Securitization, Screening and Housing Bubbles

Pedro Franco de Campos Pinto*

Centre for Macroeconomics, London School of Economics (LSE)

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Abstract

What led to the recent housing boom and bust in the US? We seek to add to the literature in this area by proposing that the substantial increase in securitization of mortgages in the 2000s altered the incentives of loan originators, resulting in a decrease in screening. As a consequence, borrowers with a low value of owning houses started receiving loans, enabling them to buy houses, with the intent of taking advantage of capital gains. When loans are non-recourse and low value borrowers become marginal sellers, we find that a rational housing bubble can develop under boom conditions. We thus predict that, for a given level of securitization of loans, markets with non-recourse laws should have higher house prices during a boom period and should experience greater falls of prices during a associated bust, during which we should also see more defaults in these markets. We test these predictions by using heterogeneity in non-recourse status for mortgage loans in US states and find evidence for our boom prediction, wherein non-recourse status nearly doubles the positive effects of securitization on house prices, but not for our bust predictions. We also find evidence that securitization was important for both house prices and defaults in both periods.

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*Address: London School of Economics, Houghton St, London WC2A 2AE, United Kingdom, e-mail: p.f.pinto@lse.ac.uk. The author is indebted to Kevin Sheedy for his supervision and to Michael Peters, Rachel Ngai, Shengxing Zhang and Paolo Surico for their suggestions, and to the seminar participants at the LSE, RES Easter School and York/Sheffield/MMF/Bank of England PhD Workshop for their helpful comments.

1 Introduction

The rise and fall in house prices experienced in the US during the 2000s was unparalleled in the last 100 years, and several questions arise from this fact. What were the causes for this unprecedented event? And was this boom and bust a bubble, wherein prices deviated from fundamentals? The literature is still grappling with these two important questions, and 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 answer these two questions 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, unsurprising perhaps, as securitization also reached unprecedented levels in the 2000s. We seek to add to this literature by providing a theoretical mechanism by which securitization can affect house prices and test this mechanism empirically.

We do this by considering the possibility of a bubble[1]. We focus on the approach originated in Allen and Gorton (1993), where asymmetries of information and agency problems allow rational bubbles[2] to occur. 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 generates bubbles in asset prices (Holmen, Kirchler and Kleinlercher, 2014). In particular, Barlevy and Fisher (2010), hereafter B&F, use this mechanism to build a model

[1]The issue of identifying and classifying whether an asset class experienced a bubble in given time period a is notoriously tricky, as can be seen in Gürkaynak (2008) and Jones (2014); the very definition of what constitutes a bubble is disputed in the literature. For this recent period, the hypothesis that the US experienced a housing bubble is supported by some research, such as in Coleman, Major and Vandell (2008), Brunnermeier and Julliard (2008) and Mikhed and Zemcík (2009), but the literature has not achieved a consensus and, given the difficulties of this area, is unlikely to do so soon; amongst others, Holly, Pesaran and Yamagata (2010) find that prices were aligned with fundamentals in that period.

[2]Such bubbles happen in the context of an agent-principal problem, wherein there are asymmetric payoffs for a risky investment, where 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 asset and leads to a deviation from the fundamental value.

where rational bubbles are possible in 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) and those who do not (low types) and lenders are unable to tell them apart. They find that under certain conditions, a housing bubble, wherein prices are higher than their fundamental value[3], can arise during a housing boom triggered by an increase in housing demand[4]. This appreciation in prices is mainly due to these loans being non-recourse[5], which is true for some states in the US, creating an option value for low-type sellers who become marginal sellers, pushing house prices up. The model predicts that either demand increases for enough time for a new, permanent high level for house prices to be the equilibrium price, or, if housing demand stops rising before that, prices immediately drop and defaults happen.

We use B&F's framework, but introduce two new elements into their model: 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 lender at that time; 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. 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.

With these two new elements, we find that for markets where loans are non-recourse, when securitization is not available, screening takes place, and when securitization occurs, screening can stop happening[6]. This is due to loan originators being unable to credibly signal to the securitization market whether a loan has been made to a high or a low type[7]. As a consequence, in the absence of securitization, we find that a housing boom does not lead to a housing bubble, because low types do not receive loans, but when securitization exists, low types gain access to loans which, as in B&F, creates a housing bubble. Furthermore, if the change in fundamentals driving the boom stops, house prices fall further and defaults are higher when loans are securitized. If loans are recourse, however, there is never a option value for borrowers, and prices always follow the fundamentals, independently of whether securitization is or is not possible.

