Securitization, Non-Recourse Loans and House Prices

Pedro Franco de Campos Pinto*

Musashi University and Centre for Macroeconomics (LSE)

April, 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. As a consequence, originators stop screening due to the absence of credible signalling to securitizers. This allows speculator borrowers to start receiving loans and, when these loans are non-recourse, there is a put option that pushes up house prices during a demand boom. We thus 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 explain 75% of the difference in prices between recourse and non-recourse states. 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 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 the LSE, RES Easter School, York/Bank of England PhD Workshop, Midwest Macro, TADC, EDP Jamboree, UNLV, Riksbank and Insper 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 done in the period (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, such as CDOs and MBOs, had in affecting prices, which 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 certain laws, can affect house prices, and proceed to test this mechanism empirically, finding some evidence of its effects during the boom period.

We do this by focusing on 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; they provide the framework we use 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

[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 and leads to a deviation from fundamentals.

[3]As we dicuss in the Apendix, there is substantial evidence that speculators/investors were a

them apart. They find that under certain conditions, house prices can be higher than 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 heteregenous when it comes to recourse status[5]. This creates a put option value for speculators, as they can default costlessly should prices fall. When speculators subsequently become marginal sellers, this pushes house prices up. The model 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 new elements: a screening technology that allows originators to screen borrowers at some cost, 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[6]. Our addition of screening and securitization may also help explain why this mechanism may have not played a significant role prior to the existence of securitization[7].

With these two new elements, we find that for housing markets where loans are non-recourse and under some parameter restrictions, there are two possible equilibrium. In one, borrowers are screened and speculators are denied loans, however, counter-factually, 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.

As a consequence, in the absence of securitization, house prices follow fundamentals during a housing boom, but when securitization occurs, speculators access to loans

significant part of house buyers during the 2000s housing boom in the US.

[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 mortgage loans, but Brazil is one important exception, as, according to article 27 of law 9.514, in the category of loans 'alienacao fiduciaria', loans 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.

[6]Elul also 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, one reason why we assume that securitizers cannot screen loans themselves.

[7]Although our data does not allow us to test the extent that this mechanism may have played a role prior to the 2000s.

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.

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. Some evidence for this mechanism can be seen in Figure 1 where house prices in non-recourse states seem to experience higher growth at similar period when private securitization took off, around 2003/2004.

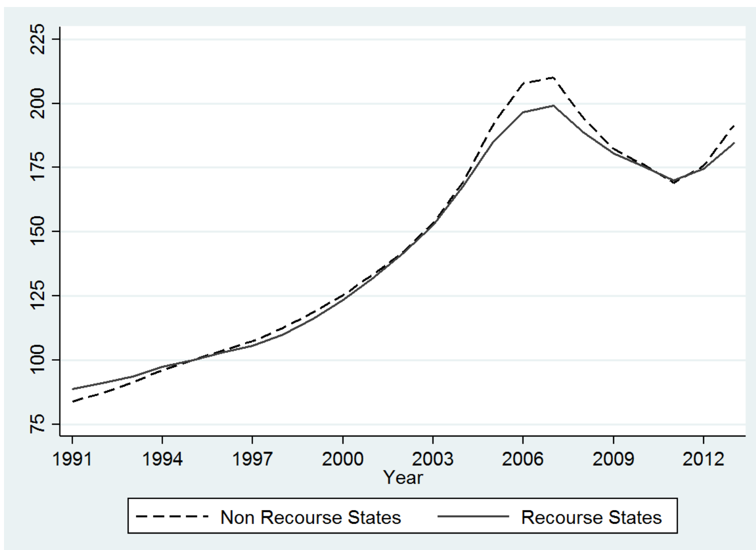

Figure 1: House Prices in recourse and non-recourse states

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 largely survives a number of robustness checks. This interaction between securitization and non-recourse can explain around 75% of the difference in house prices in 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 MSA to the two closest headquarters of 'originate and securitize' mortgage institutions. We find similar results to our main regressions, but we do note that there may be first stage problems with our instrument, particularly in recourse states. We take this as more evidence, although 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, without a housing model, by looking at the effects of recourse laws on house prices during the boom period and 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, all of which conforms to our model's predictions. 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, the initial period being divided into two subperiods. The first of which is when 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). The second subperiod is when 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 assumptions we make for each agent and market of our model setup 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 default. 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/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 $\kappa_i = 0$[8] 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 $r_{i,j}$.

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). 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).

$\Lambda_j = (SC(j), BO(j), \{r(.)\})$ consists of $SC(j)$ a indicator function which takes value 1 if j screens borrowers, $BO(j)$ a indicator function which takes value 1 if loans

[8] 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.

will be given to both types (as opposed to only high types), and, if $SC(j) = 0$, $r^{P,j}$ (for a non-screening Originator, where P stands for pooled), if $SC(j) = BO = 1$, $r^{H,j}$ and $r^{L,j}$, and if $SC(j) = 1$ and $BO = 1$, $r^{H,j}$. 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 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 j_i^B offering the lowest interest rate from set J. They never default or sell. Speculators choose j offering the lowest interest rate from set J', of Originators offering loans to speculators. They default when prices fall, otherwise they do not default and sell the house.*

2.2 Originators

Originators 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. We assume deep pockets for originators, so they can provide any quantity of loans.

Originators will take 2 sets of actions in the model. In the first subperiod, they will post a set of information Λ_j for borrowers about the loans they will provide, and after borrowers approach them, they act according to the information they post; we do not allow deviations from Λ_j; in summary, originators have possible actions, they choose whether to screen or not, and if they screen, to grant loans to both types or just owner-occupiers. In the second subperiod, originators with loans can choose to to sell loans 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 a originator j, the set of information they post Λ_j is only visible to borrowers, not securitizers. As mentioned previously, $\Lambda_j = (SC(j), BO(j), \{r(.)\})$ consisting of whether they will be screening borrowers or not, if they will extend loans to both types or not and either one or two interest rates.

