are two equilibrium. The first is such originators screen and only lend to owner-occupiers and no loans are sold to securitizers. In the second, originators do not screening, thus allowing both types to have access to loans, and originators sell both loans to the securitization market. Alternatively, if $\frac{q}{1-q} > 1$, then both types receive loans, both are screened and only speculator loans are sold.

[12]Note that $\gamma \leq \frac{1}{2(1-q)}$ guarantees that both our high cost and low cost conditions will hold simultaneously.

This result illustrates the basic mechanism that will drive our results in the general equilibrium set-up. The non-recourse nature of loans and their 100% LTV ratio means that borrowers will not self-select, putting the onus on originators to screen out low and high types. In the absence of a credible signalling, originators could mask speculators as owner-occupiers when selling them to securitizers, which impedes any equilibrium wherein owner-occupiers loans are sold.

As we discuss further below, we believe that the equilibrium we find in our model when there is no securitization taking place may describe the state of the world before the securitization boom of the 2000s, whereas the equilibrium where it does may delineate how the market started operating once securitization increased.

3 General equilibrium

3.1 Setup

The general equilibrium model differs from the partial equilibrium one as we now endogenize the prices of houses, by having house sellers in addition to buyers/borrowers. The model is of finite duration and finishes at period N[13].

We assume the same settings for this model as in our partial equilibrium model, unless noted, and a discussion of our modeling choices may be found in Appendix A, so all variables and agents are defined analogously to the partial equilibrium model.

House owners, prospective borrowers or otherwise, remain divided into two types, with analogous utility functions to their partial equilibrium model, such that for borrower i of type ζ arriving at ρ utility is:

$$U_i^\rho = \sum_{t=\rho+1}^{N} c_t + \kappa_i B_\rho ND_{\rho+1} ND_{\rho+2} \prod_{t=\rho+1}^{N} (1 - S_t)$$

who faces a budget constraint such that aggregate expenditure is:

$$\sum_{t=\rho}^{N} c_t + B_\rho ND_{\rho+1} (A_\rho \frac{1 + r_{\rho,j}}{2} + ND_{\rho+2} A_\rho \frac{1 + r_{\rho,j}}{2})$$

and aggregate income is:

$$\sum_{t=\rho}^{N} y + B_{i,\rho} ND_{i,\rho+1} ND_{i,\rho+2} (\prod_{t=\rho+1}^{N} S_{i,t} A_{i,t})$$

where c_t is consumption, y income, A_t house prices, $r_{t,j}$ interest rate from a loan by originator j, B_t, ND_t and S_t indicator functions for buying a house, not defaulting

[13]The model generalizes to a infinite horizon model, as there is a simple mapping from flow utility of owning houses and receiving a stock utility at the end of time in a finite period model

and selling a house. In addition, period by period budget constraints exist, as house buyers cannot save or borrow except via their (potential) single house purchase.

Originators will now seek to maximize

$$U_j^O = \sum_{t=1}^{N} E(W_{j,t}^O) - aV(W_{j,t}^O) - n_{j,t} * C$$

where where W is their wealth/profits in period t, a is the coefficient of risk aversion, $n_{j,t}$ total borrowers screened and C is the cost of screening per borrower. We further define wealth analogously to the partial equilibrium model, as

$$\begin{aligned} W_{j,t}^O(I(j,t)) &= SC_{j,t}(1 - BO_{j,t})Y(Q^0, 1, 0, I(j,t), t) \\ &+ SC_{j,t}BO_{j,t}Y(Q^0, 1, 1, I(j,t), t) \\ &+ (1 - SC_{j,t)}Y(Q^0, 0, \emptyset, I(j,t), t) \end{aligned}$$

where again $SC_{j,t}$, $BO_{j,t}$ are indicator functions for screening and type lending, $Y(Q^0, SC, BO, I(j,t), t)$ is expected profit earned conditional loans originated $(I(j,t))$ and on loans sold (Q^0) at every period t. More precise definitions of $Y(.)$ can be found in the Appendix A, and they are defined analogously to the partial equilibrium model.

Finally, the representative securitizer seeks to maximize

$$U^S = \sum_{t=1}^{N} E(W_t^S(Q_j))$$

i.e., the sum of their expected utility, where their wealth/profit per period is

$$\begin{aligned} W_t^S(Q_j) = \sum_{j \in J} \{ [&\sum_{i \in I(j,H)} q_{i,j}^O (X_H(r_i) - P^*(r_i))] \\ + [&\sum_{i \in I(j,L)} q_{i,j}^O (E(X_L(r_i)) - P^*(r_i))] \} \end{aligned}$$

We assume that there exists a fixed[14] housing stock at $t = 1$ such that Ψ of houses are owned by low types and that all current high types own houses. To simplify our analysis, we assume there does not exist a renters market for this housing market[15] and we exclude the possibility of borrowers owning multiple houses.

At each time period, starting at 1, with probability q a cohort of size 1 of new borrowers will enter this housing market and may buy houses, with $(1 - \gamma)$ borrowers being owner-occupiers. This is conditional on a cohort having arrived in the last period,

[14] We can relax this restriction as long as the amount of housing being added every period is smaller than the size of new cohorts of borrowers. A further discussion may be found in B&F and Glaeser, Gyourko, and Saiz (2008).

[15] One could be incorporated without loss of generality, as in B&F.

so if a cohort does not arrive in period M, no cohorts arrive in $M+1$, $M+2$... Arriving speculators, as in the partial equilibrium model, will want to buy houses with the intent of reselling them, and will optimally default if a cohort fails to arrive at any period.

We have two necessary conditions on the size of the housing stock, such that $2(1-\gamma) < \Psi \leq 2-\gamma$[16], and for analytical convenience, we assume that $\Psi = 2-\gamma$. We discuss how our results would change if we altered the size of our cohorts and/or housing stock in Appendix A.

The loan structure is such that loan repayments occur over a two periods of time, so for a loan originated in t, half of the total loan payment of $A_t(1+r_t)$ is paid in $t+1$ and the other half at $t+2$. Loans remain non-recourse and if defaults happen, whoever owns the loan contract at the moment of default proceeds to repossess the house and sell it in the market for the prevailing price.

Originators can costlessly identify between new arrivals and buyers from previous periods and will only extend loans to buyers of a new cohort. Buyers are required to acquire a loan to buy a house[17]. Borrowers' income is such that they can always cover their loan payments in every period and/or make early repayment of loans, for which there is no penalty.

The timing within each period is now as follows: at the start of each period, a new cohort does or does not arrives and, after this, buyers with outstanding loans decide whether to default or not. New house buyers proceed to establish conditional prices[18] for houses via a Walrasian auctioneer. New buyers can then approach originators for loans and if they succeed, proceed to buy houses, with new owner-occupiers moving first in acquiring houses from existing owners (as arriving owner-occupiers always value houses more than speculators, they could always bid some positive ϵ to guarantee this). Finally, originators can sell loans to securitizers. This timeline is summarized in the figure below.

3.1.1 Prices and Fundamental Value

The key uncertainty in our model is whether at the end of time, the number of new high types exceeds the housing supply or not.

In periods 4 and beyond, if cohorts have arrived in all periods, the number of owner-occupiers exceeds the stock of houses immutably, so the equilibrium price must

[16]The first guarantees that the housing stock is greater than the number of new high types until at least period 3; the second guarantees that, in period 2, if houses are sold, then at least 1 is was bought by a low type who arrived in the cohort of period 1. With more time periods and longer loans, we would have less strict conditions.

[17]This would not necessary in a model with more lengthy loan payment schedule where the price of houses can always be above the income of buyers, making it necessary to acquire loans to buy a house.

[18]If a new cohort fails to arrive, we have no way of establishing the price of houses, as no transactions take place, so in such cases, we simply establish the price that would prevail if a single new high type arrived and sought to buy a house, i.e., the value of a marginal seller.

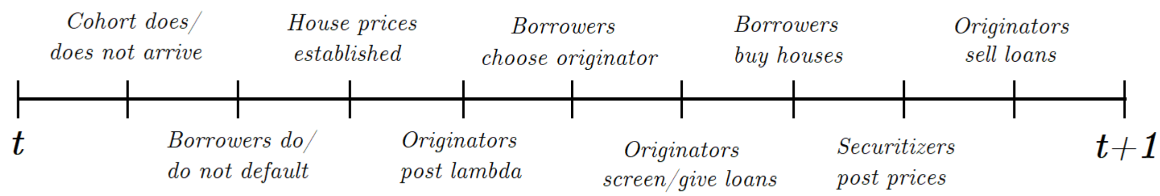

Figure 3: General Equilibrium Timeline

be equal to the valuation of the marginal buyer, owner-occupiers borrowers, which is κ[19].

If not, housing supply exceeds the number of owner-occupiers forever, so the equilibrium price for houses will be equal to the value of the marginal seller, 0[20]

So if a cohort fails to arrive prior to period 4, the price is equal to 0 from that period onwards. If cohorts arrive in the first 3 periods, then the price will be equal to κ for all periods onwards. In particular, as there is never any uncertainty for periods 4 and beyond, the price must either be κ or 0, as either enough cohorts have arrived or not.

To compare our house prices with some notion of fundamental value, we define fundamental value of housing. Following Allen et al. (1993) and rlated literature, this is the 'Value of an asset in normal use as opposed to (...) as speculative instrument'. That is, the fundamental value is the value/price an asset would have if house buyers did not have loan contracts that skewers their incentives by 'safeguarding them from a negative shock'.

For periods 4 and beyond, as there is no 'speculative' element, the prices we have established is equal to the fundamental value. For periods 1 to 3, the fundamental value is by definition equal to the expected value for what the price will be in period 4, as this is the value of a house if buyers could buy houses outright, without loans. Appendix B discusses and proves this claim. As such, the fundamental value after the arrival of new cohort in period 3 is equal to κ, in 2 the value is $q\kappa$ and in 1, it is $q^2\kappa$. As we will demonstrate below, this will be equal to the price that prevails when no securitization takes place.

3.1.2 Borrower's optimal actions

We briefly outline the optimal actions of borrowers, which is identical to the partial equilibrium case. Owner-occupiers arriving in ρ gain κ from owning a house, as long

[19]If the price was lower, then any owner-occupier who currently does not own a house would be willing to bid for a house at a higher price $A' = A + \varepsilon \leq \kappa$. And as no high type is willing to sell for a price less than κ, the only equilibrium price is κ.

[20]As proof, first note that there is no chance of being able to re-sell the house in the future for a greater price, as no new cohorts can arrive, so all speculators/low types value the house at zero. If the equilibrium price was some $A' > 0$, then any low type seller who is not selling could post a price $A' - \varepsilon \geq 0$ instead and make a profit, so only $A = 0$ can be a equilibrium price.

as the overall cost of a mortgage is lower than their utility value, they will always be willing to take on a loan and repay the loan fully, that is

$$\kappa \geq A_\rho(1 + r_{\rho,j})$$

As A_ρ and $(1 + r_{\rho,j})$ are fully determined when they arrive and in equilibrium will always hold for all time periods, owner-occupiers will always seek loans and will always repay them.

Speculators will wish to take a loan and buy a house as long as there is some potential appreciation value, stemming from the increased probability that prices will reach κ, as they can always default costlessly next period. Furthermore, as we know that in equilibrium, speculators who arrive in t will be marginal sellers in $t+1$, we can focus on the potential appreciation in between those periods, so speculators arriving in ρ buy if:

$$q(A_{\rho+1} - A_\rho(1 + r_{\rho,j}) \geq 0$$

As this will always hold in equilibrium, speculators will always seek to buy, at any price and interest rate. This means there is no self selection by speculators. Furthermore, they will not default in $\rho + 1$ when a new cohort arrives only if $A_{\rho+1}/A_\rho \geq (1 + r_{\rho,j})$, which constrains the interest rate.

A speculator who bought in ρ will have 3 actions in $\rho + 1$, defaulting, selling and waiting. If no cohort arrives, they will optimally default, as they have no further chance of selling a house to future cohorts and houses will now be worth zero. If a cohort arrives, they will sell if the returns from selling this period exceeds the expected returns from waiting. The latter consists of the expected gains of the appreciation of the house next period minus the cost of the mortgage installment today:

$$q[A_{\rho+2} - \frac{A_\rho(1 + r_\rho)}{2}] + (1 - q) \times 0 - \frac{A_\rho(1 + r_\rho)}{2}$$

The return from selling the house this period is equal to $A_{\rho+1} - A_\rho(1 + r_\rho)$. So speculator sell when:

$$A_{\rho+1} - A_\rho(1 + r_\rho) \geq q[A_{\rho+2} - \frac{A_\rho(1 + r_\rho)}{2}] + (1 - q) \times 0 - \frac{A_\rho(1 + r_\rho)}{2}$$

On the other hand, a no-loan low type, who initially owns the housing stock, has no put option, so they sell in any period t if the value of selling is great than the expected appreciation, $A_t \geq qA_{t+1}$.

Finally, the optimal choice of originator remains exactly the same as in the partial equilibrium case. This means that when contemplating a deviation from equilibrium, originators will not be able to offer a higher interest rate from the equilibrium, as no borrower would take that interest rate.

3.1.3 Restricted selling Equilibrium

Like in the partial equilibrium case, we first find the equilibrium when we restrict originators from selling loans to securitizers. We solve the model via a PBE, much like in the partial equilibrium model, finding the equilibrium actions that prevail in periods 3, 2 and 1 assuming that cohorts have arrived in every such period, as for all other cases, we know what the equilibrium actions and prices are. We use analogous results from our partial equilibrium model where applicable, and our equilibrium result is similar: as long as risk aversion is high enough and speculators are a minority, speculators will not receive loans.

Period 3 We begin by assuming that in periods 1 and 2, arriving owner-occupiers, but not speculators, have bought houses, which we show will be an equilibrium action. If a new cohort fails to arrive, then owner-occupiers who bought houses in previous periods will not default as long as the total cost of their loan is less than that their value of the house, which we will show will hold if costs are not too high. So equilibrium prices will be 0 and no defaults happen.

If a new cohort has arrived, as owner-occupiers move first when buying houses, all houses will be purchased by owner-occupiers. This is because there will be $3(1-\gamma)$ new owner-occupiers, and the housing stock, $\Psi = 2 - \gamma$, is smaller for $\gamma < \frac{1}{2}$.

The new owner-occupiers thus exhaust the supply of housing, meaning that even if a speculator were to receive a loan, they would never be able to purchase a house. As there is no risk, there is no need to screen borrowers by originators. As a consequence, originators will post a single interest rate, will not screen borrowers and interest rates will be, due to the Bertrand-like competition, $r_{P,3} = 0$. This means that all high types receive loans, so the equilibrium price of houses must be equal to the value of the marginal buyer:

$$A_3 = \kappa$$

Period 2 We show in the Appendix B that if originators have risk aversion such that

$$a \geq a'' = \frac{\sqrt{\gamma^2 + \frac{(1-\gamma(1-q))^2}{q(1-q)}} - \gamma}{2q^2\kappa}$$

originator's utility from not-screening and lending to both types is always less than or equal to zero. This means that the unique equilibrium action will be for originators to screen borrowers and only lend to owner-occupiers. We assume $a \geq a''$ mainly for tractability, as otherwise originators' actions encompass a wide range of possibilities, depending on the values of our parameters and how bad a risk speculators are, given q and γ.

Thus, in period 2, the number of buyers is smaller than the number of sellers, so price will be equal to the value of the marginal seller. As in equilibrium no speculators receive loans, this is the value of no-loan low types, so house prices are:

$$A_2 = q\kappa$$

Under Bertrand competition/free entry, expected utility of originators remains zero, so the equilibrium interest rate will be $r_{H,2} = \frac{C}{(1-\gamma)q\kappa}$, for which we need that $C \leq q\kappa(1-q)(1-\gamma)$ for high types to accept loans; otherwise the cost of screening is too high and originators do not lend. So under $a \geq a''$, originators screen and only lend to owner-occupiers.

Period 1 Under our assumptions $a > a''$ and $\gamma < \frac{1}{2}$, as we show in the Appendix B, speculators would not receive loans in either a non-screening or a screening equilibrium. As the number of onwer-occupiers is smaller than the housing stock, equilibrium house prices are determined by the expected value of the marginal sellers, the no-loan low type house owners. In this case, $A_1 = qA_2 = q^2\kappa$ and the equilibrium interest rate will be the same as in period 2, $r_{H,1} = \frac{C}{(1-\gamma)q\kappa}$.