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

[4] This is caused by a change in fundamentals, specifically the arrival of more buyers.

[5] That is, of limited liability, where in the case of a default, lenders can only recover the asset securing the loan, and cannot sue to make up any differences in the contract and the current value, usually it's sell price, of said asset.

[6] There are two possible equilibrium, screening equilibrium having identical outcomes to when no securitization is not available.

[7] In part, as consequence of the absence of self-selection by borrowers.

We thus predict that US states that have non-recourse laws for mortgages and experienced higher levels of securitization, that is to say, the interaction effect between these two characteristics, should have higher house prices during the boom period prior to 2007, and should experience a greater fall in prices and higher levels of defaults in the subsequent bust period. We test these three predictions empirically using US state-level data, and find evidence that for a given level of securitization, the positive effect of securitization on house prices was nearly doubled when this state is considered non-recourse.

However, we fail to find evidence that higher levels of securitization in non-recourse states in the boom period resulted in greater drops in prices later, nor do we find evidence that defaults increased due to this interaction effect. We also find evidence that securitization as whole played an important role in determining house prices and defaults. As there is an issue of causality between securitization and house prices, we acknowledge that our estimation procedure of pooled OLS may be inconsistent; however, we take these results to be tentative evidence that our mechanism played a role in the US housing market, and conclude that the it might be wise for regulators to force mortgage originators to have 'skin in the game', that is, to hold on to at least some percentage of any mortgages they create, even in markets where subprime mortgages well regulated or non-existent.

This paper is organized as follows. The next section presents a simple, two period version of the model with static prices to illustrate our basic model mechanism. We then proceed in Section 3 to extend this to a general equilibrium model with endogenous prices. We then 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 static version of the model, the initial period being divided into two subperiods, the first of which is when transactions between borrowers (of both types, high (H) and low (L)) and originators (O) happen and wherein mortgages are created, the second subperiod is when originators can sell mortgages to securitizers (S), if they exist, and/or choose to hold on to them instead. In the second period, a exogenous house price increase/decrease happens and borrowers must decide to whether default or repay.

Houses initially cost 1 in period 1, and in period 2, with probability q, house prices increase to $1 + \tau$, and with probability $(1 - q)$, house price decrease to $1 - \tau$.

We discuss the various assumptions we make for each agent and market of our model setup in Appendix A.

2.1 Borrowers

Borrowers will attempt to buy houses, either for their own personal consumption, or to sell them later, and they can only do so by first acquiring a loan from originators. Borrowers consist of two types, $\zeta \in \{H, L\}$ signifying high and low types, with a distribution of γ low and $(1-\gamma)$ high types. They both have an income of ω, realized in period two, and we assume that ω is large enough to fully cover any level of mortgage repayments. That is, a borrower only defaults, if he wishes to do so, never because of lack of income.

Borrower's utility function is separable between consumption goods and house ownership, $U^B_\zeta = c + \kappa_\zeta$, where c is the consumption in period 2 and κ_ζ is the utility a given borrower receives from owning a house at the end of period 2, if they own one, with $\kappa_H = 1 + \kappa$ and $\kappa_L = 0$.[8] We assume that $\tau \leq \kappa$, the equivalent condition must hold when we endogenize prices.

Borrowers have a total of three actions they can take and that form their strategy set $S_{\zeta,B}$: they decide which originator $j_\zeta \in J$ (where J is the set of Originators) to approach for a loan, whether to default on a loan (D_ζ where $D_\zeta = 0$ means a default), and whether to sell a house (Q_ζ, where $Q_\zeta = 1$ means selling the house).[9]

2.2 Originators

Originators have two separate, but intertwined roles in our model, as they decide whether to extend loans to borrowers and at what rates (r) and they may, if they exist, sell these loans to securitizers.

We assume that originators are risk averse, with the following utility function, $U^O_j = E(W^O_j) - aV(W^O_j) - C$, where W^O_j 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 and C is the cost of screening (if incurred) per individual they screen. Note that we assume deep pockets for originators, so they can provide any quantity of loans.