For all $i \in I(j)$, originator j will choose $q_{i,j}^O$, whether they sell loan i or not, $q_{i,j}^O = 1$ indicates a sale. They do so by choosing the highest available price for any given loan, $P^*(r) = \arg\max_{s \in \$} P_{r,s}$[9], where $P_{r,s}$ is the price securitizer s posts for a loan of interest rate r and \$ is the set of securitizers. 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. 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, $X_L(r_{(.)}) = -\pi$[10], 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. We then have that:

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

[9]Securitizers also have deep pockets, so originators can sell all their loans to a single securitizer for the posted price.

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

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

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

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

$$W_j^O(I(j)) = SC_j(1-BO_j)Y(Q^0,1,0,I(j))+SC_jBO_jY(Q^0,1,1,I(j))$$
$$+(1-SC_j)Y(Q^0,0,\emptyset,I(j))$$

Finally, note that the interest rates on loans can be used as signal of loan quality by originators to securitizers[11]. 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

Securitizers in our model consists of risk-neutral agents who buy loans from originators and only care 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. We use risk neutrality as a reduced form for the securitization process, in particular, as the reduction of uncertainty that stems from securitization, see Appendix A for a further discussion.

We assume that any individual securitizer has deep pockets, and that there is free entry into the securitization market. Securitizers' only action will be, for every securitizer s in the market, to post, the price $P_{r,s}$ for which they be will willing to buy a loan of interest rate r. Securitizers cannot condition their purchase of loans to specific originators[12].

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. We assume that securitizers hold common beliefs about loans.

[11] Although this is the only signal we allow between originators and securitizers, in practice other characteristics of a loan, such as loan-to-value ratios/down payment, might also be used as such. A further discussion may be found in the Appendix A.

[12] By doing so, we deliberately wish to avoid the issue of allowing originators to develop reputations, as this is not within the scope of this paper.

As we show ahead, we can focus our attention on a representative securitizer s, whose wealth at the end of period 2 will be:

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

So the strategy set $S_{s,S}$ of securitizer s consists of a set of P_r.

2.4 Definition of an equilibrium

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, with each agent taking other players' actions as given. 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 $S_{s,S}^*$) and a set of beliefs (Ω_s) for for all agents, that is, for all $\forall i$, $\forall j \in J$ and $\forall s \in \$$, such 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:

$$S_{j,O}^* \in \arg\max E(W_j^O(I(j)^*)) - aV(W_j^O(I(j)^*)) - n_j(I(j)^*) * C$$

where their wealth W_j^O is defined above, $I(j)^* \in S_{i,B}^*$.

Securitizers:

$$S_{s,S}^* \in \arg\max E[(W_s^S(Q_j^*))/\Omega\}]$$

where their wealth is defined above and $\{Q_j^*\} \in S_{j,O}^*$.

Securitizers 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^*. This is because the optimal behaviour of the borrowers is fully characterized and originators know what will happen if they change their actions.

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. With free entry, the equilibrium price, conditional on beliefs, will be such that expected utility of securitizers will be equal to zero. A proof of this can be found in Appendix B. For this reason, we use a representative securitizer for this proof.

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 $r \leq \pi$:

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

With free entry, $P_\Omega = 1 + (1 - \Omega)r_\Omega - \Omega[qr_\Omega - (1 - q)\pi]$. 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 for clarity ($P_H = 0$ and $r_H = r_0$). 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, $S^*_{s,S}$, conditional on their beliefs. As we assume that securitizers hold common beliefs, all securitizers will offer the same price for a given belief.

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 monotonically increasing in r.

2.5.1 Preview of results and strategy

We now 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, then present the results for special subcase where originators are not restricted from selling loans.

In a screening equilibrium, if any selling of loans to securitizers were to happen, because the price paid for low type loans is less than the cost of lending, the only loans that could be sold to securitizers would be those consisting of high types. But originators are capable of masquerading low types as high types by offering them high type 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.

In a no-screening equilibrium however, when costs are high enough to stop originators from 'skimming the cream', loans are sold to securitizers and both types 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. That is, the variance term in originator's utility is only applicable due to the uncertainty from house prices, and only speculators' actions are conditional on house prices.

As we show in Appendix B, if originators are sufficiently risk averse, satisfying $a \geq max\{\overline{\overline{a}}, \overline{a}\}$, they will screen borrowers and only lend to owner-occupiers. Furthermore, as originators are competing among each other via Bertrand-like pricing, we have to have that $EU^{O,H} = 0$[13].

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 $\overline{\overline{a}}$ redudant.

Conclusion 2 *If originators are restricted from selling loans to securirizers and we have $a \geq \overline{a}$ and $\frac{C}{(1-\gamma)} \leq \pi$, a unique screening equilibrium exists when there is only high type borrowers receive loans.*

We maintain these parameter assumptions for the partial equilibrium version of our model.

2.6 Screening equilibrium

As previously discussed, we have that borrowers of a type will choose to approach originators with lowest possible interest rates, conditional on receiving a loan, meaning that there *can only be, at most, two values for interest rates on loans that are originated* in equilibrium. This implies that a screening equilibrium, such that both types of borrowers receive loans at different interest rates, can only exist if, in equilibrium, all originators who extend loans to a certain borrower type, do so at the same interest rates.

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, $P_i(r_i) \geq 1$.

[13]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.

We begin by setting $\frac{q}{1-q} < 1$, as we are interested in asymmetry in house price movements which we have in the general equilibrium version of our model. This implies that $P_L < 1$[14].

Originators will not wish to hold on to the loans with $a \geq \overline{a}$ as we discussed in the previous Section. So in a screening equilibrium, if $\Omega = 1$, $P_L < 1$ and as the cost of a loan is 1, no equilibrium can exist where screening takes place and low types receive loans.