To summarize, assuming that originators are sufficiently risk averse, $a > a''$, that speculators are a minority, $\gamma < \frac{1}{2}$, and that costs are not too high, $C < q\kappa(1-q)(1-\gamma)$, we find a unique equilibrium when originators are restricted from selling loans. Under these conditions, as long as a new cohort of borrowers arrives every period, house prices experience a boom, progressing from $q^2\kappa$ to $q\kappa$ to κ, loans are only ever extended to high-types, with interest rates that eventually fall to zero at the end of the boom, and no defaults ever happen. If a new cohort fails to arrive at any point, then house prices immediately collapse to 0 and remain there; no new loans are extended, but no defaults happen as only high types have received loans.

3.2 Screening and non-screening equilibrim

To distinguish our variables from the previous case, we denote the variables in this equilibrium with a tilde. We begin by providing some intuition and a discussion of the results we find.

We have 4 possible equilibrium results, but focus our attention on just two equilibria, analogous to the partial model results, with either screening or no-screening taking place in both periods 1 and 2. The other two possible equilibrium outcomes consists of no-screening taking place in period 1 and screening takes place in period 2 or vice-versa.

We can trim this set of 4 equilibria by assuming that securitizers will not switch beliefs about the quality of loans between periods, a refinement that we believe seems reasonable in this context[21]. We prove in Appendix B that the other two equilibria

[21] As is discussed in Lewis (2011), there is anecdotal evidence that securitizers / buyers of securitized assets beliefs about loans were largely unchanging throughout the 2000s up until the house prices themselves stopped increasing around 2007. As in our model the only big 'shock' that can take place is a cohort falling to arrive, we believe it is reasonable to assume that securitizers will maintain their

produce outcomes in house prices identical to the screening equilibrium, i.e., there is no securitization, and also discuss how relaxing this refinement of no belief switching would affect our results in a more general model.

In the no-screening equilibrium, we have that both types receive loans in periods 1 and 2. This means that in period 2, the marginal seller of houses will be a speculator. This seller will have a put option value, so house prices in period 2 are now higher. As a consequence, the price in period 1 is also greater than the fundamental value, due to rational expectations. If a cohort fails to arrive, this also implies that the fall in house prices will be much greater than that would happen in the non-securitized market. We also have that speculators who receive loans will default, as they lack further opportunities to sell.

We now proceed to prove and discuss, period-by-period, our equilibrium. For both cases, in periods 4 and beyond, prices are equal to the fundamental value, as we discuss above.

3.2.1 Period 3

To establish the price securitizers are willing to pay, we establish the beliefs of securitizers and then make sure that these beliefs are consistent, in a Bayesian sense, with what actually happens in equilibrium.

In period 3, we have that if a cohort arrives, as the housing supply is exhausted, only owner-occupiers buy houses and take on loans. As a consequence, this is the belief that securitizers will have of loan composition, so that they can expect returns of:

$$\tilde{U}^S_{H,3} = \tilde{A}_3(1 + \tilde{r}_{H,3}) - P_{H,3}$$

With free entry, we have that $P_{H,3} = \tilde{A}_3(1+\tilde{r}_{H,3})$. If originators choose to sell their loans, they will have a payoff of:

$$\tilde{U}^O_{H,3} = P_{H,3} - \tilde{A}_3 = \tilde{A}_3\tilde{r}_{H,3}$$

As housing supply is exhausted and only high-types receive loans / buy houses, prices must be, in equilibrium, $\tilde{A}_3 = \kappa$. Due to Bertrand-like competition, in equilibrium $\tilde{r}_{H,3} = 0$. This means that $P_{H,3} = \tilde{A}_3$, so originators are indifferent between selling and not selling loans, and either equilibrium can be sustained.

If a cohort fails to arrive, prices collapse and are equal to 0.

3.2.2 Period 2

If a speculator receives a loan in period 2, they will default if a cohort does not arrive in 3. As we show in the Appendix, the equilibrium cost of the loan granted in period 2 is always smaller than the price in 3, so if a new cohort arrives in 3, all speculators from period 2 sell their house to the new arrivals and repay the loan completely.

belief structure as long as cohorts are arriving.

Thus, the prices that securitizers will be willing to pay will depend on their belief about the loan composition. As we show in Appendix B, if securitizers believe a loan to consist exclusively of high types or low types, the price is respectively

$$P_{H,2} = \tilde{A}_2(1 + \tilde{r}_{H,2}) \quad P_{L,2} = \tilde{A}_2 q(1 + \tilde{r}_{L,2})$$

If $P_{L,2} \leq \tilde{A}_2$, that is, if the cost of loan $\tilde{A}_2$, is higher than the amount they receive for the loan, $P_{L,2}$, then originators will not sell speculator loans. The price is lower than the cost of the loan if $(1 + \tilde{r}_{L,2}) \leq \frac{1}{q}$, and in Appendix B, we show that this is true for all values of $\tilde{r}_{L,2}$; if $1 + \tilde{r}_{L,2} > \frac{1}{q}$, then speculator always default in period 3 and the price of the loan is zero. As such, we have a analogous situation to that of the exogenous price case, as loans believed to consist only of low types will never be sold in equilibrium.

As we now show, this means only two possible equilibrium can exist. Either originators screen and do not sell their loans, or originators do not screen and sell loans to securitizers.

Screening equilibrium As per the partial equilibrium case, as the price that a loan believed to consist of speculators is too low to compensate originators, we cannot have an equilibrium outcome where low type loans are sold to securitizers.

We can equally rule out a screening equilibrium where loans are extended only to owner-occupiers and are then sold to securitizers, with speculators denied loans, as originators would deviate by not-screening and masking speculators as owner-occupiers by setting interest rates to be the equilibrium rate. This would be a profitable deviation for both originators, as $P_{H,2} \geq 0$, and for speculators, who would gain access to loans.

Consequently, if originators choose to screen, then the only possible equilibrium outcome is for them to hold-on to loans. We can sustain this with off the equilibrium path beliefs by securitizers that any loans sold are speculator loans. The equilibrium outcome is thus for originators to screen, deny loans to speculators and set $\tilde{r}^{H,2} = \frac{C}{(1-\gamma)q\kappa}$ as the interest rate. Owner-occupiers receive loans and no loans are put on sale on the securitization market.

As we are assuming there is no belief switching, we must have had that this is the action that happened in period 1. So the outcome of the housing market is identical to that which we with restricted selling. That is, only high types received loans in period 1 and only they receive loans in period 2. For this, we need the same set of assumptions, $a > a''$ and $C < q\kappa(1 - q)(1 - \gamma)$. House prices will then be equal to $\tilde{A}_{SC,2} = q^2\kappa$, where SC denotes a screening equilibrium.

No-screening equilibrium The other equilibrium is where originators choose to not screen and sell the loans in the securitization market. Securitizers believe that any loan sold by the equilibrium interest rate $\tilde{r}_{NSC,2}$ (where NSC denotes the no-screening equilibrium) has $\Omega = \gamma$ low types and any loan sold off the equilibrium path has $\Omega = 1$. From our assumption that there is no belief switching, in period 1 both types received loans. As $\Psi = 2-\gamma$, in period 2, at least one speculator who bought a house in period 1 will sell in period 2, and so becomes the marginal seller.

The price of loans is then:

$$P_{NSC,2} = \tilde{A}_2(1-\gamma(1-q))(1+\tilde{r}_{NSC,2})$$

The expected utility of originators is $E\tilde{U}^O_{NSC,2} = P_{NSC,2} - \tilde{A}_2$, such that due to Bertrand-like competition, this will be equal to zero and the equilibrium interest rate is $1+\tilde{r}_{NSC,2} = \frac{1}{1-\gamma(1-q)}$.

As we discuss in the partial equilibrium case, there is only one possible profitable deviation for originators, which would be to 'skim the cream'[22], wherein originators screen, sell speculator loans and hold-on to owner-occupier loans. In the Appendix, we show that originators will not deviate if $C > \frac{\tilde{A}_2(1-\gamma)\gamma(1-q)}{1-\gamma(1-q)}$, which holds simultaneously with $C < q\kappa(1-q)(1-\gamma)$. If costs are too low, then we will not be able to sustain this equilibrium and only a screening, no selling equilibrium remains.

The marginal sellers are now speculators who bought in period 1. As per the discussion of their optimal actions, speculators sell, in equilibrium, only if

$$\tilde{A}_2 - \tilde{A}_1(1+r_{NSC,1}) \geq q\kappa - (1+q)\frac{\tilde{A}_1(1+\tilde{r}_{NSC,1})}{2}$$

which implies that $\tilde{A}_2 \geq q\kappa + \frac{1-q}{2}\tilde{A}_1(1+r_{NSC,1})$, a deviation from the fundamental value of houses.

As in period 2 we have more sellers than buyers, the equilibrium price will be exactly equal to that of the marginal seller, and $\tilde{A}_2 = q\kappa + \frac{1-q}{2}\tilde{A}_1(1+r_{NSC,1})$. Combined with our results below from period 1, this implies that equilibrium prices will be:

$$\tilde{A}_2 = q\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q))-q(1-q)} > q\kappa^{23}$$

So in a no-screening equilibrium, originators set interest rates $\tilde{r}_{NSC,2} = \frac{1}{1-\gamma(1-q)} - 1$, and sell these loans to securitizers; securitizers believe that any loan with a different interest rate consists of a low type. Both types of borrowers buy houses and, as the marginal seller will be a speculator who bought a house in period 1 and has the put option value, house prices are higher than the screening equilibrium.

[22]That is, any deviation with higher interest rates would not attract borrowers, and any deviation to a lower interest rate would, given securitizers beliefs and the lack of self-selection by speculators, result in lower prices for loans.

[23]Note that if $\tilde{A}_2(1+\tilde{r}_{NSC,2}) \geq \kappa$, the price would simply become that the value the high type borrower has of the house, as otherwise high types would default. As we show in the Appendix, this never holds in equilibrium and $\tilde{A}_2 < \kappa$.

3.2.3 Period 1

Speculators who buy in period 1 will have identical actions to speculators who buy in period 2, that is to say, if no cohorts arrive, they default on their loans. If a cohort arrives, all arriving speculators are capable of selling their houses to the new buyers, and no defaults happen. As consequence, the beliefs of securitizers map into prices in the same way as before, so we have the same equilibrium price function as in period 1.

Screening equilibrium Analogously to our discussion of period 2, a screening equilibrium can then be sustained if the off-the-equilibrium path beliefs are set such that any loan sold consists of a low type. In which case originators post a single interest rate $\tilde{r}_{S,1} = \frac{C}{(1-\gamma)q\kappa}$, and choose to screen and deny loans to speculators. As such, only owner-occupiers receive loans and no loans are put on sale in the securitization market, so prices are equal to the fundamental value:

$$\tilde{A}_{S,1} = q^2\kappa$$

No-screening equilibrium A no-screening equilibrium, can also be sustained by setting identical conditions to the no-screening equilibrium of period 2, which, as we show in the Appendix, will stop originators from 'skimming the cream'. Thus originators extend loans to both types, and then sell these loans to securitizers.

As the marginal seller, a no-loan low type, has no put option value, we have to have that in equilibrium:

$$\tilde{A}_1 = q\tilde{A}_2$$

As the equilibrium interest rates are the same as that in period 2, we can combine this with our previous result that $\tilde{A}_2 = q\kappa + \frac{1-q}{2}\tilde{A}_1(1 + r_{NSC,1})$, to find that

$$\tilde{A}_1 = q^2\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q)) - q(1-q)}$$[24]

3.3 Summary and discussion

Our results are found under the assumptions that $a > a''$ (sufficiently high risk aversion), $\frac{\tilde{A}_2(1-\gamma)\gamma(1-q)}{1-\gamma(1-q)} < C < q\kappa(1-q)(1-\gamma)$ (restricted costs)[25] and $\gamma < \frac{1}{2}$ (low types are a minority).

We find two mains results under no belief switching. In the screening equilibrium, originators do not sell loans to securitizers, being the no securitization result. Assuming cohorts arrive every period, as high types are the only borrowers to receive loans, house

[24]As $\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q))-q(1-q)} > 1$, this shows this is a positive deviation from fundamentals.

[25]If costs are too high, then no loans are granted in a screening equilibrium; if costs are too low, then we cannot sustain a no-screening equilibrium.

prices follow $A_1 = q^2\kappa$, $A_2 = q\kappa$, $A_3 = \kappa = A_4 = ... = A_N$, and if a cohort fails to arrive before period 4, house prices collapse immediately to 0, and no defaults happen.

In the no-screening equilibrium, both borrower types receive loans, which are sold to the securitization market every period. As a consequence of the put option value of non-recourse loans, house prices deviate from fundamentals. Assuming cohorts arrive every period, starting from period 1, we have that $\tilde{A}_1 = q^2\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q))-q(1-q)}$, $\tilde{A}_2 = q\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q))-q(1-q)}$, $\tilde{A}_3 = \kappa = \tilde{A}_4 = ... = \tilde{A}_N$. Finally, if a cohort fails to arrive before period 4, house prices collapse immediately to 0, and defaults happen from speculators who received loans.

House prices thus experience a 'boom-like' behaviour for both cases, but without screening/when securitization is taking place, the put option value of speculators pushes house prices above the other. Furthermore, as we show in the Appendix, when loans are recourse and lacking the put option value, prices follow fundamentals.

Thus the combination of securitization and non-recourse laws has a positive effect on house prices. We illustrate this graphically in Figure 4 by comparing house prices when there is both non-recourse laws and securitization, and a housing market where at least one is not present, during a boom.

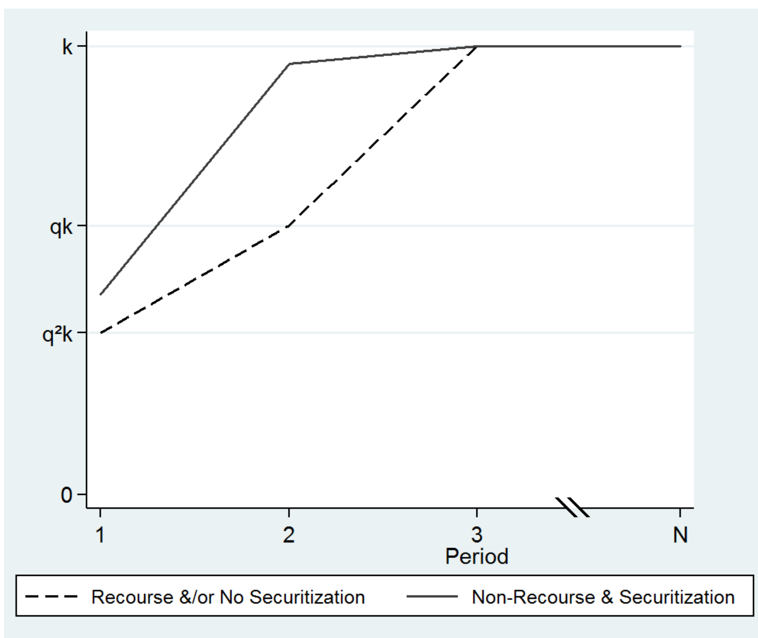

Figure 4: House prices in a sustained boom.

Note that cohorts arrive until the housing stock is exhausted in both cases, thus house prices eventually become equal at a new high point κ, and the recourse/no-securitization market experiences a much larger increase in prices at the end.

Should a cohort fail to arrive at, for example, period 3, then prices in both markets would immediately fall to zero. In such a case, a market with non-recourse and securitization would fall from a higher price level and, subsequently, experience a greater boom and a greater bust. This is illustrated in Figure 5.

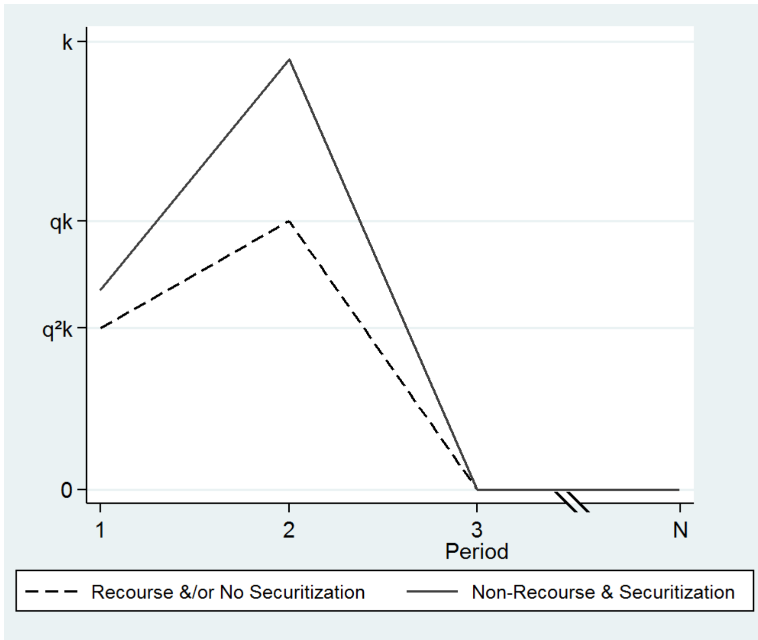

Figure 5: House prices in a boom and bust.