All loans will be of size 1 with total repayment in period 2 equal to $1 + r$[10]. As we only have one repayment period, any default is for 100% of the loan.

The first action taken in the model is done by originators. They will choose to either post one or two interest rates, the latter case providing them with the possibility of offering loans at different interest rates to different borrower types, otherwise they can only offer one interest rate.

After this, they post a Λ_j set of information, which is only visible to borrowers, not securitizers, and which contains either one ($r_{P,j}$) or two interest rates ($r_{H,j}$, $r_{L,j}$),

[8]Although assuming that low-types derive zero utility from owning a house may seem extreme, we could re-normalize this without loss of generality.

[9]As we explain further ahead, borrowers are always at least weakly better off buying a house.

[10]We restrict our interest rates to be positive for all cases and models.

and whether they'll be extending a loan or not to low types, and whether they'll be screening borrowers or not[11].

Borrowers then choose which originator to approach and deal with. Every originator who is approached proceeds to do the actions they posted in Λ_j, by first either screening borrowers or not, then denying loans to low types or not, and finally extending loans to all eligible borrowers, either at the same interest rate if they choose a single one, or at $r_{L,j}$ for all low types and $r_{H,j}$ for all high types. An originator who chooses not to screen will have to hold beliefs about the type of borrower that they are lending to, which we denote by Γ, equal to the probability that a borrower is a low type for every loan they've extended.

When the securitization market is available, originators will then choose for each loan they've created, whether to put it up for sale or not. After which, they finally choose which of the posted prices by securitizers they will accept for their loans. That is, they choose for what posted price $P_{q,s}$, where s denotes a particular securitizer and q indicates that a loan was chosen to put on sale, they will sell any loan of interest rate $r_{q,j}$.

Their wealth at the end of period 2, W_j^o, depends on whether the securitization market exists or not. When securitization is not available, their wealth will be the realized value on non-defaulted loans plus the value of houses for which loans were defaulted. When securitization is available, their wealth will be equal to the sum of the values defined previously, plus the value they receive from selling their loans to the securitization market.

Finally, note that the interest rates on loans can be used as signal of loan quality by originators to securitizers[12]. So the strategy set of a originator j, $S_{j,O}$, consists of choosing to either post one or two interest rates, and conditional on that, posting Λ_j, of choosing whether to sell a loan or not, $Q_{\cdot,j}$, and which of the available prices they wish to sell their loans for, $P_{q,s}$.

2.3 Securitizers

Securitizers in our model consists of risk-neutral lenders who buy loans from originators and only care about their expected wealth at the end of period 2, $U^S = E(W_s^S)$, where W_s^S is the wealth they hold at the end of period two[13].

We again 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 who enters the market, to post, for every loan of interest rate $r_{q,\cdot}$ that

[11] Although we restrict originators to screening if they choose to deny loans to low types for consistency, they can choose to screen and give loans to low types.

[12] 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/downpayment, might also be used as such. A further discussion may be found in the Appendix

[13] Risk neutrality is as a reduced form of the securitization process, see the Appendix for further details.

is put on sale, the price $P_{q,s}$ for which they will willing to buy that loan. That is to say, securitizers cannot condition sales to specific originators[14], they must be willing to transact with any originator selling a loan at the price they have stated. Due to asymmetry of information, the price securitizers are willing to pay depends on their beliefs, denoted by $\Omega(\ r_{q,.})$ which is the probability that a loan of a given interest rate $r_{q,.}$ is of a low type.

The wealth they will hold at the end of period 2 will be the realized value on non-defaulted loans plus the value of houses for which loans were defaulted, for all loans they acquired, minus the cost of these loans, which is the the sum of the price paid for every loan they bought from originators.

So the strategy set $S_{s,S}$ of a securitizer s consists of a set of $P_{q,s}$ for all posted $r_{q,.}$.

2.4 Definition of an equilibrium

We can 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, taking and each agent takes 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 ($S^*_{\zeta,B}$, $S^*_{j,O}$ and $S^*_{s,S}$) and a set of beliefs (Γ_j, Ω_s) for for all agents, that is, for all $\forall\zeta = (H, L)$, $\forall j \in J$ and $\forall s \in S$, such that:

Borrowers:

$S^*_\zeta \in \arg\max E[c + \kappa_\zeta]$

$s.t.\ c + D_\zeta(1 + r_{.,,j}) \leq \omega + Q_\zeta(\tau - r_{.,j})$ if they receive a loan or $c = \omega$ if they don't.