We can also rule out a screening equilibrium where loans are extended only to high types and are then sold to securitizers, and low types are denied loans.

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 low types and set $r^{L,j'} = \overline{r^H}$, masking low types as high types. Low types would then choose $j = j'$ and this originator would have higher payoff, as $P_H \geq 0$.

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.

Conclusion 3 *In a screening equilibrium, only high types receive loans and originators do not sell loans to securitizers.*

We can sustain this equilibrium by setting the off the equilibrium path beliefs of securitizers such that any 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.

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'.

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

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)[15] we find there are two equilibrim. 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 loans to the securitization market.

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 low types as high types when selling them to securitizers, which impedes any screening equilibrium wherein loans to low and high types are sold and identified at separate interest rates.

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.

As we set-up our model to have non-recourse loans, we thus far only have predictions for house prices for that is the law, although we wish to compare the outcome when the law is recourse. We do not need to find these results explicitly, however, as within the framework that we work with, when loans are recourse, prices cannot deviate from fundamentals as there is no put option value.

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[16].

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:

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

[16] 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

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

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 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, securitizers seek to maximize

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

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

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

We assume that there exists a fixed[17] 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[18] 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 high types. This is conditional on a cohort having arrived in the last period, so if a cohort does not arrive in period M, no cohorts arrive in $M+1$, $M+2$... Arriving low types, 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 $2(1-\gamma) < \Psi \leq 2-\gamma$[19], 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[20]. 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 the first subperiod, the new cohort arrives (or not) and, after this, buyers with outstanding loans decide whether to default or not. In the second subperiod, new buyers establish conditional

[17]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).

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

[19]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.

[20]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.

prices[21] for houses via a Walrasian auctioneer. In the third subperiod, new buyers approach originators for loans and if they succeed, proceed to buy houses, with new high types moving first in acquiring houses from existing owners[22]. In the forth subperiod, originators can sell loans to securitizers.

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. If cohorts arrive every period, then by period 3, high types outnumber the stock of housing supply permanently; if a cohort fails to arrive before then, then the housing stock will exceed the number of high types also permanently. From this we determine the prevailing price in each circumstance.

In periods 4 and beyond, if cohorts have arrived in all periods, the number of high types exceeds the stock of houses immutably, so the equilibrium price must be equal to the valuation of the marginal buyer, high types borrowers, which is κ[23].

In the second scenario, the housing supply exceeds the number of high types forever, the equilibrium price for houses will be equal to the value of the marginal seller, 0. 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 (and high types) can arrive. 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.

So if a cohort fails to arrive in either periods 1, 2 or 3, the price is equal to 0 from that period onwards. If cohorts arrive in those 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.

Following Allen et al. (1993) and the literature, we define the fundamental value of an asset as being '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'[24].

For the cases discussed above, as there is no 'speculative' element, the price we have established is equal to the fundamental value. For periods 1 to 3, the fundamental value

[21] 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.

[22] Arriving borrowers also buy first from old low types, as their lack of a put option value means they are willing to sell houses for cheaper prices.

[23] If the price was lower, then any high-type 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.

[24] As B&F discuss in greater detail, the price of houses is equivalent to the social value if we were to marginally relax the supply of housing, so prices above the fundamental are a skewed signal for the construction of new houses; such deviations may be deemed as bubble valuations for this reason.

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.

Note that fundamental values follow a boom/bust pattern, should at least one, but not all cohorts arrive before 4. For example, if a cohort arrives in periods 1 and 2, but not 3, prices go from $q^2\kappa$ to $q\kappa$ to 0. This is the consequence of increasing probability, as each period passes, that the final price of houses will be κ, until demand collapses.

3.1.2 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. We need only find the equilibrium actions that prevail in periods 3, 2 and 1 assuming that cohorts have arrived in every such period. For all other cases, we know what the equilibrium actions and prices are. We use analogous results from our partial equilibrium model where applicable.

To facilitate the discussion ahead, note that in every period, a house seller will always decide how much they value a house they own today by comparing the current price with their expected value of waiting for the next period. That is, because speculators value houses at 0, if they choose to not sell today, their only benefit will come from the potential value of waiting and selling it tomorrow.

Period 3 We begin by assuming that in periods 1 and 2, arriving high types, but not low types, have bought houses, which we show will be an equilibrium action. If a new cohort fails to arrive, then high types who bought houses in previous periods will not default as long as the total cost of the loan, $A(1+r)$, 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 high types move first when buying houses, all houses will be purchased by high types. This is because there will be $3(1-\gamma)$ new high types, and the housing stock, $\Psi = 2-\gamma$, is smaller for $\gamma < \frac{1}{2}$.

The new high types thus exhaust the supply of housing, meaning that even if a low type were to receive a loan in period 3, they would never be able to purchase a house. As there is no risk from low types, 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:

$$A_3 = \kappa$$

Period 2 We first establish what will be the equilibrium price that will prevail if only high types receive loans in all periods. The number of high types will be smaller than the number of houses still owed by old low types, so prices will be equal to the value of the marginal seller. This is the expected value that houses may appreciate next period

$$A_2 = q\kappa$$

[25]

Note that if low types receive loans, this would only increase (non-strictly) house prices. 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 high types, as in partial equilibrium. So under $a \geq a''$, no lending to low types takes place and originators will wish to screen out low types. The equilibrium interest rate (due to Bertrand-like competition) 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.

Period 1 We assume the conditions that $a > a''$ and $\gamma < \frac{1}{2}$, such that low types are a minority in every arriving cohort. As we show in the Appendix B, these are sufficient such that low types would not receive loans in either a non-screening or a screening equilibrium. As the number of high types is smaller than the housing stock, equilibrium house prices are determined by the expected value of the marginal sellers, the old 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 low types 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.

[25] That is, as low types have no intrinsic value of owning houses themselves, the only value from sell value of the house, and if they wait, they expect to receive $q\kappa$.