This is the core prediction of our model. We would also expect to find that, in case of a housing bust, defaults are non-zero in the non-recourse and securitization market.

Concerning welfare, as we discuss in the Appendix A, the no-screening/securitization equilibrium is ex-ante, welfare increasing, as it leads to a reduction in the screening costs. Note that this result stems from our assumption that securitizers are risk-neutral, which itself stems from our use of risk-neutrality as a proxy for the securitization process.

Our equilibrium results are partly due to the 100% loan-to-value ratios, so we explore what happens when we introduce down-payments to our model. Although we do not fully characterize all the possible set of equilibria, in the Appendix, we discuss and show we can sustain our no-screening equilibrium with the addition of down-payments, as long as originators are sufficiently small[26].

Taken literally, our model predicts that if a securitization markets exists, then 100% of loans would be sold off by originators and securitized. As we have omitted many important characteristics that matter to participants of these markets, we would not expect to, and do not find, such levels of securitization. Instead, the key prediction in our model comes from the extent that securitization allows for originators to extend loans to type borrowers/speculators.

[26] And incomes are restricted, as with high enough incomes, we find a trivial equilibrium where borrowers buy houses with a 100% down-payment.

That is to say, in US states where mortgage loans are non-recourse, we would expect that with higher levels of securitization, the probability that speculators have managed to buy houses and, in subsequent periods, become the marginal seller is increased.

Thus, our model predicts that there is a positive effect on house prices coming from the interaction between percentages of loans (privately) securitized in US states and whether that state has non-recourse law on mortgage loans; this goes beyond the positive effect that securitization has been found to have empirically by the literature (Keys et. al. (2010), among others). This is the primary prediction of our paper that we wish to test.

In addition, it is possible to test if this interaction effect subsequently lead to greater drops in house prices during the bust period, and to higher levels of defaults, in non-recourse states. As our model is static after prices collapses, which takes place immediately after the drop in demand, we do not believe that our model is as well suited for dealing with the bust period. This is particularly true as, in practice, defaults, foreclosures and bankruptcies can be lengthy processes, and a richer model in those characteristics would be better suited to testing this mechanism in the bust period.

Finally, concerning other mechanisms that the literature has suggested causes for the boom and bust, from moral hazard issues to overoptimism to increase in loan supply to mispriced loans, we surmise that most likely they would interact with our own model in such a way as to enhance each other. For example, consider moral hazard issues such as outright fraud and, more generally, anything that makes it such that securitizers are not fully aware/misled about the composition of mortgage loans. We expect that this would make our conditions for an equilibrium less stringent (particularly the cost restriction for no 'skimming the cream'), whilst simultaneously providing an additional reason for why house prices might have increased.

In similar fashion, if there is a mispricing of loans in the securitization market, this make it harder for any signalling to happen between originators and securitizers, making it easier for an equilibrium such as ours to come about, even with large originators and down-payments. We believe that by setting up the model as we do, we are likely finding a lower bound for under what conditions our mechanism might contribute to increased house prices.

4 Data

We begin by first describing our dataset and sources, and how we define non-recourse states. This is followed by a discussion of issues with our data and how we address them, and by a discussion concerning the literature on non-recourse status of mortgage laws in the US.

4.1 Securitization

To test the predictions of our model, we use the LAR datasets of the HMDA. The HMDA act was originally passed to collect data to check for discrimination in the US housing market. It requires most loan originators to report certain types of information on any loan request, successful or not. The act now covers around 80% of the mortgage loans according to Fishbein and Essene (2010), and is available in the aggregated LAR datasets, on a annual basis.

Amongst other things, originators must report to whom they sell a loan, if the loan is sold within the same calendar year of being originated. The possible categories to whom a loan is sold were changed in 2004, and have remained the same since. This change included the addition of the category 'Private Securitization', which consists of any sale to a non-GSE entity where the originator believes the loan will be securitized in the private market[27].

Our main measure of private securitization, 'Sec' is thus the percentage of loans believed will be privately securitized by originators, out of all successfully originated loans intended for houses purchases.

Using the same category, we also find which loans were originated and sold to/securitized by GSE entities[28], and from that we obtain our variable 'GSE', the percentage of loans sold to GSEs of all successfully originated loans intended for houses purchases.

4.2 Recourse in the US

The question of whether mortgages are non-recourse in practice in the US is more complex than seems at first. State laws dictate what are the procedures taken after mortgage repayments stop, and there is a great deal of heterogeneity in how each state deals with this, as with the possible ways borrowers and lenders can proceed once a default happens[29]. For the purposes of this paper, what matters is if the state permits deficiency judgments to be made on defaulted mortgages during a foreclosure procedure.

A deficiency judgment consists of a judicial ruling, during a foreclosure process, that the proceeds from the sale of an asset was insufficient to fully cover the loan that was secured by that asset. As such, these permit lenders to recover the difference

[27] "If an institution selling a loan knows or reasonably believes that the loan will be securitized by the institution purchasing the loan, then the seller should use code '5' for "private securitization" regardless of the type or affiliation of the purchasing institution.", according to http://www.ffiec.gov/hmda/faqreg.htm#purchaser.

[28] Categories 'Fannie Mae', 'Ginnie Mae', 'Freddie Mac' and 'Farmer Mac'.

[29] According to Ghent and Kudlyak (2011), borrowers may give the house deed to the lender in exchange for no further actions, they may find a purchaser for the house or they may enter a foreclosure procedure, which may or may not be contested, during the former of which deficiency judgments may happen.

between the contracted value of a house and the value obtained through selling the house, either by using the borrower's income, or other assets they possess.

A borrower can avoid this by declaring bankruptcy, but only if they file for chapter 7, which, according to Ghent and Kudlyak (2011), is not always possible in every American state; a chapter 13 filling does not eliminate the possibility of a deficiency judgment. Furthermore, the possibility of filling for chapter 7 bankruptcies was restricted in 2005, via the BAPCPA law, particularly for borrowers with higher income. From the perspective of our model, what matters crucially is the relative ease/how cheaply a borrower can walk away from his mortgage obligations, and as we discuss in introduction, the most recent evidence seems to suggest that non-recourse status matters significantly in this respect.

Regarding how to classify the recourse status of a state, amongst others, Ghent et al. (2011) and Mitman (2015) use a very similar list that has a high degree of concurrence, with Arizona, California, Iowa, Minnesota, Montana, North Dakota, Oregon and Washington being considered non-recourse; they differ only in that Alaska, North Carolina and Wisconsin are also considered non-recourse by Ghent et al.

This is a fairly typical result in the literature, as there is a degree of subjectivity in classifying which states are recourse or not. However, most papers' classification have a large degree of overlap in states classified as non-recourse, particularly the West Coast and Northern states; they normally only differ in their classification on a small number of states. Consequently and following most recent papers, we opt to use the Ghent et al. (2011) classification as the benchmark for our regressions. We opt to use Mitman (2015) as a robustness check, and find that our results are unaffected by this.

Finally, as Ghent et al. (2011) and Ghent (2012) documents, recourse law for the vast majority of states has largely stayed the same since the Great Depression until 2008, with, in some cases, the laws remaining unchanged since the 19th century. Subsequently and in accordance with the literature, I treat recourse status of states as exogenous for the purposes of the empirics.

4.3 Other data

We obtain house price levels from the FHFA's HPI, which uses data from Freddie Mac and Fannie Mae. For state-wide prices, this index uses the standard weighted repeat-sales methodology[30]. For MSA-level data, we use the all-transactions index, due to greater coverage, despite its methodological limitations. We believe that the limitations of using data stemming only from GSEs transactions is not a great one because there should be no significant segmentation between housing markets when it comes to the growth in house prices. Nevertheless, we do perform a robustness check using the Case-Shiller price index for 20 MSAs.

We define our controls and the other variables that we use, and the sources they come from in Table 1. On a MSA-level, we have less data available and our data is

[30]For data starting at 1991, we use the all-transactions index.

of poorer quality, so we use our state-level regressions as a baseline whenever possible. As we use fixed-effects and time dummies in most of our regressions and thus capture any nominal effects, to facilitate the interpretation of the results, we normalize house prices, population, income/ income growth, unemployment and interest rate measures to be 100 in 2004.

Variable	State-level	MSA-level
Population	'Resident Population', US census	'Resident Population', US census
Income	'Per Capita Personal Income', U.S. Department of Commerce	Mean reported income of all loan transactions, HMDA*
Unemployment	'Unemployment rate', US. Bureau of Labor Statistics	N/A
Subprime loans	% of purchase, originated loans with rates above 3%, HMDA**	% of purchase, originated loans with rates above 3%, HMDA**
Unemployment	'Unemployment rate', US. Bureau of Labor Statistics	N/A
LTI	Loan Amount divided by Income of the applicant, HMDA***	N/A
Interest rates	Interest rate on 'conventional loans', FHFA	N/A
Defaults	% of mortgage debt 90+ days delinquent, FRBNY	N/A

*Including non-originated loans, around 10-15% of observations missing per annum.
**In 'RateSpread', following Mayer and Pence (2008), see also the Appendix A.
***Only for originated loans, around 10-15% of observations missing per annum.

Table 1: Data sources for controls and other variables

A summary of the descriptive statistics of our main variables for the boom period (2004-2006) and the overall period of our analysis (2004-2012) can be found in Table 2. The average values of our main variables are very similar for both types of states; non-recourse states do experience slightly less defaults than recourse states, but this difference is not statistically significant.

4.4 Discussion of Data and Recourse

4.4.1 Securitization

There are two important limitations for our securitization data. Firstly, as the category 'Private Securitization' only began to used from 2004 onwards, we have a limited amount of data points available. Our main regressions will thus cover the period from 2004-2006, giving us only 3 years worth of data. The second concern is that the category 'Private Securitization' only reports originators' beliefs on how sold loans will be put to use, not on whether securitization actually took place, and only for loans sold within the same calender year of origination.

This means that there could be misreporting of the actual securitization levels of loans within states/MSAs due to at least 3 effects. Originators might report that loans

Average 2004-2006	Non-Recourse States	Recourse States
Securitization (%)	3.66 (2.47)	3.94 (2.47)
Income	34523 (3360)	35481 (6451)
Income Growth (%)	4.91 (1.65)	5.29 (1.88)
Population	6922 (9464)	5485 (5296)
Unemployment (%)	4.98 (1.09)	4.83 (1.05)
Mortgage Defaults (%)	0.85 (0.32)	1.21 (0.52)
Subprime (%)	19.23 (7.97)	21.84 (7.13)

Average 2004-2012	Non-Recourse States	Recourse States
Securitization (%)	1.86 (2.07)	1.75 (2.19)
Income	38350 (4957)	39021 (7882)
Income Growth (%)	3.77 (3.48)	3.47 (3.19)
Population	7147 (9704)	5627 (5469)
Unemployment (%)	6.37 (2.28)	6.34 (2.25)
Mortgage Defaults (%)	2.93 (2.60)	3.47 (3.00)
Subprime (%)	10.42 (8.37)	12.54 (8.86)

Standard deviation in parenthesis.

Table 2: Descriptive statistics for Boom and full sample periods

as having been securitized when they were not, it is possible that loans reported as sold to other types of purchasers were, subsequently, securitized and not reported as such[31], and loans may have been sold to be securitized in a subsequent calendar year. We strongly suspect that the second and/or third of these effect is dominant, as the LPS data used in Krainer and Laderman (2014), using somewhat different criteria for what loans to include, report that around 38% of loans in California were privately securitized in 2006, whereas we find it to be around 10%.

If our measure is under-reporting the amount of securitization in each state by the same fixed amount (for example, by 5 p.p. in each state), then this error would be captured by our state fixed-effects. However, if this error is proportional to the level of securitization taking place in each state, then our estimates for the coefficient of securitization will be biased upwards. Finally, there are likely to be the classic measurement error bias with our measure that should not affect our results significantly.

Fortunately for the purposes of this paper, we are mainly concerned with relative, across states measures of securitization, not absolute measures. Unless there are systematic differences in the way originators in each state/MSA reported this category, then it should provide an accurate measure of relative securitization.

As such, our estimates for the coefficient of securitization may be biased. But the relative effects of securitization, when compared to other sources of variation on house prices, should be captured more accurately as we are using fixed-effects and time dummies.

[31] Of particular concern are the categories "Life insurance company, credit union, mortgage bank, or finance company" and "Other type of purchaser".

4.4.2 Non-recourse literature

The evidence concerning recourse and how it affects the housing market has changed over time, and earlier evidence for the importance of recourse is more ambiguous: Pence (2003) summarizes the literature up to that point, noting that the effects of recourse/deficiency judgements on mortgages was ambiguous. They state that "lenders rarely pursue deficiency judgements" and they find weak empirical evidence for its importance. Despite this, they suggest that for people purchasing houses to speculate and when borrowers are in a 'non-hardship' situation recourse matters, both being cases where deficiency judgements are more likely to be pursued.

Ohter papers, particularly more recent papers, finds otherwise, however. Ghent et al. (2011) seminal paper finds that non-recourse states have higher default rates and that non-recourse alters the way borrowers default, which they take as evidence of strategic defaults on the part of borrowers. Pennington-Cross (2003) finds significant evidence that loans being recourse increases the amounts recovered by lenders in case of a default. Dobbie and Goldsmith-Pinkham (2014) find evidence in the recent bust that home-owners in non-recourse states experienced greater declines in debt, which they attribute to the protections afforded by these laws, but also saw greater falls in house prices (due to increased foreclosures), leading to a greater fall in consumption and income when compared to recourse states. Chan et al. (2016) find similarly that non-recourse status increases defaults on all types of housing debt. Westrupp (2015) also finds evidence of the importance of recourse status on the volume and discount levels of foreclosure sales.

Thus the most recent evidence for whether a state's recourse law affects how borrowers and lenders behave seems to indicate that has significant effects. Given the results of Pence (2003), this suggests that recourse may have become more important during the boom and bust of the 2000s.

5 Empirical strategy and results

5.1 Boom period

We first test our model predictions for the boom period. To do this, we regress house prices on the interaction effect between securitization and the non-recourse status of a US state, at both a state and a MSA level:

$$HPrice_{i,t} = \beta_1 Sec_{i,t} + \beta_2 NonRec_i + \beta_3 Sec \times NonRec_{i,t} + \gamma_{i,t} + D20XX_t + \varepsilon_{i,t}$$

$HPrice_{i,t}$ are house prices in state/MSA i at time t, $Sec_{i,t}$ is the percentage of mortgages that are privately securitized of all house-purchase loans originated in i, t, $NonRec_i$ is a dummy for whether state i (or the state i in which a MSA is located)

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice
Securitization	1.031***	1.177**	0.728***	0.784***
	(0.388)	(0.484)	(0.192)	(0.225)
NonRecourse	-1.015		0.582	
	(0.953)		(0.586)	
Securitization×NonRecourse	1.018**	1.262**	0.215	0.526**
	(0.473)	(0.542)	(0.232)	(0.253)
Observations	153	153	1,076	1,076
R-squared		0.880		0.821
Number of State/MSA	51	51	359	359
Dataset	State	State	MSA	MSA
Method	RE	FE	RE	FE

Robust, clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1,
Regressions include controls and year dummies. Annual data from 2004 to 2006.

Table 3: Boom period, main regressions

is non-recourse, $\gamma_{i,t}$ are the controls[32], consisting of income (Inc), population[33] (Pop), income growth (IncG) and unemployment (Unemp) for a state i, and income (Inc) and population (Pop) for a MSA i, and $D20XX_t$ are year dummies.

The regressions are run for 2004-2006 period using either fixed-effects (FE) or random-effects (RE), clustering the standard errors at either state or MSA level; when using FE, non-recourse is automatically absorbed and is thus omitted. We treat our control variables as exogenous, that is, we assume that they are not affected by changes in house prices in the 3 year period of our regressions. As we regress house prices using year dummies, from a normalized index, these regressions deal only with house price growth.

As the prediction of our model is that the interaction effect between securitization and non-recourse should have positive effects, we focus our attention on the interaction effect in the subsequent discussion. Wherever possible, we focus on the results of the FE regressions, which can control for omitted variables bias, and on the state level results, as discussed in the previous section. The results of our regressions can be seen in Table 3, with the results for our controls in Table 8 in Appendix C.