Originators:

$S^*_{j,O} \in \arg\max E[E(W^O_j)\ + aV(W^O_j)/\Gamma_j, j^*_\zeta] - n_jC$

where their wealth W^O_j is defined above and $j^*_\zeta \in S^*_{\zeta,B}$.

Securitizers:

$S^*_{s,S} \in \arg\max E[(W^S_s)/\Omega_s, \{r^*_{q,.}\}]$

where their wealth is defined above W^S_s and $\{r^*_{q,.}\} \in S^*_{j,O}$ and q indicates that a loan was put on sale.

Their beliefs must satisfy:

$\Gamma(\zeta/j^*_\zeta) = p(\zeta)j^*_\zeta/(\sum\limits_{\zeta=L,H} p(\zeta)j^*_\zeta)$

$\Omega(\zeta/r^*_{q,.}) = p(\zeta)r^*_{q,.}/(\sum\limits_{\zeta=L,H} p(\zeta)r^*_{q,.})$

In other words, two signalling games, played out in succession. The first signal comes from the action undertaken by each borrower, as they decide which originator they wish to approach, j_ζ, based on this, originators that don't screen form beliefs about the probability that a borrower is a low type. The second one comes from the posted interest rates of any loan that's put on sale on the securitization market,

[14]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.

$r_{q,\cdot}$, from which securitizers form beliefs about the probability that all loans with that specific interest rate has been extended to a low type.

To find our equilibrium, we first proceed to work out the optimal actions of borrowers. We then find the equilibrium actions if securitization does not exist. We then find the equilibrium actions with the securitization market.

2.4.1 Borrowers' optimal behaviour

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. High types will derive utility from owning the house for it's own sake, and low types will simply wait and see if they can make capital gains. As a consequence, high types will simply choose the lowest interest rate posted (either $r_{P,j}$ or $r_{H,j}$), and low types will, conditional on a originator posting a Λ_j where they receive a loan, do the same (either $r_{P,j}$ or $r_{L,j}$)[15].

We can thus establish when borrowers wish to default and create random variables indicating the returns for lending to each type. To keep our notation simple, henceforth let r_h designate the interest rate paid by a high type loan, and r_l the interest rate paid by a low type loan.

High types never wish to sell the house as $\tau \leq \kappa$. As long as $r_h \leq \kappa$, they never wish to default in the second period and, as $\tau \leq \kappa < r_h$, if $r_h > \kappa$, they default on the loans in period 2, irrespective of what happens to house prices.

For low types, if house prices decrease, their best action (weakly if $r_l = 0$) is to default; if house prices increase, their best action depends on whether $\tau \geq r_l$ or not. If $\tau \geq r_l$, they can make a profit by selling the house and do so; otherwise their best action is to default.

The equilibria that result from having $r_h > \tau$ and $r_l > \tau$ are thus not of interest to us, since originators would never wish to extend loans to high types or low types respectively. We thus restrict our attention to equilibria that result from $r_h, r_l \leq \tau$.

Under that restriction, the set of optimal actions for borrowers, $S^*_{\zeta,B}$, is to first choose the originator that satisfies the criterion described above. High types will never choose to sell, low-types default for a drop in house prices, and choose to sell otherwise. This is very similar to the set of actions they will take in the general equilibrium model.

In case of default, whoever is holding on to the mortgage contract immediately sells the house they've repossessed and immediately realizes the gains or losses stemming from changes in house prices (i.e., $\pm\tau$). With this, we establish the returns from any loan.

Let $X_\zeta(r_\zeta)$ be a random variable that indicates the rate of return from a loan to type ζ (i.e., excluding the principal of 1). For high types, $X_H(r_h) = r_h$ and for low types $X_L(r_h) = r_h$, with probability q and $-\tau$, with probability $(1-q)$.

[15] As borrowers will always accept the best loan offered to them, it is up to originators to screen them out.

2.5 Equilibrium without securitizers

We begin by showing that if originators are sufficiently risk adverse, we have a separating equilibrium, where originators screen borrowers and only lend to high types.