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 periods 1 and 2. The other two possible equilibrium outcomes consists of firstly, no-screening taking place in period 1 and screening takes place in period 2, and, secondly, having the opposite happen.

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[26]. We prove in Appendix B that the other two equilibria produce outcomes in house prices identical to the screening equilibrium, and also discuss how relaxing this refinement of no belief switching would affect our results in a more general model.

Focusing on the no-screening equilbria, 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. Crucially, and unlike the low types who initially own houses, this seller will not wish to sell the house for just $q\kappa$, due to their put option value. Instead, it will be equal to $q\kappa + m$, where m is the outstanding value of the loan after they repay their first installment of the loan, $\frac{\widetilde{A}_1(1+\tilde{r})}{2}$.

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 low types who receive loans will default, as they lack further opportunities to sell.

We now proceed to prove and discuss, period-by-period, the 'pure' screening and no-screening equilibrium. For both cases, in periods 4 and beyond, prices are equal to the fundamental value. I.e., if a cohort has failed to arrive in a preceding period, then prices are 0. Any owner-occupiers who received loans proceed to repay and/or have repaid their loans and any speculators who have yet to fully repay their loans default on them. If cohorts have consistently arrived, the price is at κ, no defaults have happened and owner-occupiers own all of the housing stock.

[26] 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 belief structure as long as cohorts are arriving.

3.2.1 Period 3

As in the partial equilibrium model, securitizers are risk neutral and free entry to the securitization market, such that in equilibrium their utility are equal to zero. 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, then the optimal behaviour of originators is to simply extend loans to any buyer who approaches them. That is only owner-occupiers buy houses and take on loans, by virtue of moving first. 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:

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

If a cohort has arrived, housing supply is exhausted and only high-types receive loans / buy houses, so prices must be, in equilibrium, $\tilde{A}_3 = \kappa$. If a cohort fails to arrive, prices collapse and are equal to 0. In the former case, due to Bertrand-like competition, will have in equilibrium that $\tilde{r}_{H,3} = 0$.

If originators chose to not sell their loans to securitizers, we achieve an identical outcome in prices. We could sustain this as an equilibrium outcome by setting beliefs of securitizers that any loan put on sale consists exclusively of speculators. In such a scenario, as these low types would have wait until the next period to sell their newly acquired houses, the price that securitizers would pay would be less than the equilibrium price. As originators only achieve 0 utility, they would not wish to sell their loans and this belief would be sustained as an off the equilibrium path belief.

3.2.2 Period 2

If a low type borrower receives a loan and buys a house in this period, they will default if a cohort does not arrive (with probability $(1 - q)$). If a new cohort arrives, all period 2 low types immediately sell their house to the new arrivals and repay the loan completely, as $\Psi = 2 - \gamma$. Thus, the prices that securitizers will be willing to pay for loans originating in this period will be similar to those in the exogenous price case and 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 sell low type loans[27]. The price is lower than the cost if $(1+\tilde{r}_{L,2}) \leq \frac{1}{q}$, and in Appendix B, we show that this is true for all values of $\tilde{r}_{L,2}$. As such, we have a similar 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 We apply a similar line of reasoning as in the partial equilibrium model. As the price that a loan believed to consist of low types 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 high types and are then sold to securitizers, with low types denied loans, as originators could once again mask low types as high types. 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. High types are screened and 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 low type who bought a house in period 1 will sell in period 2, and so becomes the marginal seller.

The price of loans is then:

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

[27] $P_{L,2} = \tilde{A}_2$ if low type borrowers choose to default when indifferent between defaulting and selling their loans.

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

As we discuss in the partial equilibrium case, there is only one possible profitable deviation for originators, which would be to 'skim the cream' and screen whilst extending loans to both types. They do this by selling loans extended to low types and holding on to loans to high types. 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 will hold simultaneously with $C < q\kappa(1-q)(1-\gamma)$.

For markets to clear, the price must be greater than or equal to the value that low types who bought houses in period 1 have of those houses, who are marginal sellers. These speculators have 3 possible actions they can take this period: they can default at no cost, they can pay the installment of their mortgage and wait for period 3 or they can sell the house and repay their loan completely. Assuming a cohort arrives, we now proceed to work out the equilibrium value they hold of houses.

The expected returns from waiting are the expected gains of the appreciation of the house next period

$$q[\kappa - \frac{\tilde{A}_1(1+\tilde{r}_{NSC,1})}{2}] + (1-q)\times 0$$

minus the cost of the installment today $\frac{\tilde{A}_1(1+\tilde{r}_{NSC,1})}{2}$. The return from selling the house this period is equal to $\tilde{A}_2 - \tilde{A}_1(1+\tilde{r}_{NSC,1})$. As, in equilibrium, we know they will sell, we have to have that

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

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 $\tilde{A}_2 = q\kappa + \frac{1-q}{2}\tilde{A}_1(1+r_{NSC,1})$. As we see from our results in period 1, this implies that equilibrium prices will be:

$$\tilde{A}_2 = q\kappa + q^2\kappa\frac{1-q}{2(1-\gamma(1-q)) - q(1-q)} > q\kappa^{28}$$

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.

[28]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.

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 low types. 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:

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

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 stpo originators from 'skimming the cream'. Thus originators extend loans to both types, and then sell these loans to securitizers.

As the marginal seller, a low type without a loan, 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

$$\tilde{A}_1 = q^2\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q)) - q(1-q)}$$ [29]

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) 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. Assuming cohorts arrive every period, as high types are the only borrowers to receive loans, house 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

[29] 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.

non-recourse loans, house prices deviate from fundamentals. Assuming cohorts arrive every period, starting from period 1, we have that $\tilde{A}_1 = q^2\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q))-q(1-q)}$, $\tilde{A}_2 = q\kappa + q^2\kappa\frac{1-q}{2(1-\gamma(1-q))-q(1-q)}$, $\tilde{A}_3 = \kappa = \tilde{A}_4 = ... = \tilde{A}_N$. 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. Futhermore, as we discussed in the partial model, we do not need to model the equilibrium outcomes when loans are recourse as within the framework that we work with, recourse loans lack a option value.