The interaction effect is positive and significant in all but one specification. As

[32]One potentially important control that we do not include is the loan-to-value ratio, due to data availability issues for those years, and this may result in a omitted variable bias in our results; see also the Appendix A.

[33]As most regressions will have state or MSA fixed-effects and land can be supposed to be largely fixed for those 3 years, means that we are controlling for population density.

securitization has a coefficient of around 1[34], this means that a 1 p.p. increase of securitization is associated with a 1% increase in house prices in recourse states. But when this state is non-recourse, a 1 p.p. increase in securitization is associated with a 2% increase in prices in non-recourse.

We are not too concerned that the coefficient in the MSA-RE specification is not significant at 10%, as MSAs should have higher levels of heterogeneity than states and there should be higher uncertainty when using a RE specification. In all other cases, the value of the interaction coefficient is at a similar level when compared to the securitization coefficient.

These results suggests that the association between securitization and house prices is around double in size in non-recourse states when compared to recourse states, and this is consistent with our model predictions.

5.1.1 Robustness checks

We perform 22 baseline robustness checks (including variations on state/MSA), and each test is described and discussed in detail in Appendix A. We opt not to include certain controls in our baseline regressions, such as our measure of subprime mortgages and our measure of GSE securitized loans, due to concerns about endogeneity.

Among our robustness checks, we reinterpret our model predictions, by taking it more literally assuming that there is a cut-off point at which the effects of high securitization are felt and speculators start receiving loans. We propose and test this interpretation in two different ways. We first by restrict our sample to those MSAs with high level of securitization and run the same regressions as the baseline. Alternatively, we create a dummy for MSAs above the average value of securitization ('Top Securitization MSA') and use it instead our main measure of securitization, using the same specifications as our baseline regressions.

Some of these robustness checks are shown in Table 4, specifically, the results when we include a measure of subprime mortgages, when we exclude California, when restrict our sample to non-Western states/non-Coastal states, and when we use the 'Top Securitization MSA' dummy. Our other robustness test results are are reported in Appendix C, in Tables 9 and 10[35].

We interpret the results of our numerous robustness checks as showing that they our baseline results largely hold; the notable exception consists of when we regress only in non-Western states, which we discuss below. The interaction effect otherwise is positive and mostly significant, with a coefficient ranging from 0.36 to 3.7. This is a fairly high range, as is expected given that we change the range, measurement and add variables to our regressions in these tests. The coefficient is not significant when we extent our range to 2007, when we use the Case-Shiller index, when we do

[34]However, as discussed in Section 4, we are likely underestimating the amount of securitization that took place, this means that the estimated effects is likely larger than the actual effect and should be treated as a upper bound.

[35]Results for our controls are omitted for brevity's sake.

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice	(5) HPrice
Securitization	0.409	0.456	1.189	0.160	
	(0.600)	(0.598)	(0.726)	(0.335)	
Securitization×NonRecourse	0.969*	1.264*	-0.862**	1.487	
	(0.518)	(0.667)	(0.403)	(0.954)	
Top Securitization MSA					1.655***
					(0.552)
Top Securitization MSA×NonRecourse					2.938**
					(1.172)
Observations	153	150	114	81	1,074
R-squared	0.888	0.886	0.844	0.887	
Number of State/MSA	51	50	38		358
Dataset	State	State	State	State	MSA
Method	FE	FE	FE	FE	RE
Change	Subprime	No Cali	Non-Western	Non-Coastal	Top 50%

Robust, clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, Regressions include controls and year dummies. Annual data from 2004 to 2006.

Table 4: Boom period, robustness checks

Coastal and non-Coastal level regressions and when our measure of subprime loans (on a MSA, but not state level) is added. However, the coefficients we find in these tests are compatible with our baseline regressions and it is only in these 5 of our 21 robustness checks (excluding the non-Western result) that the interaction term is non-significant.

The coefficient for securitization is significant in 9 of our 19 robustness checks, although always being positive and (excluding Subprime MSA-level and Non-Coastal regressions) with a coefficient ranging from 0.3 to 1.4, all of which suggests that this is a less robust result. We also note that, aside from concerns about endogeneity, the coefficient for Subprime is positive and statistically significant at 1% in all regressions, indicating that subprime mortgages were tightly linked with house prices at that time period[36].

5.1.2 Non-Western states

Concerning the non-Western state result, which seems to goes against our model predictions, we find that the average securitization level of MSAs in non-Western, non-recourse states was 2.2%, compared to 5.9% in Western, non-recourse states. Similarly, whereas the Western, non-recourse states 85% of MSAs are among the top 50% of our measure, in non-Western, non-recourse states, only 19% of MSAs (24 in total) could be classified as such. And the highest level percentage of securitization experienced by any MSA in the latter was only 5.9%, compared to 15.7% in the former.

Given these statistics, we conclude that non-Western, non-recourse states experienced relatively low levels of securitization. This suggests that, unlike most other

[36]Similarly, the coefficient for GSE is negative and mostly significant in our specifications, whereas its interaction is positive and significant, suggesting that GSE securitization had some effects on house prices at that time, albeit differently in recourse and non-recourse states; this result is somewhat surprising and may warrant further research.

states, non-Western, non-recourse states may have been closer to the no-securitization prediction of our model. Assuming this is the case, the most reliable regressions for these states should be the ones where we use our dummy for top 50% highest securitization, as we can then focus on the few MSAs that did have 'sufficiently high' levels of securitization.

We thus run the same regressions for these states, using the $TopSecuritization$ dummy instead of our measure of securitization Sec, and either using it directly (with RE) or interacted with year dummies (so we can use FE). The results can be found in Table 12 in Appendix C and we find that they are are closer to what our model predicts. Although the coefficients on the interaction effect are not significant and, for FE regression, smaller in size when compared to our baseline results, they are nevertheless positive, in the direction that our model predicts.

We thus conclude that there very likely were not enough MSAs in non-Western, non-recourse states that had high enough levels of securitization for us to test our predictions on a state level. And when we test these states using our securitization dummy, the few MSAs in non-recourse, non-Western states that did have higher levels of securitization did experience higher house prices as our model predict, albeit with coefficients that are non-significant.

5.1.3 Discussion of results

From these regressions we conclude that we have fairly robust evidence that the interaction between securitization and non-recourse is associated with higher growth in house prices in that period. This conforms to our model prediction and we take this as evidence for our model mechanism. On that basis, it is possible to try to quantify how much this mechanism is associated with the difference in house price growth in the average recourse and average non-recourse state in the period.

To do so, we use the results from our main regressions using our state-FE results as a benchmark. We take the average changes in each of our explanatory variables and, using the coefficients from the state-FE, report the % that each variable explains of the total fitted change of house prices in Table 5. By doing this, we conclude that securitization is associated with around 31% of the increase of house prices in non-recourse states, compared to 18% in recourse states.

Moreover, by the same method we can estimate how much the difference in growth of house prices in the period between states was related to the interaction effect. Non-recourse states experienced an increase in prices of around 21%, compared to around 16.5% for recourse states in the period, of which around 75% is associated with our mechanism (around 3.4 p.p. increase from 2004). The rest is mainly associated with differences in the effects of population growth (25%), as securitization and income growth were largely similar for both types of states, and the effects of unemployment and income roughly cancel each other out.

Variable	Non-Recourse	Recourse
Sec	15%	18%
SecNonRec	16%	N/A
Inc	41%	55%
Pop	18%	16%
IncG	-1%	-1%
Unemp	11%	11%

At average values, shares each covariate explains fitted, average house price growth in recourse and non-recourse states from 2004-2006.

Table 5: Share of covariates in explaining average, fitted house price growth

5.1.4 House prices

One concern about our main empirical strategy is the possibility that non-recourse states may have systematically experienced bigger housing booms in the past, compared to recourse states. Our data for house prices ranges from 1975 until 2016, and during that time, according to Agnello and Schuknecht (2011), the US experienced a single housing boom and a single housing bust, which makes it difficult to identify whether this is the case.

Observing the previously discussed Figure 1 finds no observable detachment prior to 00s. Figure 6, although consisting of lower quality data, show house price growth in recourse and non-recourse states tends to differ little except for around 3 periods, from around 1985 to 1992, from around 2003 to 2011 and from around 2013 to 2016. We interpret both the joint growth, long-term trend and the first detachment, being the inverse of what a put-option would predict, as suggesting that risk-shifting mechanisms were likely not boosting house prices prior to the 2000s, which is in accordance with out model predictions.

However, the subsequent detachment in house prices after 2012 is more concerning, and raises the question whether our interaction term is perhaps acting as a proxy for a more general detachment in house prices in non-recourse states starting in the 2000s. Given the observable convergence during the bust period from 2008-2011, this is not a simple question to answer and we believe that further investigation may be necessary for periods subsequent to the 2007-2008 bust.

5.2 Endogeneity and IV strategy

5.2.1 Discussion of endogeneity

There is a critical issue of endogeneity/reverse causality for our interaction effect. For example, non-recourse states should be inherently more risky for lenders and owners of mortgage loans (i.e., securitizers), when compared to recourse states, due to the lack of deficiency judgments. In addition, lenders and securitizers may believe that when house prices are growing faster, loans are safer, as prices would have to fall more before the value of a house goes below the loan value. I.e., higher price growth may provide a buffer margin against defaults. If both these hypothesis hold, then higher levels of house prices would be required in non-recourse states to achieve similar levels of securitization, when compared to recourse states.

As this is what we find in the data and is an equivalent prediction when compared to our model, we cannot rule out the possibility that house price growth is reverse-causing securitization. If this is the case, than the standard problems with endogeneity apply and our baseline regression results may not be consistent.

In addition, the hypothesis that higher house price growth increases the buffer margin against defaults has other implications for endogeneity. In particular, this would lead to reverse causality between securitization and house prices, which would also bias our results.

We opt for a instrumental variable approach to deal with these issues. As omitting any constituent component of an interaction term biases the estimates of the interaction itself, we choose to focus our attention on finding an instrument for securitization. A valid instrument for securitization would also result in a valid instrument our interaction term, by interacting the instrument with non-recourse, as non-recourse can be considered exogenous. This would solve both issues with endogeneity simultaneously; having fixed-effects means we need not worry about endogeneity from the non-recourse term directly.

5.2.2 Instrumental Variable strategy and results

To address the issue of endogeneity, we use what we believe is a new instrumental variable for securitization. There is a long tradition of using geographic distance as an instrumental variable, one widely cited example being Hall and Jones (1999)[37]. Inspired by this and similar approaches, we use distance from a MSA as a instrument, specifically the minimal distance to the headquarters of the largest 'originate and securitize' mortgage originators in the period.

A common element in the explanation for the housing boom and bust, such as seen in Lewis (2011) among others, is that certain loan originators were 'originate and sell' institutions. These are institutions that specialized in creating mortgages and selling them to other entities so that these loans could be privately securitized, particularly subprime loans. We seek to identify a analogous subset of such originators in our HMDA data. To do so, for 2004, 2005 and 2006, we select the top 15 originators who most originated loans destined for home purchases and that were sold to be privately securitized. We then verify that at least 30% of their total loans originated were sold in such a fashion, and only select originators who satisfy both criteria. This leaves us with a total of 18 institutions, covering 33%, 78% and 87% of loans originated for private securitization 2004, 2005 and 2006 respectively. We proceed to identify 17 of these

[37]They use distance from the equator as an instrumental variable for social infrastructure of a country.

institutions via their 'RespondentID' codes[38] and investigate where their headquarters are located and the year they were founded.

Our IV strategy assumes that if a MSA is closer to where the headquarters of these originators is located, than it is easier for the originators to participate in the housing market of that MSA. We propose that closer MSAs make it easier for headquarters to monitor branches, that headquarters will more likely have greater knowledge, including legal knowledge, of closer housing markets, headquarters will have incurred the fixed cost of complying with state regulations, etc. At the same time, the validity of our instrument requires that these headquarters are not based in or near to locations where house prices were expected to grow more in our period of 2004 to 2006. For this reason, we exclude 3 originators who were founded post-1996, leaving us with the originators found in Table 16 in Appendix B, all of which were founded at least 8 years before our 2004, which we conjecture is enough time to satisfy the exclusion restriction.

In addition, as some of these institutions are very large, and some are quite small, we wish to give appropriate weights reflecting their size. For this, we use the amount of loans originated[39] in 2003 as weights. Finally, we opt to select the two closest originators, as a proxy for the level of competition that a MSA encountered between originators. We give more weight to the distance of the larger one of the two and this results in our instrument, $DistW$.

We acknowledge the limitations of this instrument. Of particular concern is that our model results imply that no-screening takes place with securitization, which would suggest that a deeper knowledge of local markets would not matter in equilibrium, weakening our instrument's power. In addition, it is possible that as loan originators have less knowledge of more distant MSAs, this could lead to moral hazard problems and more loans being securitized the further away the MSA is from the headquarters, as opposed to being held. Thus, if the heterogeneity of securitization from MSA to MSA has a larger effect than the effect of expansion of branches, then our instrument may have had the opposite effect on securitization. A further discussion of these issues may be found in Appendix A.

To implment our IV, we use both $DistW$ and its interaction, $DistW \times NonRec$, as instruments. The former is used to instrument Sec and the latter to instrument $Sec \times NonRec$. We then proceed to estimate a similar same equation to our baseline results:

$$HPrice_{i,t} = \beta_1 Sec_{i,t} + \beta_2 NonRec_i + \beta_3 Sec \times NonRec_{i,t} + D20XX_t + \gamma_{i,t} + \varepsilon_{i,t}$$

We use fixed effects, using a clustered (at a MSA level), robust standard errors; as both our instruments are time invariant, to be able to use fixed effects on these

[38]One, covering 1% of loans in 2005, was impossible to identify.

[39]Which resulted in excluding one more originator, LOAN CENTER OF CALIFORNIA, as there is no available data for loan origination prior to 2004; we believe it was previously exempt from reporting to the HMDA.

regressions, we interact both our instruments with year dummies[40].

Before discussing our IV regression results, we first focus on the first stage results seen in Table 6, as they are not as expected. When instrumenting securitization, the coefficients for distance (interacted with our year dummies) are positive, the opposite of what we would expect; the F-statistic on excluded instruments is 8.28, which may be a sign of a weak instrument. When instrumenting for the interaction between securitization and non-recourse, however, the coefficients on both distance and its interaction are negative as expected, with a F-statistic of 15.71.

These results suggests that our instrument is not working as intended for all MSAs or, possibly due to some of problems we discuss above, has differential effects depending on the status of recourse law of the state; we do not currently have a working proposition for the latter. To deal with this issue, we split our sample into recourse and non-recourse states and run them separately[41]. We acknowledge, however, that an instrument that only works in part of our sample is concerning and raises the question of whether it is truly satisfying the first stage restrictions.

VARIABLES	(1) Securitization	(2) Securitization×NonRecourse	(3) Securitization	(4) Securitization
D2005×Distance	0.00097***	-0.00009	0.00098	-0.00163***
	(0.0002)	(0.0001)	(0.00025)	(0.0004)
D2005×Distance	0.00073***	-0.00021	0.00076	-0.0014***
	(0.0002)	(0.0002)	(0.00026)	(0.0005)
D2005×Distance×NonRecourse	-0.0027***	-0.0018***		
	(0.0005)	(0.0003)		
D2006×Distance×NonRecourse	-0.0022***	-0.0018***		
	(0.0005)	(0.0003)		
Observations	1,076	1,076	792	284
Number of MSA	359	359	264	95
Dataset	MSA	MSA	MSA	MSA
Method	FE	FE	FE	FE
States	All	All	Recourse	Non-Recourse
F-Stat on excluded instruments	8.28	15.71	7.73	7.69

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Regressions include controls and year dummies as instruments. Annual data from 2004 to 2006.

Table 6: First stage regressions for distance as an instrument

The first stage coefficients in recourse states remain positive and significant and have a low F-statistic, at 7.7, means that the possibility of a weak instrument problem remains, and the positive coefficient has the same implications as before. However, for non-recourse states, our first stage has instruments with the correct signs, in addition to being significant. The F-statistic is still below 10, also at 7.7, which means that our results may be biased.

In addition, in Table 13 in Appendix C, we also present the results of the reduced form estimates for our instruments. We find similar results as the first stage regres-

[40]Which assumes a time-differential effect of the instrument, another limitation of our approach.

[41]If there is a differential effect of our instrument on securitization due to recourse status, this would allow it to work as intended

sions, with evidence that our instrument are weak, and is inconsistent and/or has differentiated effects for recourse states, but works as expected for non-recourse states.