Thus the presence of both securitization (allowing speculators to receive loans) and non-recourse laws (creating a put option) has a positive effect on house prices. We show this graphically in Figure 2 by comparing house prices when there is both non-recourse laws and securitization, and a market where at least one is not present, during a boom.

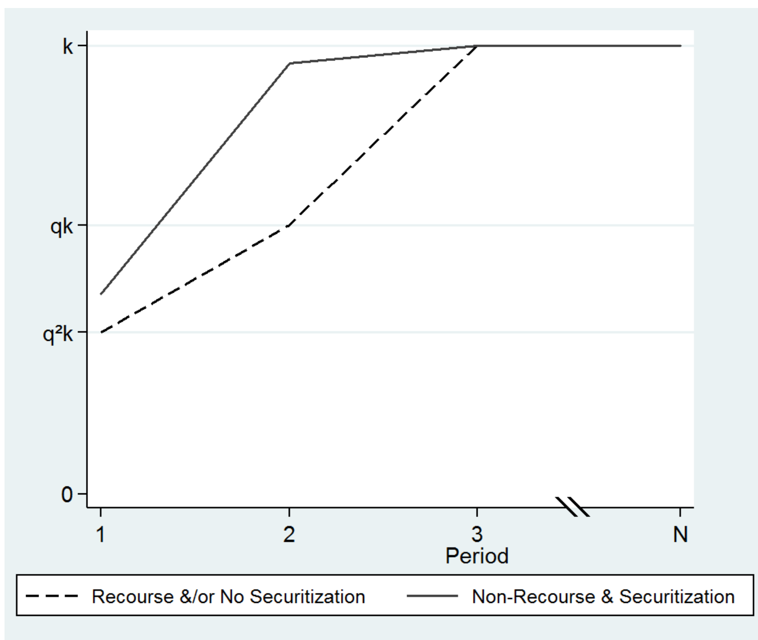

Figure 2: House prices in a sustained boom.

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 a market without securitization 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 3.

This is the core prediction of our model. We would also expect to find that, in

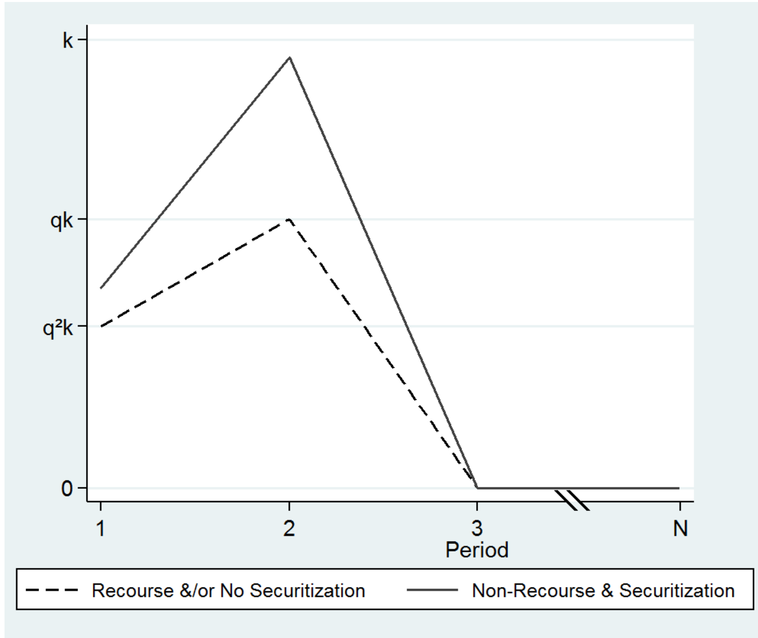

Figure 3: House prices in a boom and bust.

case of a housing bust, defaults are non-zero in the non-recourse and securitization market[30].

Taken literally and with non-recourse loans, 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.

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 is beyond the positive effect that securitization has been found to have empirically by the literature (Keys et. al. (2010), among others), and 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,

[30]Concerning welfare, we surmise that the no-screening equilibrium is ex-ante, welfare increasing, as it leads to reduction in (real) screening costs. This depends on our assumption that securitizers are risk-neutral, whereas we use risk-neutrality as a proxy for the securitization process; thus this will depend on how well this approximation works.

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 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, 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 finance is loose and increase lending supply leads to a general reduction in interest rates and/or higher LTV ratios, we expect this might make it harder for any signalling to happen between originators and securitizers, making it easier for an equilibrium such as ours to come about. 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[31].

[31] "If an institution selling a loan knows or reasonably believes that the loan will be secu-

Our main measure of securitization will be the percentage of loans in this category 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[32]. 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 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, and 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 with which 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 if overlap 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

ritized 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.

[32]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.

al. (2011) classification as the basis for our regressions. We opt to use Mitman (2015) as a robustness check, and find that are 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. For MSA-level data, we use the all-transactions index, as, in spite of its methodological limitations due to greater coverage. 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 of poorer quality, so we use our state-level regressions as a baseline whenever possible. As we use fixed-effects 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, HDMA*
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**
Interest rates	Interest rate on 'conventional loans', FHFA	N/A
Defaults	% of mortgage debt 90+ days delinquent, FRBNY	N/A

*Including non-originated loans.
**In 'RateSpread', following Mayer, Pence and Sherlund (2009).

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;

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

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 as originators might report that loans 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[33], and loans may have been sold to be secutized in a subsequent calendar year. We strongly suspect that the second anda/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%.

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

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 problems 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.

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 recourse's importance is more ambiguous. Pence (2003) summarizes the literature up to that point, noting that the effects of recourse/deficiency judgments on mortgages was ambiguous. They state that "lenders rarely pursue deficiency judgments" 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 judgments are more likely to be pursued.

More recently, Ghent et al. (2011) find 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 homeowners 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 a MSA is contained) is non-recourse, $\gamma_{i,t}$ are the controls, consisting of income (Inc), population[34] (Pop), income growth (IncG) and unemployment (Unemp) for a state i, and just 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. 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, 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 securitization has a coefficient of around 1[35], 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.

[34] As most regressions will have state or MSA fixed-effects, this will guarantee that we are controlling for population density throughout.

[35] 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.

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

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 18 baseline robustness checks (including variations on state/MSA), and each test is described and discussed in detail in Appendix A. As a additional test of our model, we also take our model more literally and assume 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. Alternatively, we create a dummy for MSA above the median value of securitization and use it instead of the actual measure of securitization in otherwise the same specifications as our baseline.

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 our mediam value dummy for securitization. Our other robustness test results are are reported in Appendix C, in Tables 9 and 10 (results for our controls are omitted for brevity's sake).

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

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

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 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 17 robustness checks (excluding the non-Western result) that the interaction term is non-significant.

The coefficient for securitization is only significant in 6 of our 15 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 variable 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.

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 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 $TopSec$ 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 11 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 strongly suggestive 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

5.2 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 could believe that when house prices are growing faster, loans are safer, as prices would have to fall more before the value of a house was below the loan value. I.e., there higher price growth provides 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. 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 is 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)[36]. 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 narrative about the housing boom and bust, such as seen in Lewis (2011), is that certain loan originators were 'originate and sell' institutions. These are institutions that specialized in creating mortgages and selling them to other entities, in particular, so that these loans could be securitized. We seek to identify this subset of originators in our HDMA 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 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 2004, 2005 and 2006 respectively. We proceed to identify 17 of these institutions via their 'RespondentID' codes[37] and discover 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. For example, it is easier for the headquarters to monitor branches, headquarters will more likely have greater 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 15 in Appendix C, all of which were founded at least 8 years before our 2004, which we assume 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[38] 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, $DistW$.

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

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

[38]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 HDMA.

As we discussed above, 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 regressions, we interact both our instruments with year dummies.

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 perhaps not working correctly for all MSAs, but does work in non-recourse MSAs. To deal with this issue, we split our sample into recourse and non-recourse states and run them separately.

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, against our prediction, and the F-statistic, at 7.7, means that the possibility of a weak instrument problem remains. This suggests that are estimates for the effects of securitization on recourse are likely inconsistent and biased. 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. We accede that having 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.

In addition, in Table 12 in Appendix C, we also present the results of the reduced form estimates for our instruments. We find similar results as the first stage regressions, with evidence that our instrument are weak and/or inconsistent 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.

	(1)	(2)	(3)	(4)
VARIABLES	HPrice	HPrice	HPrice	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[39], and find that although not significant, our coefficient for the interaction effect remains positive and in line with our previous result. Given the first stage issues we report, we take these results as further, but not conclusive evidence, for our model mechanisms.

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

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.

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:

$$\begin{aligned} HPrice_{i,t} =& \beta_1 D20XX_t * PastSec_i + \beta_2 D20XX * NonRec_i \\ &+ \beta_3 D20XX * PastSec \times NonRec_i + \gamma_i + \beta_4 D20XX_t + \upsilon_i \end{aligned}$$

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.

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 13 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 cause 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 [40].

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 securitiza-

[40] 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.

tion 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 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 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. 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:

$$MDefault_{i,t} = \beta_1 D20XX * PastSec_i + \beta_2 D20XX * Past \times SecNonRec_i + \gamma_i + \beta_4 D20XX_t + \pi_{i,t}$$

As before, we interact our static variables with year dummies to allow for fixed effects. Our results are found in table 14 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. 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 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[41].

[41]Higher LTV ratios should lead to better self-selection of borrowers, and would also dampen the effects of our mechanism in our model.

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 recent changes[42] by US regulators that relaxed the Dodd-Frank laws may have been counterproductive. The law requires 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.

References

Allen, Franklin, and Douglas Gale. "Bubbles and crises." The Economic Journal 110.460 (2000): 236-255.

Allen, Franklin, and Gary Gorton. "Churning bubbles." The Review of Economic Studies 60.4 (1993): 813-836.

Allen, Franklin, Stephen Morris, and Andrew Postlewaite. "Finite bubbles with short sale constraints and asymmetric information." Journal of Economic Theory 61.2 (1993): 206-229.

Angelides, Phil, and Bill Thomas. "The Financial Crisis Inquiry Report: Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States." Government Printing Office, (2011).

Ashcraft, Adam B., and Til Schuermann. "Understanding the securitization of subprime mortgage credit". No. 318. Now Publishers Inc, (2008).

Barlevy, Gadi. "A leverage-based model of speculative bubbles." No. 2011-07. working paper, Federal Reserve Bank of Chicago, (2011).

Barlevy, Gadi, and Jonas DM Fisher. "Mortgage choices and housing speculation." No. 2010-12. Working Paper, Federal Reserve Bank of Chicago, (2010).

Bayer, Patrick, Kyle Mangum, and James W. Roberts. "Speculative fever: Investor contagion in the housing bubble". No. w22065. National Bureau of Economic Research, (2016).

[42] As reported in "Banks Again Avoid Having Any Skin in the Game ", *New York Times, 23rd of October, 2014*.

Bernanke, Ben S. "Monetary policy and the housing bubble." speech at the annual meeting of the American Economic Association, Atlanta, Georgia. Vol. 3. (2010).

Bhutta, Neil. "The ins and outs of mortgage debt during the housing boom and bust." Journal of Monetary Economics (2015).

Case, Karl E., and Robert J. Shiller. "Is there a bubble in the housing market?." Brookings Papers on Economic Activity 2003.2 (2003).