We present the results of our instrumented regressions for all three cases, with all states and with just recourse or non-recourse states, in Table 7.

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice
Securitization	-0.695	-1.201	4.072***	-2.161
	(1.683)	(1.713)	(1.093)	(3.403)
Securitization×NonRecourse	3.527**			3.394
	(1.725)			(2.070)
Observations	1,076	792	284	1,076
Number of MSA	359	264	95	359
Dataset	MSA	MSA	MSA	MSA
Method	FE	FE	FE	FE
States	All	Recourse	Non-Recourse	All+Subprime

Robust, clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
Regressions include controls and year dummies. Annual data from 2004 to 2006.

Table 7: Instrumental variable regressions

Our results for the whole sample are consistent with our previous results, as the interaction effect is positive and significant. The results for when we split our sample are also consistent, as securitization in recourse states has no significant effect on house prices (although the negative coefficient is unexpected), whereas the effect is positive and significant in non-recourse states. Furthermore, the coefficient is larger than in the estimates from our baseline regressions, which we take as suggestive evidence that our mechanism is playing a role in increasing house prices in these states.

We also regress for our whole sample including our subprime measure as a control. We do this without subprime being instrumented[42], and find that although not significant, our coefficient for the interaction effect remains positive and in line with our previous result. Overall, given the first stage issues we report, we take these results as further, but not conclusive evidence, for our model mechanisms.

5.3 Bust period

Our model also predicts that the cumulative effect of securitization in a non-recourse state should lead to greater falls in house prices during the bust period.

[42]Given the potential endogeneity between house prices and subprime mortgages, however, this estimation may not be consistent.

To explore this prediction, we create a new variable, $PastSec$, which is the average securitization done from 2004 to 2006 in each state. From this variable, we can derive the interaction effect between this measure and the non-recourse status, $PastSec \times NonRec$. With this, we can test our prediction by regressing house prices on these variables:

$$\begin{aligned} HPrice_{i,t} =& \beta_1 D20XX_t * PastSec_i + \beta_2 D20XX * NonRec_i \\ &+ \beta_3 D20XX * PastSec \times NonRec_i + \gamma_i + D20XX_t + \upsilon_i \end{aligned}$$

where γ_i is the same set of controls as in the boom period and $D20XX_t$ are year dummies. That is, to be able to include state fixed effects, we interact our static variables with year dummies; this assumes a time-differentiated effect of these variables during the bust.

As it is less clear when the bust period ended, we vary the end date of our regressions, using as end 2009/2010, with the first period being 2007. We also include in some of our main regressions $PastSubprime$, which is the average percentage of subprime mortgages in new originations during 2004-2006. When included, $PastSubprime$ is also time interacted. Our results can be seen in table 14 in Appendix C.

Our results provide evidence for our mechanism, but with important caveats. In the absence of subprime mortgages, the coefficient for our interaction effect is negative and significant for two years, 2008 and 2009, suggesting that our mechanism is explaining some of the drop in house prices, more than doubling the effects of securitization stemming from the boom period. And securitization itself seems to have also caused significant drops in house prices, specially in 2009 and 2010, conforming to the results found in the literature.

However, when subprime mortgages are included in these regressions, we find that our interaction coefficients, whilst still negative and of a similar order of magnitude, are no longer statistically significant. Given the importance the literature has found for subprime mortgages in explaining the housing market in the period, we feel that the results from the specification that includes should receive significant weight.

Securitization still has significant and negative coefficients, as expected, and we find that subprime mortgages, although not reported here, also adversely affected house prices in the period, with negative and statistically significant coefficients [43].

Unlike our boom period regressions, as both $PastSec$ and $PastSubprime$ are measured prior to when we run our regressions, it less likely that there will be reverse causality with respect to house prices. Endogeneity issues may still exist if securitization was higher in states where house prices were expected to grow the most during 2004-2006 and these states experienced the biggest falls in prices afterwards. As a simple test of this, we calculate the correlation between house price growth in states

[43] For every extra 1% of (average) mortgages that were subprime in a given state during the boom period, there was a corresponding fall in house prices of around 0.5% for every year from 2008-2010, in 2004 prices.

from 2004-2006 with 2007-2009. We find a correlation of -0.56 which we interpret as being sufficiently high for this to be remain a concern, meaning that our bust period results should be treated with a degree of caution.

As such, we find further, albeit weaker evidence for our mechanism's effects on house prices during the bust period, and evidence that securitization and subprime mortgages created in the boom period played an important role in determining house prices during the bust.

5.3.1 Defaults

Our model also predicts that defaults are increased in a bust when there are higher levels of securitization in non-recourse states during a boom.

For defaults, we use $MDefault$, the percent of mortgage debt balance that is 90+ days delinquent in each state, for all mortgages; this may be a too broad measure of defaults, however, as it our model focuses on defaults of home-purchase mortgages created during the boom. As before, we use the start date of 2007 and use as end dates of 2009/2010. We then regress defaults on past securitization and its interaction effect:

$$\begin{aligned} MDefault_{i,t} = {} & \beta_1 D20XX * PastSec_i + \beta_2 D20XX * Past \times SecNonRec_i \\ & + \gamma_i + D20XX_t + \pi_{i,t} \end{aligned}$$

As before, we interact our static variables with year dummies to allow for fixed effects. Our results are found in table 15 in Appendix C.

In none of our regressions are the coefficients of our interaction significant, nor are they consistently positive, from which we conclude that there is little evidence that our mechanism lead to increased defaults during the bust, albeit given the limitation of using a broad measure of defaults. We do find evidence that securitization from the boom period increased defaults in the bust period, a result that is robust, as the literature has previously found. Similarly, subprime mortgages from the boom period, the results of which we do not report here, also lead to increased defaults during the subsequent bust.

6 Conclusion

The literature on the housing market has sought out many explanations for what led to the unprecedented boom and bust in the US during the 00s. We seek to add to this literature by proposing that the non-recourse status of mortgage loans in some states in the US, when combined with the increase in securitization experienced at that time, pushed up the prices of houses in those states.

Our model generates a increases in house prices using a 'risk shifting' mechanism, where asymmetry of payoffs between loan originators and borrowers creates a put option value. We base our model on the work of Barlevy and Fisher (2010), but introduce two important elements, screening of borrowers by originators and a securitization market.

Securitization allows loan originators to pass on the risk associated with mortgages, and we find that with non-recourse loans, originators stop screening borrowers. This is because they cannot credibly signal whether a borrower is a owner-occupier or a speculator who seeks capital gains. If demand growth continues for long enough, speculators become the marginal sellers, and as non-recourse loans have a put option value, this pushes up house prices. With rational expectations, this increases the price of houses happens even before these speculators become sellers.

We find some empirical support for this. We regress house prices, on a MSA and state level from 2004 to 2006, on securitization and its interaction with non-recourse status of states. We find a positive association of securitization and house prices in the US, as is consistent with the literature, but crucially find that this association was roughly doubled in non-recourse states, compared to recourse states. Whereas every increase of 1 p.p. securitized mortgage loan (of originated mortgages) in recourse states is associated with an increase of house prices by around 1%, the same 1 p.p. of securitization is associated with a 2% increase of house prices in non-recourse states. The mechanism is can potentially explain around 75% of the differences in growth of house prices between these states.

To control for potential endogeneity issues between house prices and securitization, we use as an novel IV, the weighted distance between a MSA and the two closest headquarter of 'originate and securitize' mortgage institutions. Our results largely hold when doing so, particularly for non-recourse states, but note that the first stage F-statistic is small and our first stage coefficients are inconsistent or have a differentiated effect for recourse states. We take this as more evidence, but not conclusive evidence, that our proposed mechanism influenced house prices during the boom.

Our model also makes predictions for the bust period, although, due to the static nature of its bust period, it is less suited for doing so. It predicts that the same interaction effect between securitization and non-recourse status from the boom period should lead to greater falls in house prices and more defaults during a subsequent bust. We find weak evidence for this on house prices, and no evidence of this in defaults during the bust. We also find evidence that higher levels of securitization during the boom lead to greater falls in house pries and increased defaults during the subsequent bust.

We conclude by noting that there is currently an ongoing debate about whether mortgage originators should be forced to have a 'skin in the game', that is, to hold on to at least some percentage of any loan they originate. Given the results discussed above, we believe that it would be wise, particularly in jurisdictions where mortgage loans are non-recourse, to make these rules binding, or, as an alternative, proportional to the loan-to-value ratio of a mortgage.

Although securitization levels have currently fallen, it or similar financial innovations which allow mortgage originators to sell their loans could easily reappear in the near future. In that sense, the relatively recent changes[44] by US regulators that relaxed the Dodd-Frank laws may have been counterproductive. The law originally required originators to have a substantial 'skin in the game' and these changes have, instead, exempted the vast majority of mortgages in the US from such a requirements.

Taking note that our model results and, to a lesser extent, our empirical results are independent of the existence of subprime mortgages, these changes might be re-laying the foundations for future problems, even if subprime mortgages are more tightly controlled and regulated, or even non-existent[45].

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7 Appendix A - Model and empirics discussion

7.1 Borrowers

We can think of low type borrowers as being speculators as they only wish to buy a house to take advantage of (potential) capital gains by selling it in a later period. There is substantial evidence that house buyers seeking to make capital gains were an important part of the housing market in the US during the recent boom, as can be seen in Haughwout, Lee, Tracy and van der Klaauw (2011), Bhutta (2015) and Bayer, Mangum and Roberts (2016). Haughwout et al. (2011) for example, finds that around half of mortgage originations for house purchases in states with greatest price appreciation at the top of the housing boom were done by such borrowers.[46] In our model, we need not assume such a large number of speculators: a small number of low types is sufficient to generate increased house prices, as long as they have the opportunity to become the marginal sellers.

For the purposes of our model, we have that speculators and owner-occupiers are a separate set of agents, but in practice there is likely a 'spectrum' of intentions from borrowers concerning what they wish to do with houses. That is, borrowers utility from owning a house likely span a wide range of values, which would turn owner-occupiers into speculators if prices have risen sufficiently. We surmise that making such an addition to our model would generate analogous results, and opt for two separate sets of agents for tractability.

7.1.1 Risk Averse Borrowers

If we made borrowers risk averse with equivalent utility to that of the originators, then there is no change to the optimal behaviour of owner-occupiers, as their optimal decision is still to never default, so there is no uncertainty/variance.

With non-recourse loans, speculators remain protected from a fall in house prices. However, the uncertainty stemming from the change in house prices means that they only take a loan if the negative utility from this variance is smaller than the expected benefit, i.e., if $q(\pi - r_P) \geq aq(1-q)(\pi - r_P)^2$, where r_P is the equilibrium, no-screening interest rate.

This is true if $a \leq \frac{1}{(1-q)(\pi - r_P)}$, which can show hold simultaneously with $a \geq a' = \frac{1}{2(1-q)\pi}$, thus any a that satisfies both restrictions allows for both risk averse borrowers and originators and finds the same result in a no-screening equilibrium.

If, however, risk aversion is sufficiently high, then speculators never wish to take

[46]Unlike our model, Haughwout et al. (2011) find evidence of speculator-like buyers by looking at second home purchases, but as they conclude that this was done speculators "apparently misreporting their intentions to occupy the property", as "(...) many of the borrowers who claimed on the mortgage application that they planned to live in the property they were purchasing had multiple first-lien mortgages when the transaction was complete". This can be thought as a part of the information that good screening discovers.

on loans in either equilibrium. In such a case, our model predicts that only owner-occupiers receive loans.

We show in the Appendix B, that the analogous result holds in general equilibrium for a large enough probability, $q > 0.25$.

7.2 Originators

The interaction within the group of originators and between originators and borrowers is similar to that of a Bertrand competition, as borrowers can see the interest rate schedule and the loan decision before deciding which originator to approach. Because of this Bertrand-like marketplace, in the absence scale effects, and with linear costs, we need not specify the number of originators that exist; the model would work equally well with just two originators as with a continuum of them.

Furthermore, this means that with deep pockets and free entry, we would find the same results, which allows us to use a representative originator to find some results.

Originators' capacity to distinguish between the two types of borrowers comes at a cost of C per each individual they screen. We can think of this being the cost needed to obtain extra information necessary to tell apart two borrowers whose observable characteristics are identical (that is, any and all information used to price loans/mortgage securities). This could, for example, be thought of as information that only becomes available from when experienced bank managers carefully investigate and vet potential borrowers.

A 2013 article by The Economist illustrates how this cost of screening can be significant: *"Marquette's [a bank] (...) approach was to have a lending officer accompanied by one of the bank's trustees (board members, in effect) visit every mortgage applicant on the Saturday after each application was filed."* and how originators may have problems in being able to signal the quality of loans, affecting the incentives to screen if originators can sell: *"Its overseers wanted it to sell its mortgages to protect itself from swings in property prices. (...) The subprime crisis revealed so much slapdash issuance that buyers of mortgages consider valuations provided by the originators worthless. So Marquette can no longer conduct its own appraisals. Saturday visits have ended."*[47]

As Keys, et al argue, only contractual terms (such as LTV ratios and interest rates) and FICO scores were used by investors to evaluate the quality of a securitized pool. As such, although we have restricted the signal of loan quality between originators and securitizers to be interest rates, other 'hard' characteristic of loans might have been used instead, in particular, the loan-to-value ratio, which we discuss below.

7.3 Securitization and Securitizers

We focus on the private securitization market in our modelling, as opposed to the GSE market. We do this for several reasons, firstly because the incentives of GSEs are

[47] *Economist, Nov. 2013.*

difficult to ascertain and model, given their dual role as a for-profit companies which were also tasked with helping finance low and middle income loans[48].

Secondly, the literature has evidence that lending standards of loans associated with GSEs changed little during the 2000s. GSE securitization has a long history in the US, and their overall participation rate in creating loans changed little in the decade preceding the crisis. As Adelino, Schoar and Severino (2016) summarize "Loans that were sold to (and then guaranteed by) the GSEs had to conform to higher origination standards than those sold to other entities". This can be seen in the default rates of GSE loans in 2008 and 2009 which, although high by historical standards, were not even half as large as those at the lower end of the housing market sold to the private sector (Angelides and Thomas, 2011).

Note as we do find evidence that house prices were affected by GSE loans in our regressions, albeit negatively, whether our mechanism may have had some effect in the 2000s remains an open question, and we cannot exclude such a possibility.

Private securitization expanded to unprecedented levels in the late 90s and the early 00s. This resulted in new financial agents buying these products and becoming exposed to the US housing market for the first time, including agents outside of the US. Many of these agents, as discussed by Lewis (2011), had very little understanding of the US housing market, much less of the constituent mortgage loans they held via the CDOs and MBS they owned. As we discuss in the previous section, products were typically evaluated over aggregated/averaged information over the thousands of loans backing a single product, such as the average FICO score. In addition, Elul (2011) finds evidence that originators of loans may have had access to private information beyond that typically used by buyers of securitized products, resulting in adverse selection. For these reasons, why we model securitizers as not being able to distinguish between the different types of borrowers behind a loan.

Buyers of securitized products would use such averaged information in part due to the complexity of the securitization process, which may have been deliberately made more complex due to moral hazard issues (Hofmann, 2008).

This makes securitization quite complex to model, as it involves numerous agents and steps[49]. We can summarize it as consisting of aggregating loans from a number of different markets, on the assumption that they exhibit some statistical independence from each other, and then slicing the returns from these loans into different tranches, so that the senior tranches receive priority in payments, and losses are absorbed by the lower tranches first. The whole process involves a number of intermediaries and steps, most saliently a loan originator and a securitization arranger, normally a investment bank.

[48] As per the Housing and Community Development Act of 1992, they 'have an affirmative obligation to facilitate the financing of affordable housing for low- and moderate-income families in a manner consistent with their overall public purposes, while maintaining a strong financial condition and a reasonable economic return"

[49] See Ashcraft and Schuermann (2008) for a discussion of the stages and the problems that might arise in each of these.

The aggregation should result, if loans are statistically independent at least to some extent, in both a reduction in uncertainty about the outcomes and a reduction in the variance. Combined with the creation of tranches, this would theoretically allow for high tranches to be relatively safe products; the arranger banks would normally hold-on to the lowest tranches, the so called 'residual' or 'junior' tranches.

Given these complexities, we focus our attention on just one consequence of the securitization process, the reduction in uncertainty. We do this by having securitizers be risk neutral as opposed to risk averse, allowing us to proxy this aspect of securitization in a tractable way. That is, as they do not have any loss of utility from risk aversion, securitizers will be willing to pay a higher price for loans compared to originators, much like owners of securitized products should do if securitization reduces uncertainty (especially for owners of high tranches).

We can rationalize this approach as being directly equivalent to having a continuum of identical and independent housing markets, and allowing risk-adverse securitizers to purchase a diversified portfolio of each, and having all markets have the same equilibrium outcome of screening or no-screening. In such a case, there is no uncertainty about outcomes for securitizers, so no risk-aversion, and our ex-ante results become ex-post too.

This way of modeling securitization, although tractable, does have limitations. Although we capture to some degree the benefits of securitization due to a reduction in risk and uncertainty, the absence of tranches is a significant omission. It may be possible, through having multiple housing markets, to create tranches in our model, albeit a previous version with just two markets had unreasonable had impracticably difficult dynamics. We surmise that including tranching would not rule our our equilibrium results, even if originators held-on to junior tranches; we conjuncture this would result in higher interest rates/prices to compensate originators such that for small enough risk of loss, originators would be compensated.

Note finally that in our model we do not split up securitizers into the intermediaries that securitize the products and the ultimate holders of the the securitized loans. This should be thought of as a reduced form of the process and simplifies the analysis by not adding an additional agent.

7.4 General equilibrium

We define the profits for Originators conditional on what actions they take, $Y(.)$, as follows. If they screen and only lend to owner-occupiers:

$$Y(Q_j^O, 1, 0, I(j)) = \sum_{i \in I(j)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) X_H(r_i)$$

If they screen and lend to both types:

$$Y(Q_j^O, 1, 1, I(j)) = \{ \sum_{i \in I(j,H)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) X_H(r_i) \} + \{ \sum_{i \in I(j,L)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) E(X_L(r_i)) \}$$

And finally, if they don't screen:

$$Y(Q_j^O, 0, \emptyset, I(j)) = \{ \sum_{i \in I(j,H)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) X_H(r_i) \} + \{ \sum_{i \in I(j,L)} q_{i,j}^O (P^*(r_i) - 1) + (1 - q_{i,j}^O) E(X_L(r_i)) \}$$

The choice of N periods of time may seem arbitrary and it is, to some extent. Our set-up is isomorphic to having 3 periods of time by extending the set of actions taken in period 3 and allowing borrowers choose to fully repay or default on their loans. Consequently, for the purposes of our model, our interest lies, in particular, with periods 1, 2 and 3, where a securitized and non-securitized market might differ; periods 4 and beyond are necessary only because we have loans that are paid out in 2 periods of time and loans may be granted in period 3 need those periods to repay[50].

The entry of new borrowers, which increases the stock of high types, can be interpreted as an increase of demand for housing, and might be endogenized via the mechanisms of Duca, et al. (2011) or Case et al. (2012), among others, for the recent boom. Consequently, our model cannot explain why fundamentals are changing, but may explain why our mechanism can have potent effects on house prices during a boom.

The assumption that mortgage loans are repaid in two, equal sums in is not innocuous, as the higher the first repayment is in the first period, the smaller house prices will deviate from their fundamental value, as the option value of waiting is decreased in proportion to that. Similarly, having repayments happen over only two periods of time and a LTV ratio of 100% both increase how much prices deviate. A richer model would most likely have house price deviate from fundamentals over a longer period of time and by smaller amounts[51].

7.4.1 Housing stock and cohort size

We make specific assumptions about our housing stock and cohort size, unlike B&F. We do so primarily so we can focus our attention on a model where the fundamental

[50]B&F have a similar modeling technique, as even though they have an infinite number of periods, their model experiences no further changes once a sufficient number of periods have passed and either cohorts stop arriving, or the number of high types exceeds the housing stock.

[51]We also surmise that in a more general model, having teaser rates (smaller fixed rates that only last for the beginning of the loan), would lead to greater deviations of prices, as both of which make it cheaper for a borrower to wait.

uncertainty, whether high types will exceed the housing supply, is resolved by period 3.

This is the smallest number of periods where it is possible to illustrate our model mechanism, as we require at least one period where low types can buy, and at least one period where they can become marginal sellers before high types exceed the housing supply.

As we discuss in Section 8.2 of Appendix B, we surmise that our model results would generalize to changes in housing supply and cohort size such that the fundamental uncertainty is resolved for some period greater than 3. The only substantial difference would be that price deviation from fundamentals would not necessarily take place only if securitization happens every period, but more generally, when there is 'sufficient securitization' such that speculators have had access to loans.

7.4.2 Recourse loans

When loans are recourse, we can show that speculator's marginal value of housing is always equal to the fundamental value. A speculator obtaining a loan in period 1 can choose, in period 2, to either sell and repay today, $A_2 - A_1(1+r)$. The can also pay the installment $-A(1+r)/2$ and wait, and with probability q a cohort arrives, so they sell and repay $A_3 - A_1(1+r)/2$, but with probability $(1-q)$ a cohort fails to arrive, in which case they still have to repay their loan installment, $A_1(1+r)/2$. Ergo, as speculators are the marginal sellers in period 2, we have that their value determines house prices, so $A_2 - A_1(1+r) = -A(1+r)/2 + q(A_3 - A_1(1+r)/2) + (1-q)(-A_1(1+r)/2) = qA_3 - A_1(1+r)$, so $A_2 = qA_3$. As can be seen in the math, this holds more generally for any period t.

7.4.3 Loan-to-value ratio

Adding loan-to-value to our base model, as a choice variable for originators results in a trivial equilibrium wherein down-payments are set to 100% and borrowers buy houses outright. The reason for this is that with risk neutrality and no discounting, the payment of interest rates is always negative to utility of both types, so simply letting borrowers buy houses outright would be the trivial equilibrium result.

Instead, if we wish to have a meaningful result with down-payments, we have to restrict incomes of borrowers to y_ρ, such that there a maximum down-payment $\bar{d}$, $y_\rho = \bar{d}A_\rho$ when they arrive.

As we show in the Appendix B, a no-screening equilibrium identical to our main result can now be sustained, but only if loan originators are small and take the prices of houses as given; otherwise we will have a new equilibrium wherein down-payments are set to be as high as possible, $\bar{d}$, and interest rates are set high enough so as to discourage speculators, creating self-selection without the need for screening.

The main reason for this result is the asymmetric effects of (restricted) down-payments for speculators and owner-occupiers. Any positive $d < 1$ means that there is now a range of interest rates where speculators, but not owner-occupiers, do not wish to take-on loans, as defaults are no longer costless. Owner-occupiers will be sufficiently compensated with a high enough d if house prices 'switch' to the fundamental price level when originators deviate, ergo, originators are large enough; if house prices remain at the no-screening level when owner-occupiers contemplate the deviation, then no deviation exists, and we maintain our no-securitization equilibrium with zero down-payments[52].

As such, the extent to which our model results may be true depend on what are the LTV ratios that prevail. Concerning the housing boom and bust of the 2000s, the literature has found that these were very close to 100%. For example, Mayer, Pence, and Sherlund, (2009) find that for securitized assets, "median combined loan-to-value ratio for subprime purchase loans rose from 90 percent in 2003 to 100 percent in 2005", meaning that over 50% of these loans had 100% LTV ratios, and find a similar result for Alt-A mortgages, with LTV ratios increasing from 90% to 95%. Given in the no-speculator equilibrium we described above our model predicts down-payments that are as high as possible, versus the zero down-payments in the no-screening result, this suggests that most likely we were in a equilibrium where speculators were receiving loans.

Finally, although our model predicts that speculators will not accept loans with positive down-payments, if this were to happen then house price growth would depend on the down-payment, as with the higher the down-payment, the smaller the put-option value, so the less house prices deviate from fundamentals. As such, as a precaution, we would wish to include the LTV as a explanatory variable in our regressions as a robustness check, although there would also be concerns about reverse-causality and endogeneity if we had such a measure (for much the same reasons as there are for securitization and subprime loans). At this point, we do not have data that would allow us to include a measure of the average LTV for states or MSAs in the time period which we do our regressions. As a consequence, we acknowledge there our regressions may suffer from omitted variable bias.

7.4.4 Welfare

Note that in all our equilibria, originators never hold-on to speculators loans, thus their risk-aversion portion of utility is never a part of welfare considerations. This means that the difference between the screening and a no-screening equilibria will consist of transfers of wealth between 'de facto' risk-neutral agents. This would suggest

[52]In addition to these results, there are several ways we can maintain a no-screening equilibrium with large originators by departing from our model assumptions. The simplest is if neither interest rates nor the loan-to-value ratio are used as signaling devices to securitizers. In that case, securitizers assume that loans are given out to both speculators and owner-occupiers, i.e., $P_{NSC,.} = P_{L,.} = P_{H,.}$. This means that originators will wish to sell as many loans as possible, as they do not benefit from signalling, so they optimize by setting $d = 0$. Thus, this result is equivalent to a mispricing of securitized assets by the securitization market, which Nam and Oh (2014) among others have found evidence for.

that welfare is the same for both situations, however, in the screening equilibria, there are real costs of screening, which increase the interest rates, lowering overall welfare.

Note that originators and securitizers, due to 'Bertrand-like' competition/free entry always have ex-ante zero utility in both cases, although if price collapse, whoever holds loans will have losses in a no-screening equilibrium. Instead, ex-ante, welfare changes happen between borrowers and no-loan low types. In particular, we have that interest rates on loans are smaller without screening, $C/(1-\gamma) > 1 - /(1-\gamma(1-q))$ due to our no-skimming condition. However, as house prices are also higher, the overall effect is ambiguous for owner-occupiers. But for speculators, who proceed to gain access to loans and can potentially gain from speculation, and no-loan low types, who receive higher prices for their houses, are unambiguously better off in a no-screening equilibrium.

7.5 Empirics

7.5.1 Subprime variable

To obtain our measure of subprime mortgages, we follow the methodology of Mayer and Pence (2008). They find that classifying loans with interest rate spread above 3% in the HMDA dataset provides a measure of subprime that is largely similar to alternative measures, such as using the HUD classification. Our main measure of subprime thus consists of the percentage of all loans destined for house purchases successfully originated that have that interest rate spread, to differentiate it from those originated from subprime specialists, which may otherwise lead to issues with our IV strategy.

7.5.2 Robustness checks

All robustness checks use the same basic regression structure as our main regressions, but vary in the following ways: the start (2005) and end (2007) dates of our regressions are changed (both state); we use an alternate measure (Case-Shiller) of house prices (MSA only); we use an alternate definition ($NonRecKM$) of recourse (state only); we include a measure of the percentage of subprime loans (Subprime) originated for house purchases (both state and MSA); we include a measure of state (Int) interest rates on mortgage loans (state only); we omit California from our sample (both state and MSA); we run our regressions only in coastal or non-coastal states (state only); we run our regressions only in Western or non-Western states (state only); we extend the range of our regressions to start from 1991 until 2004, for which we assume, incorrectly, that securitization is zero prior 2004 (state only); we restrict our sample to the MSAs that were in the top 50% of MSAs with highest percentage of securitization (MSA only); instead of Sec and $Sec \times NonRec$, we use a dummy for the MSAs with the top 50% highest percentages of securitization, also including the related interaction effect with non-recourse ($TopSec$and $TopSec \times NonRec$), both interacted with year dummies (MSA only); we include our measure of securitization done by government sponsored agencies GSE and run with and without its interaction with non-recourse $GSENonRec$ (state only); we include a measure of the loan-to-income ratio LTI (state only); and we use all our additional controls, GSE and interaction, subprime, interest rates and loan-to-income *All* (state only).

We include these for a number of reasons. State interest rates are used as a proxy for financing conditions, but omitted in the main regressions due to concerns about endogeneity. Similarly, including subprime loans is due to concerns that our measure of securitization may be just capturing the effects of subprime loans instead of securitization, with similar concerns about endogeneity. As California is a non-recourse state that experienced particularly high increases in house prices and high levels of securitization, omitting it serves to verify that we are not just capturing the effects of that state. Similarly, by using just coastal or Western states, we try to guarantee that we are not just capturing the effects of securitization in coastal vs inland or Western vs non-Western states. As GSE were responsible for a large amount of securitization at the period, we aim to make sure that we are not capturing their effects with private securitization with and without the interaction with non-recourse.

7.5.3 IV discussion

One way to test the validity of our instrument is to compare the percentage of securitization done in each city by each originator. If we have correctly identified our set of originators as 'originate and securitize' types, then the variation of securitization done in each city should change little. To test for this, for every year and for every originator, we calculate the average securitization level done for each city. We then calculate the standard deviation of each subset for each originator in each year, finding that the average standard deviations for each year are as follows: in 2004, 15.8%; in 2005, 15.5% and in 2006, 21.3%, relatively high numbers.

Furthermore, the evidence for each originator is mixed, and it seems that some, but not all of our originators are satisfying our criteria. Both 'LOAN CENTER OF CALIFORNIA' and 'CHAPEL MORTGAGE' originators have low standard deviation of these frequencies, at less than 1%, and 'COUNTRYWIDE HOME LOANS', 'AEGIS MORTGAGE' and 'FREMONT INVESTMENT & LOAN' have persistently low standard deviations, at less than 15%. On the other hand, 'EAGLE HOME MORTGAGE', 'DELTA FUNDING' and 'FIRST RESIDENTIAL MORTGAGE' all have standard deviations of above 30% in at least one year, suggesting that they may not be satisfying out criteria. These results suggests that further refinement of originators being used as instruments may be required, and it not yet clear whether the issues we raise in the main text are being dealt with appropriately.

8 Appendix B - Proofs

8.1 Partial Equilibrium Proofs

In equilibrium, securitizers expected utility will be equal to zero due to free entry.

Much like with Bertrand competition and the previous proof, if the equilibrium P' were such that $E(U'/\Omega, r) > 0$ for a securitizer, a different securitizer could enter the market offering $P'' > P'$, buy the same loans and increase their payoff. In equilibrium, only a price such that $E(U'/\Omega, r) = 0$ is sustainable.

■

If originators are restricted from selling their loans and are sufficiently risk averse, they screen and only lend to owner-occupiers.

In a screening equilibrium, if a loan is composed of high types the expected utility of holding the loan is $EU^{O,H} = E(X_H) = r_H$ and for low types it is $EU^{O,L} = E(X_L) - aV(X_L) = -aq \times (r_L)^2(1-q) + q[1 - 2a(1-q)\pi] \times r_L - \pi(1-q)[1 + aq\pi]$.

A sufficient condition for loans never be extended to low types is $U^{O,L} \leq 0$ for all r_L, and a sufficient condition for this to hold is if $q[1 - 2a(1-q)\pi] < 0$, which is true if:

$$a > \frac{1}{2(1-q)\pi} = \overline{a}$$

So for $a \geq \overline{a}$, originators only lend to high types in a screening equilibrium (SC)and have expected utility of $EU^{O,SC} = (1-\gamma)r_H - C$.

If originators don't screen (NSC), their utility is:

$$EU^{O,NSC} = \gamma EU^{O,H} + (1-\gamma)EU^{O,L}$$

This implies that their utility in a no-screening equilibrium will be smaller or equal to that in a screening equilibrium, $EU^{O,NSC} \leq EU^{O,SC}$, if and only if:

$$(1-\gamma)EU^{O,H} + \gamma EU^{O,L} \leq (1-\gamma)EU^{O,H} - C \Leftrightarrow U^O_L \leq \frac{-C}{\gamma}$$

This will hold if $\overline{\overline{a}} > \frac{C}{q(1-q)\gamma\pi^2}$[53]. So if $a \geq max\{\overline{\overline{a}}, \overline{a}\}$, where, we have that $EU^{O,NSC} \leq EU^{O,SC}$.

■

If $(1-q)/q > 1$, then a equilibrium where both types receive loans and only speculator loans are sold can be sustained.

With $(1-q)/q > 1$, then $P_L \geq 1$, so speculators will receive loans which are sold. In that case, owner-occupier loans cannot be sold, as either the equilibrium interest rates are the same, in which case not screening dominates, or they are different, in which

[53] This guarantees that the term independent of r in $U^{O,L}$ is less than or equal to zero.

case not screening and setting interest rates equal to the lowest equilibrium interest rate dominates, in both cases due to the real cost of screening.

Thus, the only possible equilibrium is to hold on to originator loans and sell speculators. This can be sustained if speculator loans are the lowest possible (i.e., if $r_L = (1-q)\pi/q$), there exists a r_H such that $EU^O = (1-\gamma)r_H + \gamma(qr_L - (1-q)\pi) - C \geq 0$, which is $r_H = C/(1-\gamma) < \pi < \kappa$, so owner-occupiers accept. Note that as $r_H = C/(1-\gamma) < (1-q)\pi/q = r_L$, there is no way for a originator to deviate not screening and setting $r_H = r_L$, as onwer-occupiers would not accept a higher interest rate.