Case, Karl E., Robert J. Shiller, and Anne Thompson. "What have they been thinking? Home buyer behavior in hot and cold markets." No. w18400. National Bureau of Economic Research, (2012).

Chan, Sewin, Andrew Haughwout, Andrew T. Hayashi, and Wilbert Van der Klaauw. "Determinants of mortgage default and consumer credit use: the effects of foreclosure laws and foreclosure delays." Journal of Money, Credit and Banking 48.2-3 (2016).

Dell'Ariccia, Giovanni, Deniz Igan, and Luc Laeven. "Credit booms and lending standards: Evidence from the subprime mortgage market." Journal of Money, Credit and Banking 44.2-3 (2012): 367-384.

Dobbie, Will and Paul Goldsmith-Pinkham. "Debtor Protections and the Great Recession." Working Paper. (2014)

Duca, John V., John Muellbauer, and Anthony Murphy. "House prices and credit constraints: Making sense of the us experience*." The Economic Journal 121.552 (2011): 533-551.

Elul, Ronel. "Securitization and mortgage default." No. 09-21. Federal Reserve Bank of Philadelphia (2011).

FHFA Office of Inspector General. "FHFA's Oversight of the Enterprises' Efforts to Recover Losses from Foreclosure Sales." AUD-2013-001 (2012).

Fishbein, Allen and Ren Essene. "The Home Mortgage Disclosure Act at Thirty-Five: Past History, Current Issues." MF10-7, August (2010).

Glaeser, Edward L., Joseph Gyourko, and Albert Saiz. "Housing supply and housing bubbles." Journal of Urban Economics 64.2 (2008): 198-217.

Glaeser, Edward L., Joshua D. Gottlieb, and Joseph Gyourko. "Can cheap credit explain the housing boom?." Housing and the Financial Crisis. University of Chicago Press (2013). 301-359.

Ghent, Andra. "Americas mortgage laws in historical perspective." Working paper, pages 140, 2012.

Ghent, Andra C., and Marianna Kudlyak. "Recourse and residential mortgage default: evidence from US states." Review of Financial Studies 24.9 (2011): 3139-3186.

Hall, Robert E., and Charles I. Jones. "Why Do Some Countries Produce So Much More Output Per Worker Than Others?." The Quarterly Journal of Economics 114.1 (1999): 83-116.

Haughwout, Andrew, Donghoon Lee, Joseph S. Tracy, and Wilbert Van der Klaauw. "Real estate investors, the leverage cycle, and the housing market crisis." FRB of New York Staff Report 514 (2011).

Hofmann, Anett. "Rien ne va plus-The 2007/2008 Credit Crunch and what gambling Bankers had to do with it." The Warwick Economics Research Paper Series 892 (2008).

Holmen, Martin, Michael Kirchler, and Daniel Kleinlercher. "Do option-like incentives induce overvaluation? Evidence from experimental asset markets." Journal of Economic Dynamics and Control 40 (2014): 179-194.

Krainer, John, and Elizabeth Laderman. "Mortgage loan securitization and relative loan performance." Journal of Financial Services Research 45.1 (2014): 39-66.

Keys, Benjamin J., Tanmoy K. Mukherjee, Amit Seru, and Vikrant Vig. "Did securitization lead to lax screening? Evidence from subprime loans." Journal of Monetary Economics 56.5 (2009): 700-720.

Lewis, Michael. "The big short: Inside the doomsday machine." WW Norton & Company, (2011).

Mayer, Christopher, Karen Pence, and Shane M. Sherlund. "The rise in mortgage defaults." The Journal of Economic Perspectives 23.1 (2009): 27-50.

Mian, Atif, and Amir Sufi. "The consequences of mortgage credit expansion: Evidence from the US mortgage default crisis." The Quarterly Journal of Economics 124.4 (2009): 1449-1496.

Mian, Atif, and Amir Sufi. "House of Debt: How They (and You) Caused the Great Recession, and How We Can Prevent It from Happening Again." University of Chicago Press (2014).

Mitman, Kurt. "Macroeconomic Effects of Bankruptcy & Foreclosure Policies." PIER Working Paper No. 11-015 (2015). Available at SSRN: http://ssrn.com/abstract=1857517

Obstfeld, Maurice, and Kenneth S. Rogoff. "Global imbalances and the financial crisis: products of common causes." London: Centre for Economic Policy Research (2009).

Nam, Tong Yob, and Seungjoon Oh. "Recourse Mortgage Law and the Housing Bubble." Working Paper (2014).

Pence, Karen M. "Foreclosing on opportunity: State laws and mortgage credit." Review of Economics and Statistics 88.1 (2006): 177-182.

Pennington-Cross, Anthony. "Subprime and prime mortgages: Loss distributions." Office of Federal Housing Enterprise Oversight Working Paper 03-1 (2003).

Piskorski, Tomasz, Amit Seru, and James Witkin. "Asset quality misrepresentation by financial intermediaries: Evidence from RMBS market." No. w18843. National Bureau of Economic Research, (2013).

Westrupp, Victor. "Foreclosure Sales and Recourse." Working paper (2015).

7 Appendix A - Model discussion

7.1 Partial equilibrium

7.1.1 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.[43] In our model, we need not assume such a large number of speculators: a small number of low types is sufficient to generate a bubble, 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.

7.1.2 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 and deep pockets, 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. For analogous reasons, we need not worry about the distribution of securitizers, as long as two of them exist, an equilibrium will be reached where securitizers make zero profits, due to free entry.

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

[43] 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.

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."*[44]

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, another possible characteristic of a loan that might have been used instead, could be, for example, the loan-to-value ratio.

One possible reason why we might rule this out is that the literature has found that the "median combined loan-to-value ratio for subprime purchase loans rose from 90 percent in 2003 to 100 percent in 2005" (Mayer, Pence, and Sherlund, 2009), which suggests that the usefulness of LTV as signaling device at the time period of interest to us was limited.

7.1.3 Securitizers

The rise of private securitization in the late 1990s and 2000s was unprecedented and resulted in an expansion of funds, banks and investors who became exposed to the US housing market[45]. Many of these agents, as discussed by Lewis (2011), had very little understanding of the US housing market, much less of the mortgage loans

[44] *Economist, Nov. 2013.*

[45] Our model and empirics' focus is exclusively on privately held loans, as opposed to those held by Government Sponsored Enterprises (GSE) such as Fannie Mae or Freddie Mac, despite the fact that securitization can be done by these agencies.

We do this primarily for two reasons, firstly because Ghent and Kudlyak (2011) find that loans held by GSEs are unaffected by recourse status of a state, which is might be related to the low recovery rates on defaulted loans by GSEs, which the FHFA (2012) found to be "$4.7 million collected out of $2.1 billion pursued". Thus the basic element of our mechanism, whether loans are recourse, seems to have little to no effect on GSE loans.

The second reason is that GSEs have a long history in the US, and their overall participation rate changed little in the decade preceding the crisis. Furthermore, default rates on GSE loans in 2008 and 2009, 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), which seems to indicate that lending standards did not change as much as those mortgages sold to the private sector.

they held via the CDOs and MBS they owned[46], 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 process is itself quite complex to model, as securitization involves numerous agents and steps[47]. 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. Thus, securitization offers several benefits, as it reduces risk, by diversifying idiosyncratic risk, and allows for different levels of exposure to risk, depending on which tranche an agent purchases.

We opt to have securitizers be risk neutral as a reduced form of what securitization can achieve, as it captures the benefit from the reduction in uncertainty stemming from securitization[48]; we are aware of the limitations of this approach, but we believe if we increased the benefits of securitization, this would work in favour of our model, by relaxing the conditions under which our equilibrium results hold.[49]

7.2 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:

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

Nevertheless, we do not rule out the possibility that sales of originators to GSEs may have affected the market via our mechanism, and we do not exclude the possibility that they may have contributed to the housing bubble, which we believe might require further study.

[46] This lack of knowledge about individual loans is an important characteristic for our model, as we will choose to model the securitization market as one where securitizers cannot distinguish between borrowers.

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

[48] But not the benefits of tranching.

[49] It might be possible to more fully model the securitization market, by adding least two different housing markets and two different tranches of the resulting security; a previous version of the model possessed the former characteristic and achieved perfect diversification of risk, but this, by itself, made dynamics infeasible to model analytically.

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 adding an additional subperiod in period 3, wherein 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. B&F have a similar modeling, 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.

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, and as we have emphasized before, our model cannot explain why fundamentals are changing, but, instead, of why non-recourse structure of loans 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[50].

7.2.1 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 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

[50]We also surmise that in a more general model, increasing LTV ratios and/or 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.

period where they can become marginal sellers before high types exceed the housing supply.

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 deviations from fundamentals would not necessarily take place only if securitization happens every period, but, as we discuss in General Equilibrium portion of Appendix B, but when there is 'sufficient securitization'.

7.3 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); and 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).

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.

8 Appendix B - Proofs

8.1 Partial Equilibrium

In equilibrium, all high types and all low types receive the same interest rate and at most two values for interest rates can exist for loans that are originated.

Assume that an equilibrium exists where loans are being granted to borrowers at 3 or more interest rates values. This means that at least one high type or low type is receiving a loan with an interest different from other borrowers of the same type. Assume to begin with that this is a low type $i = i'$.

As originators make offers that are only conditional on types, if a low type i'' is receiving a loan from a given originator, any other low type $i! = i$ can approach the same originator and receive an identical loan[51].

As such, a profitable deviation exists for at least one low type, as either $r_{i'} < r_{i!=i'}$, in which case the other low types would do better by choosing the originator offering $r_{i'}$, or $r_{i'} > r_{i!=i'}$, in which case i' would do better by choosing a originator offering $r_{i!=i'}$.

By symmetry, the same is true for high types, so only two possible interest rate values may exist for loans that are originated and all types have identical equilibrium interest rates.

■

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 cannot sell 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:

[51] We exclude the possibility that originators can use a randomization strategy on the loans they offer, i.e., an originator is not allowed to choose a strategy wherein, for example, a low type receives a loan with interest r_y with some probability and some other interest rate r_z with complementary probability, although this may happen in real life.

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

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:

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

So if $a \geq max\{\overline{\overline{a}}, \overline{a}\}$, where $\overline{\overline{a}} > \frac{C}{q(1-q)\gamma\pi^2}$[52], we have that $EU^{O,NSC} \leq EU^{O,SC}$.

■

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[53]? 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

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

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

rate they would contemplate could only be lower than the equilibrium interest rate, as otherwise they will not attract any borrowers[54], who are better off at the equilibrium 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[55] 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[56]. So we need not contemplate this deviation action further ahead 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[57], 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

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

[54] 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.

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

[56] 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 $r_H \geq 0$, $Ar_H \geq 0$.

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

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.

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.

■

8.2.1 Proofs when originators are restricted from selling loans

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[58] 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

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

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

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

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

Without securitization, originators will wish to screen and only lend to high types if $a \geq a''$ in period 1.

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.

■

8.2.2 General proofs

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, 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 from fundamentals.

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[59].

■

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 $\tilde{A}_3 = 0$[60], so $P_{\Omega,2} = \tilde{A}_2(1-\Omega(1-q))(1+\tilde{r}_{\Omega,2})$.

[59] 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.

[60] 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 $(1+r_{L,2}) \leq \frac{1}{q}$[61].

■

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.

■

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

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
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 11: 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 12: 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 13: 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 14: 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
LOAN CENTER OF CALIFORNIA	1995	Suisun City, CA
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
FREMONT INVESTMENT & LOAN	1937	Brea, CA

Table 15: 'Originate and securitize' institutions