■

In partial equilibrium when there is no screening, the equilibrium is for loans to be sold by originators.

Take our posited equilibrium actions, that originators to not screen, and offer interest rates of $\overline{r_P} = \frac{\gamma(1-q)\pi}{(1-\gamma)+q\gamma}$ to any borrower who approaches them, for borrowers to approach any originator posting those actions, and for securitizers to pay $P_P^* = 1$ for any loan with interest rate $\overline{r_P}$ and have beliefs that any loan with a different interest rate is composed of low types. First note that our equilibrium price and interest rate make the expected utility of originators and securitizers equal to zero, as is required by the way we model our markets. Also note that from our previous restriction on the value of rates, we must have that $\overline{r_P} \leq \pi$, which is true if $\gamma \leq \frac{1}{2(1-q)}$.

What are the possible actions that a originator could contemplate that would deviate from this equilibrium[54]? They can choose to not screen and offer a interest rate different from the equilibrium interest rate (and choose to hold or sell their loans)($PD1$). They could choose to screen and: not grant loans to high types ($PD2$); not grant loans to low types ($PD3$); grant loans to both and offer a different interest rate to high types (and choose to sell or keep these loans)($PD4$); grant loans to both and offer a different interest rate to low types (and choose to sell or keep these loans)($PD5$); grant loans to both and offer a different interest rates to both types (and choose to sell or keep these loans)($PD6$); grant loans to both at the equilibrium interest rate and choose to not sell either one or both of the loans($PD7$).

If they choose to not screen and offer a different interest rate than the equilibrium interest rate, first note from our previous results, due to risk aversion, they would never wish to hold-on to loans. So if they wished to sell loans, the deviation interest rate they would contemplate could only be lower than the equilibrium interest rate, as otherwise they will not attract any borrowers[55], who are better off at the equilibrium

[54]Note again that we have established the optimal actions of borrowers and securitizers, conditional on the actions of originators and the beliefs of securitizers.

[55]Originators are thus constrained by the actions of the borrowers, as any successful deviation from a equilibrium interest rate must be such that it not only increases the payoff of the originator, but must also increase (at least weakly) the payoff of the borrowers too. This is a somewhat surprising result that comes from the peculiarities of the Bertrand-like competition between originators, and we surmise that it would still hold even if other forms of competition were used instead.

interest rate. But as prices are monotonically decreasing in Ω and increasing in r_ζ, any deviation would result in a loan with a lower interest rate and a higher Ω on the part of securitizers, so the price would be smaller than the one they receive by staying in the equilibrium, ruling out $PD1$.

We now show that it is never optimal for originators to screen and not grant loans to high types. In all versions of our model, high types will never default[56] and originators can always hold-on to any loan granted. As such, originators can always be made better, vis-a-vis screening and denying loans to high types, by granting a loan to a high type and holding on to these loans, as they will have a payoff of at least 0 for each high type[57]. So we need not contemplate this deviation action further and rule out $PD2$. Similarly, their payoff would be smaller by screening and denying loans to low types, as they would have the cost of screening and the same revenue[58], so $PD3$ ruled out.

For all our other possible deviations, note that the from our discussion of $PD1$, the only possible deviation interest rate that originators could offer would necessarily be lower, and as we have demonstrated, that would result in a lower payoff by selling these loans, which means that we can rule out all other possible deviations except $PD7$. For $PD7$, originators might be better off by screening, offering loans to both types at the equilibrium interest rate, holding on to loans made to high types and only selling loans composed of low types, 'skimming the cream'.

However, the resulting expected utility is lower or equal to the expected utility of taking the equilibrium action if:

$\gamma(P_P^* - 1) + (1-\gamma)\overline{r_P} - C \leq P_P^* - 1$, which will hold as long as $\frac{(1-\gamma)\gamma(1-q)}{(1-\gamma)+q\gamma} \leq C$.

So, as long as $\gamma \leq \frac{1}{2(1-q)}$ and $\frac{(1-\gamma)\gamma(1-q)}{(1-\gamma)+q\gamma} \leq C$ holds, we have a unique equilibrium.

■

8.2 General Equilibrium Proofs

The fundamental value of houses is the expected value of houses in period 4.

From our definition of fundamental value, we note that if loans are needed to buy a house, then there is no 'speculative' element, as the consequences of buying a house are fully born by any house buyer, both positive and negative.

In such a case, arriving new types buyers will have an identical valuation to existing low type house sellers, such that if the price that prevails is that of old low type sellers, new low types will be indifferent between buying and selling a house, so, for simplicity, we assume they don't.

[56] This will be shown to be true in the general equilibrium model.

[57] If a loan granted to a high type in a given period is $A > 0$, then high types will repay $A(1 + r_H)$ in total, so originators will have a payoff of Ar_H by holding on to the loan. As $r_H \geq 0$, $Ar_H \geq 0$.

[58] Since the equilibrium price is 1, for every given loan, the revenue originators achieve by selling the loans is simply 0.

As they both value the house at 0, this consists only the value that they might gain from waiting and selling the house in a future period, which is the expected value of house prices in period 4. Finally, for periods 1 and 2, housing supply will exceed the number of new high type buyers arriving, the price that prevails will be that of the marginal seller; in period 3, either a cohort arrives such that high types exceed the number of low seller and the price is equal to the marginal buyer's value, κ, or it does not, so the price will be 0.

■

Under restricted selling, there exists a unique equilibrium such that originators screen and only lend to high types in period 2.

Under Bertrand-like competition, we know that equilibrium interest rates will be such that expected utility of originators is equal to zero. As in the no-screening equilibria there are is no cost of screening and there is the additional revenue from high types, the utility that originators have from lending with the highest possible interest rate is always greater than or equal to the utility they receive if they were to screen and lend to both types. So any condition that satisfies the former, will guarantee the latter.

Noting again that defaults happen with probability q if lending happens to low types[59] and utility is separable between types as there is no risk associated with high types, the expected utility of lending in a no screening equilibrium for originators is

$$EU^O_{P,2} = (1-\gamma)EU^O_{H,2}+\gamma EU^O_{L,2} = -aq(A_2)^2r^2_{P,2}+(1-\gamma(1-q))A_2r_{P,2}-(1-q)[\gamma+aA_2]$$

This is a quadratic function of $r_{P,2}$, with a positive coefficient only in the first order term, so the function only has non-negative values between its roots, if it has any, and it is monotonically decreasing in a. The weakest condition that guarantees that no lending will happen is if a is large enough so that there are no real roots in this equation, the condition that $Aa^2 + a\gamma - \frac{(1-\gamma(1-q))^2}{4q(1-q)A} \geq 0$, which itself is satisfied by setting a larger than the largest positive root, $a \geq \frac{\sqrt{\gamma^2+\frac{(1-\gamma(1-q))^2}{q(1-q)}}-\gamma}{2A} = a'$.

Note here that a is inversely proportional to the value of house prices in this period, risk aversion condition that makes originators wish to screen and deny loans to low types is decreasing in the price of houses. As giving loans to low types can only increase house prices, a sufficient condition comes from setting prices to be the smallest possible value.

So setting A to be the smallest possible value, $A = q^2\kappa$, we guarantee that originators will always be better of by screening and only lending to high types as long as they have $a \geq a'' = \frac{\sqrt{\gamma^2+\frac{(1-\gamma(1-q))^2}{q(1-q)}}-\gamma}{2q^2\kappa}$. ■

Under restricted selling, originators will wish to screen and only lend to high types if $a \geq a''$ in period 1.

[59] That is, they default if no new cohort arrives, and sell houses and repay their loans early if a cohort arrives.

From our previous proof, we need only show that in a no screening equilibrium originators have utility less than or equal to zero to guarantee a unique equilibrium where screening takes place and only high types receive loans. Due to the assumption of $\Psi = 2 - \gamma$, in period 2, if low types received loans in period 1 and bought houses, in period 2 high types will end up buying at least some houses from these new low types, that is, even if they first buy houses from old low types, they will, at least, have to buy a house from one new low type who bought a house in period 1.

If we assume that $\gamma < \frac{1}{2}$, and if high types arriving in period 2 buy first from new low types who bought in period 1, they could buy all houses these low types own, in which case new low types would not default and would proceed to repay their loans. As this happens with probability q, and if a cohort fails to arrive low types would default, this is identical to what happens in period 2, so the condition $a \geq a''$ is a sufficient condition.

If high types do not first acquire their houses from low types who bought in period 1, then a portion of these low types would proceed to only partially repay their loans and may or may not repay them in full in period 3. But, in such a case, this portion of low types are riskier than the the low types who repay in full in period 2, so the risk of lending to low types would be even higher, so the utility that originators would have necessarily less than or equal to the previous case, such that $a \geq a''$ is a sufficient condition for originators to wish to screen and only lend to low types.

■

The two equilibrium when we relax our refinement of no belief switching by securitizers is identical to the screening equilibrium.

Assume that securitizers beliefs changed between periods 1 and 2, such that now, it is possible for a screening equilibrium to happen in period 1 (AE1), followed by a no-screening equilibria in period 2, or vice-versa (AE2).

In AE1, as screening took place in period 1, no low types acquired loans in that period, which means there cannot be any low types with mortgages in period 2 selling houses, ergo, prices cannot deviate from fundamentals in period 2 and, by extension, in period 1. We could make this equilibrium hold by setting beliefs of securitizers analogously to their counterparts in the screening equilibrium in period 1 and the no-screening equilibrium in period 2.

In AE2, under our assumption that $\Psi = 2 - \gamma$, in the first period, the housing supply falls by 1, as both high and low types by houses, leaving the supply of houses equal to $1 - \gamma$. In period 2, arriving high types are of size $1 - \gamma$, so they are exactly equal to the housing stock still owned by old low types. As such, they buy only from old low types and prices cannot deviate from fundamentals. We could sustain this equilibrium in analogous manner to the way we discuss AE1.

Note that in both the above cases, as the risks of low types is lower than in the no-screening equilibrium throughout, as low types will not receive loans in all periods. This implies that our conditions for the no-screening equilibrium will be sufficient for these to hold too.

In a more general model, where the initial housing stock is different from our assumption that $\Psi = 2 - \gamma$, we would find different results. For example, if $1-\gamma) < \Psi' \leq 2-\gamma$ AE1 would have an identical outcome, but in AE2, high types will buy from low types who bought in period 1 and we would have a deviation in house prices.

Similarly, if the size of the housing stock was larger and/or the size of cohorts smaller, such that the point at which high types exceed the housing supply is later than 3, we might also have equilibrium outcomes where securitization takes place in some, but not all periods, and nevertheless arriving low types become marginal sellers before high types exceed the housing stock, again resulting in a deviation from fundamentals.

However, in such scenarios, it would still be necessary for 'sufficient' amounts of securitization to take place for there to be deviations from fundamental price. And the higher the number of periods where securitization takes place, the more likely it is for prices to deviate and, potentially, the larger the deviations[60].

■

The equilibrium cost of the loan in period 2 is always smaller than the price in 3.

When prices deviate from fundamentals, we have that $\tilde{A}_2 = q\kappa + q(1-q)(1+r)/2$, so $A_2(\frac{2-q(1-q)(1+r)}{2}) = \kappa$. So for a speculator to accept a loan in period 2, we must have that $\kappa - \tilde{A}_2(1+r_{NSC}) \geq 0$. Given the equilibrium no-screening interest rates $r_{NSC,2} = 1/(1-\gamma(1-q)$, we can rewrite the above to be $2 \geq 2q + q(1-q) + 2\gamma(1-q)$, so at most, when we have that $\gamma = 0.5$, this will be equal to $1 > 2q - q^2$, which holds for all values of $q < 1$. If house prices are lower, the cost of the loan is smaller, so this must also hold. ■

Securitizers pay $P_{H,2} = \tilde{A}_2(1+\tilde{r}_{H,2})$ for loans they believe to consist of high types and $P_{L,2} = \tilde{A}_2 q(1+\tilde{r}_{L,2})$ for low types.

The expected utility of securitizers for a buying a loan with belief that it has Ω of low types will be $U^S_{\Omega,2} = \tilde{A}_2(1-\Omega)(1+\tilde{r}_{\Omega,2}) + \tilde{A}_2\Omega[q(1+\tilde{r}_{\Omega,2}) + (1-q)\tilde{A}_{3,D}] - P_{\Omega,2}$, where $\tilde{A}_{3,D}$ is the price that prevails if low types default, so that with free entry, $P_{\Omega,2} = \tilde{A}_2(1-\Omega)(1+\tilde{r}_{\Omega,2}) + \tilde{A}_2\Omega[q(1+\tilde{r}_{\Omega,2}) + (1-q)\tilde{A}_3]$. As low types default in period 3 only if a cohort fails to arrive, we will have that $\tilde{A}_3 = 0$[61], so $P_{\Omega,2} = \tilde{A}_2(1-\Omega(1-q))(1+\tilde{r}_{\Omega,2})$.

■

[60] If arriving low types become marginal sellers in more than one period, say two periods, than their put option value will increase their value of waiting in both the last two periods before high types are equal or higher than the housing supply, pushing prices higher in the penultimate period than the pure RE effect.

[61] As we have discussed previously, this is a heavily stylized assumption, in so much that house prices never decline to 0 in real life. We could renormalize this value upwards as in B&F, but choose not to, as, essentially, what we must have is that the risk for buyers of loans of ending up with houses post-defaults, which will happen when house prices fall, is larger than the gains from lending to them if they don't. Any changes would still have to satisfy this in our model.

We must have that $(1+\tilde{r}_{L,2}) \leq \frac{1}{q}$ holds for all values of $\tilde{r}_{L,2}$.

Note that there is a lower bound on the value of house prices whenever a cohort arrive, which is equal to the value houses take when there is no securitization market $A_2 = q\kappa$. House prices cannot be valued by less if cohorts are arriving every period, this is the value old low types have for houses, and they value houses in such a way that is always less than or equal to the value high types, κ, and new old types, which may be higher due to the default option value. Low types won't default in the next period, assuming a new cohort arrives, if and only if $\tilde{A}_3 - \tilde{A}_2(1+r_{L,2}) \geq 0$. We have that $\tilde{A}_3 = \kappa$, so $(1+\tilde{r}_{L,2}) \leq \frac{\kappa}{\tilde{A}_2}$, which implies that the largest possible interest rate that can be charged is when $\tilde{A}_2$ is at its lower bound, $q\kappa$, so $(1+r_{L,2}) \leq \frac{1}{q}$[62].

■

Originators will not wish to 'skim the cream'.

The expected utility of skimming the cream is less than zero if and only if the cost of screening is higher than the benefits of 'skimming, which comes from selling low types and holding on to low types, which is equal to $C > (1-\gamma)\tilde{A}_2\tilde{r}_{P,2} + \gamma\tilde{A}_2[(1-\gamma(1-q))(1+\tilde{r}_{P,2})-1]$. For the equilibrium interest rate $\tilde{r}_{P,2}$, this is equal to $C > \frac{\tilde{A}_2(1-\gamma)\gamma(1-q)}{1-\gamma(1-q)}$. This will hold as long as there exists values of C such that it satisfies this equation and that $C < q\kappa(1-q)(1-\gamma)$ at the same time, which now proceed to show.

Note that as $\tilde{A}_2$ is increasing in γ and for $\gamma < \frac{1}{2}$, so is $\frac{(1-\gamma)\gamma(1-q)}{1-\gamma(1-q)}$, it is sufficient to prove there can exist values of C for the limit value of $\gamma = \frac{1}{2}$. In such case, we must have that $q\kappa(1-q)\frac{1}{2} > \tilde{A}_2\frac{\frac{1}{4}(1-q)}{1-\frac{1}{2}(1-q)}$ which equal to $2q\kappa(1-\frac{1}{2}(1-q)) > \tilde{A}_2$. For $\gamma = \frac{1}{2}$, $\tilde{A}_2 = \kappa\frac{q+q^2}{1+q^2}$, so $2q\kappa(1-\frac{1}{2}(1-q)) > \kappa\frac{q+q^2}{1+q^2}$, which simplifies to $1 > \frac{1}{1+q^2}$, which holds for all real q. Note as $C > \frac{\tilde{A}_2(1-\gamma)\gamma(1-q)}{1-\gamma(1-q)}$ is increasing in $\tilde{A}_2$, as long as $\tilde{A}_1 < \tilde{A}_2$, this condition will hold in period 1 as well. ■

Prices in period 1 and 2 are less than κ.

For our equilibrium values, $\tilde{A}_{P,2} \leq \kappa$ is equal to $\kappa \geq (q\kappa + q^2\kappa\frac{1-q}{2(1-\gamma(1-q))-q(1-q)})\frac{1}{1-\gamma(1-q)}$, which can be rewritten and simplified into $1-\gamma \geq \frac{q^2}{2(1-\gamma(1-q))-q(1-q)}$ and further simplified into $\gamma^2(1-q)-\gamma(1+(1-q)^2)+1-q(1-q)-\frac{q^2}{2} \geq 0$. First note that the zero order term, $1-q(1-q)-\frac{q^2}{2}$ is always greater than zero for $q \in [0,1]$. Then note that $\gamma^2(1-q)-\gamma(1+(1-q)^2)$ has two roots, $\gamma = 0$ and $\gamma = \frac{1}{1-q}+1-q > 1$, such that for $\gamma \in [0,1]$, $\gamma^2(1-q)-\gamma(1+(1-q)^2) \leq 0$, which means that our condition always holds.

Note that as long as $\tilde{A}_1 \leq \tilde{A}_2$, this condition holds for period 1 as well.

■

8.3 Extensions Proofs

We can have risk averse borrowers in general equilibrium.

[62] This holds strictly if we opt to have low types default when $\tilde{A}_3 - \tilde{A}_2(1+r_{L,2}) = 0$.

Like in partial equilibrium, we need to have that the benefits of screening outweigh the costs stemming from risk aversion. This means we have to have:

$q(A_{t+1} - A_t(1+r)) \geq aq(1-q)(A_{t+1} - A_t(1+r))^2$

We focus purely on speculators in period 1. If our results do not hold for speculators in period 2, we could change our housing stock size to be equal to 2, such that in the second period the housing supply be $2(1-\gamma)$, which would guarantee that arriving owner-occupiers in 2 will buy from at least 1 speculator, and the same time, they will not exhaust the housing supply, thus leading to the put option value changing house prices. Thus, the benefits outweigh the costs if

$\frac{1}{(1-q)(A_2 - A_1(1+r))} \geq a$

This holds with our restriction, for originators if

$a'' = \frac{\sqrt{\gamma^2 + \frac{(1-\gamma(1-q))^2}{q(1-q)}} - \gamma}{2q^2\kappa} < \frac{1}{(1-q)(A_2 - A_1(1+r))}$

We test this numerically for our equilibrium values, using double decimal precision for q and γ, and find that this holds for all q greater than $q_m in \in (0.27, 0.41)$, depending on the value of gamma.

■

With restricted incomes and down-payments, a no-screening equilibrium can exist with small enough loan originators, otherwise only owner-occupiers receive loans.

As per our discussion in the Appendix A, we have a trivial result when incomes are unrestricted, wherein the equilibrium is for borrowers to purchase homes with 100% down-payment. We thus focus on the case where there is a restricted income $y_\rho = \bar{d}A_\rho$, and thus a maximum down-payment, $\bar{d}$.

We begin by discussing what happens when originators wish to hold on to loans. For any initial down-payment d, the addition of down-payments mean that there is now reduced uncertainty, so a pooling equilibrium is now:

$$EU^O_{P,.} = -aq((1-d)A_.)^2 r^2_{P,.} + (1-\gamma(1-q)(1-d))A_. r_{P,.} - (1-q)(1-d)[\gamma + aA_.]$$

In the limit of $d = 1$, there is no uncertainty, so our previous results do not hold. But for any $\bar{d}$, we have that they will hold if $(1-\bar{d})Aa^2 + a\gamma - \frac{(1-\gamma(1-q)(1-\bar{d}))^2}{4q(1-q)(1-\bar{d})A} \geq 0$, which itself is satisfied by setting a larger than the largest positive root of this equation, a'''. We use this new restriction, $a > a'''$ for the results below.

We now show that speculators will now not take on loans if the interest rate is too high. Using the result from our previous extension proof, we need only show the conditions under which a speculator from period 1 will not wish to take a loan. Given d, they now take on a loan if $q(A_2 - (1-d)A_1(1+r_1)) - dA_1 \geq 0$.

Given that $A_1 = qA_2$, this will be strictly less than zero iff $1 + r > \frac{1}{q(1-d)}$, thus a originator may be able to deviate from equilibrium by selling loans with a positive d and $1 + r = \frac{1}{q(1-d)}$, knowing that this is a credible deviation and that speculators will take on such loans. In such a case, the price of these loans, where D stands for deviation, will be strictly positive and originators will be able to make positive profits. Originators will compete to attract borrowers by setting the lowest possible interest rate and the highest possible down-payment, i.e., $\bar{d}$ and $1+r = \frac{1}{q(1-\bar{d})}$

From the above results, originators will not wish to hold-on to speculators, and that if $1+r < \frac{1}{q(1-d)}$, speculators will not self-select. Thus, the only possible deviation is the aforementioned one, with $\bar{d}$ and $1+r = \frac{1}{q(1-\bar{d})}$. The only question that remains is whether owner-occupiers will wish to accept these new loans. They will not accept the new loans if the total cost of the new loan is larger, that is, if at the equilibrium value for interest rates

$$(\bar{d} + 1/q)A_D > (\bar{d} + (1-\bar{d})/(1-\gamma(1-q)))A_{NSC}$$

If loan originators are small, such that the contemplated deviation from a no-screening equilibrium remains with house prices at the no-screening equilibrium, we have that $A_D = A_{NSC}$, such that they will not deviate if $1/q > (1-\bar{d})/(1-\gamma(1-q))$. Given that $1/q > 1/(1-\gamma(1-q))$, there can be no $\bar{d} \in (0,1)$ that makes this true. Thus, the no-screening equilibrium is sustainable.

However, if loan originators are large enough to 'influence' house prices in equilibrium, then using our equilibrium results, they will deviate if

$$(\bar{d} + 1/q)(1 - \frac{(1-\bar{d})(1-q)q(1+r_{NSC})}{2}) < (\bar{d} + (1-\bar{d}(1+r_{NSC}))$$

Which we can rewrite as

$$2 + (1-q) - 2/(q(1+r_{NSC})) < \bar{d}(2-q) + \bar{d}^2(1-q)q$$

We verify this numerically and find that it holds, for up to decimal places, for all values of q and γ. Thus this is a possible deviation from the no-screening equilibrium, in which case there can be no equilibrium where speculators receive loans, and the equilibrium will have owner-occupier loans sold to securitizers, with the highest possible d and 'high' interest rates.

■

9 Appendix C - Tables

9.1 Additional tables for boom period

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice
Income	1.027***	1.025***	0.900***	0.881***
	(0.321)	(0.311)	(0.0743)	(0.0684)
Income Growth	-0.00564	-0.00694		
	(0.00909)	(0.00848)		
Unemployment	-0.149**	-0.169***		
	(0.0668)	(0.0619)		
Population	1.839***	1.821***	0.550**	0.524**
	(0.545)	(0.504)	(0.222)	(0.227)
Constant	-173.0**	-169.4**	-46.26**	-41.90**
	(68.80)	(64.48)	(20.56)	(21.08)
Observations	153	153	1,076	1,076
R-squared		0.880		0.821
Number of State/MSA	51	51	359	359
Dataset	State	State	MSA	MSA
Method	RE	FE	RE	FE

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Regressions include controls and year dummies. Annual data from 2004 to 2006.

Table 8: Boom period, main regression control results

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice	(5) HPrice	(6) H Prices
Securitization	0.708	0.957***	1.159**	0.110	0.851***	1.117**
	(0.752)	(0.264)	(0.491)	(0.243)	(0.223)	(0.492)
Securitization×NonRecourse	3.714*	0.596	1.258**	0.360	0.948***	
	(2.052)	(0.411)	(0.545)	(0.242)	(0.360)	
Securitization×NonRecourseKM						1.599**
						(0.602)
Observations	102	204	153	1,076	998	153
R-squared	0.858	0.866	0.880	0.835	0.804	0.883
Number of State/MSA	51	51	51	359	333	51
Dataset	State	State	State	MSA	MSA	State
Method	FE	FE	FE	FE	FE	FE
Change	Start 2005	End 2007	Interest Rates	Subprime	No Cali	Alt Recourse

Robust, clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 Regressions include controls and year dummies. Annual data from 2004 to 2006. NonRecourseKM uses an alternate recourse classification.

Table 9: Boom period, additional robustness checks - 1

VARIABLES	(1) HPrice	(2) H Prices	(3) HPrice	(4) HPrice	(5) HPrice	(6) HPrice	(7) HPrice
Securitization	0.901*	1.251	1.426***	0.374		0.430	3.333***
	(0.470)	(0.890)	(0.205)	(0.320)		(0.610)	(0.425)
Securitization×NonRecourse	0.452	2.428***	0.803	0.574*		0.971*	1.525***
	(0.921)	(0.786)	(0.505)	(0.291)		(0.518)	(0.570)
D2005×TopSecuritization					2.525***		
					(0.682)		
D2006×TopSecuritization					3.835***		
					(1.145)		
D2005×TopSecuritization×NonRecourse					5.036***		
					(1.345)		
D2006×TopSecuritization×NonRecourse					4.936**		
					(2.409)		
Observations	60	111	72	537	1,074	153	816
R-squared	0.773	0.737	0.911	0.843	0.828	0.888	0.949
Number of State/MSA	20	13	24	179	358	51	51
Dataset	MSA	State	State	MSA	MSA	State	State
Method	FE	FE	FE	RE	FE	FE	FE
Change	Case-Shiller	Western	Coastal	Top 50%	Top 50%	Int&Subprime	1991-2006

Robust clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, Regressions include controls and year dummies. Annual data from 2004 to 2006, apart from 1991-2006. 1991-2006 assumes securitization is zero prior to 2004.

Table 10: Boom period, additional robustness checks - 2

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice
Securitization	1.300***	1.194**	1.852***	0.552
	(0.460)	(0.469)	(0.445)	(0.405)
Securitization×NonRecourse	1.421**	1.841***	1.509***	1.386***
	(0.550)	(0.570)	(0.506)	(0.321)
Observations	153	153	153	153
R-squared	0.886	0.892	0.904	0.938
Number of State	51	51	51	51
Dataset	State	State	State	State
Method	FE	FE	FE	FE
Change	GSE	GSE w/ Interaction	LTI	All

Robust clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, Regressions include controls and year dummies. Annual data from 2004 to 2006.

Table 11: Boom period, additional robustness checks - 3

VARIABLES	(1) HPrice	(2) HPrice
TopSecuritization	2.341***	
	(0.569)	
TopSecuritization×NonRecourse	0.870	
	(3.123)	
D2005×TopSecuritization		3.045***
		(0.713)
D2006×TopSecuritization		4.753***
		(1.192)
D2005×TopSecuritization×NonRecourse		0.694
		(3.560)
D2006×TopSecuritization×NonRecourse		0.791
		(5.707)
Observations	837	837
R-squared		0.784
Number of MSA	279	279
Dataset	MSA	MSA
Method	RE	FE

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Regressions include controls and year dummies. Annual data from 2004-2006

Table 12: Non-Western states, robustness checks

9.2 Additional tables for instrumental variable regressions

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice
D2005×Distance	-0.0006	-0.0008	-0.0055**
	(0.0012)	(0.0011)	(0.0022)
D2005×Distance	-0.0017	-0.00199	-0.0076**
	(0.0021)	(0.0020)	(0.0034)
D2005×Distance×NonRecourse	-0.0042*		
	(0.0024)		
D2006×Distance×NonRecourse	-0.0046		
	(0.0038)		
Observations	1,077	792	285
Number of MSA	359	264	95
Dataset	MSA	MSA	MSA
Method	FE	FE	FE
States	All	Recourse	Non-Recourse

Robust, clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Regressions include controls and year dummies as instruments. Annual data from 2004 to 2006.

Table 13: Reduced form regressions for instrument

9.3 Bust period regressions

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice
D2008×PastSecuritization	-0.731	-0.630	-0.617	-0.483
	(0.597)	(0.576)	(0.532)	(0.509)
D2009×PastSecuritization	-1.785**	-1.652**	-1.654**	-1.502**
	(0.850)	(0.786)	(0.771)	(0.708)
D2010×PastSecuritization		-2.158**		-2.021**
		(0.808)		(0.774)
D2008×PastSecuritization×NonRecourse	-1.922*	-1.882*	-1.286	-1.261
	(1.116)	(1.121)	(0.977)	(1.018)
D2009×PastSecuritization×NonRecourse	-2.179**	-2.100**	-1.379	-1.362
	(1.008)	(0.989)	(0.991)	(1.004)
D2010×PastSecuritization×NonRecourse		-1.317		-0.658
		(0.949)		(1.072)
Observations	153	204	153	204
R-squared	0.801	0.831	0.824	0.844
Number of State	51	51	51	51
End	2009	2010	2009	2010
Extra Variable	None	None	PastSubprime	PastSubprime

Robust, clustered standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Regressions include controls and year dummies. Annual data from 2007 to 2009/2010.

Table 14: Bust period, house price regressions

VARIABLES	(1) Defaults	(2) Defaults	(3) Defaults	(4) Defaults
D2008×PastSecuritization	0.204*	0.228*	0.207*	0.211**
	(0.117)	(0.116)	(0.106)	(0.104)
D2009×PastSecuritization	0.692***	0.712***	0.666***	0.660***
	(0.206)	(0.208)	(0.191)	(0.189)
D2010×PastSecuritization		0.593***		0.588***
		(0.205)		(0.199)
D2008×PastSecuritization×NonRecourse	0.0685	0.0913	-0.0142	-0.00267
	(0.176)	(0.159)	(0.179)	(0.171)
D2009×PastSecuritization×NonRecourse	0.0771	0.128	-0.101	-0.0575
	(0.266)	(0.261)	(0.276)	(0.277)
D2010×PastSecuritization×NonRecourse		-0.143		-0.223
		(0.268)		(0.294)
Observations	153	204	153	204
R-squared	0.852	0.847	0.864	0.857
Number of State	51	51	51	51
End	2009	2010	2009	2010
Extra Variable	None	None	PastSubprime	PastSubprime

Robust, clustered standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Regressions include controls and year dummies. Annual data from 2007 to 2009/2010.

Table 15: Bust period, default regressions

9.4 Other tables

Originator	Foundation Date	Headquarter City
NOVASTAR MORTGAGE	1996	Kansas City, MO
FIRST HORIZON HOME LOAN	1995	Memphis, TN
FIRST RESIDENTIAL MORTGAGE	1995	Louisville, KY
GATEWAY FUNDING DIVERSIFIED	1994	Horsham, PA
AEGIS MORTGAGE	1993	Houston, TX
INDYMAC BANCORP	1985	Pasadena, CA
EAGLE HOME MORTGAGE	1986	Bellevue, WA
CHAPEL MORTGAGE	1984	Rancocas, NJ
DELTA FUNDING	1982	Woodbury, NY
MERRILL LYNCH CREDIT	1981	Jacksonville, FL
LONG BEACH MORTGAGE	1980	Orange, CA
COUNTRYWIDE HOME LOANS	1969	Calabasas/Pasadena, CA
SAXON MORTGAGE	1995	Fort Worth, TX
FREMONT INVESTMENT & LOAN	1937	Brea, CA

Table 16: 'Originate and securitize' institutions

10 Appendix D - Other figures

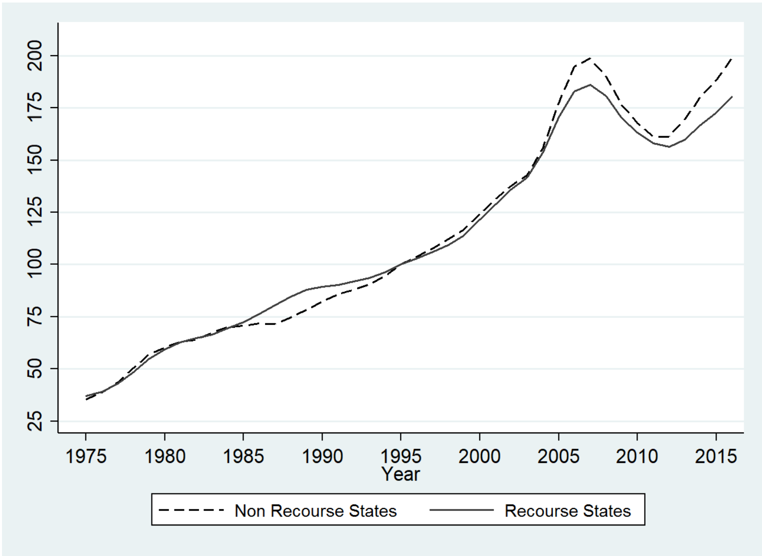

Figure 6: House Prices in recourse and non-recourse states, from 1975