As there is no uncertainty on what happens with high-types, utility is separable between borrower types. In a separating equilibrium, the utility originators gain from lending to high types is $U^{O,H} = E(X_H) = r_H$ and for low types, originators' utility will be $U^{O,L} = E(X_L) - aV(X_L) = -aq \times (r_L)^2(1-q) + q[1-2a(1-q)\tau] \times r_L - \tau(1-q)[1+aq\tau]$.

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

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

If originators don't screen, their utility will be $EU^{O,P} = \gamma EU^{O,H} + (1-\gamma)EU^{O,L}$.

Their utility in a pooling equilibrium will be smaller or equal to that in a screening equilibrium, $EU^{O,P} \leq EU^{O,SC}$ if and only if:

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

So there exists $\overline{\overline{a}} = \overline{a} + \frac{C}{\gamma}$, such that for all $a \geq \overline{\overline{a}}$, we have that $EU^{O,P} \leq EU^{O,SC}$.

As such, if they are sufficiently risk adverse, originators will want to pay the cost to distinguish between types and will only extend loans to high types after doing so. Furthermore, as originators are competing among each other via Bertrand-like pricing, we have to have that $U^O_H = 0$[16], so that the equilibrium interest rate will be $r_H = \frac{C}{(1-\gamma)}$. Note that this requires that $\frac{C}{(1-\gamma)} \leq \tau$.

2.6 Equilibrium with securitizers

2.6.1 Securitizers' optimal behaviour

For both our models, we restrict the signal that can be sent between originators and securitizers to the interest rate in a loan; this is the only information securitizers can use to try to infer the quality of a loan. 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., $P_\Omega = f(\Omega, r_\zeta)$. 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[17].

We can establish what is the utility of securitizers for each of the following loans and establish necessary conditions on the prices. Let the belief structure of securitizers

[16] If the equilibrium interest rate r' was such that $U' > 0$ for a originator making loans, a different originator could offer $r'' < r'$ and attract those borrowers instead, increasing their profits. As such, in equilibrium, interest rates must be such that their utility is zero.

[17] Much like with Bertrand competition, if the equilibrium P' were such that $E(U'/\Omega, r_\zeta) > 0$ for a securitizer, a different securitizer could enter the market offering $P'' > P'$, buy the same loans and increase their payoff.

be such that any given loan of interest rate r_ζ has probability $\Omega(r_\zeta)$ of being of a low type, noting again that we restrict ourselves to $r \leq \tau$:

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

With free entry, $P_\Omega = 1 + (1-\Omega)r_\Omega - \Omega[qr_\Omega - (1-q)\tau]$. In particular, if $\Omega = 0$, a belief that a loan is to a of high type, then, with free entry, $P^*_H = 1 + r_H$, and if $\Omega = 1$, a belief that loans consists only of low types, then with free entry, $P^*_L = 1 + qr_L - (1-q)\tau$. So we now have the optimal set of actions (the free entry prices) of securitizers, $S^*_{s,S}$, conditional on their beliefs[18]. Note that, $P_H \geq P_L$ for the same interest rate levels and the price paid is monotonically decreasing in Ω and monotonically increasing in r_Ω.

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.

In a screening/separating 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 loans, so none are sold, and a separating equilibrium then resembles the one without securitizers.

A pooling equilibrium however, where costs are high enough to stop originators from 'skimming the cream', allows for loans to be sold to securitizers.

2.6.2 Separating/screening equilibrium

From our previous results, we have that borrowers of a type will choose to approach originators with lowest possible interest rates, conditional on receiving a loan, this means that there can only be, at most, two values for interest rates on loans that are originated in equilibrium. A proof for this is found in Appendix B. This means that a separating 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.

Consider the utility that originators gain from selling a contract versus what he gains from holding on to one. If a originator creates a loan with interest rate r_i, loaning an amount of 1, and sells it off, their utility will be $U^O(r_\zeta) = P_\zeta(r_\zeta) - 1$, so originators will want to sell only if, for any given loan with interest rate r_ζ, $P_\zeta(r_\zeta) \geq 1$.

We begin by setting $\frac{q}{1-q} < 1$[19], as the symmetry in house price movements that we have in our partial equilibrium model will not exist in the general equilibrium model,

[18] That is, conditional on beliefs, and we assume that securitizers hold common beliefs, it's not possible for securitizers to deviate to a higher price (as per our previous discussion) and a lower price would lead to negative utility.

[19] Note that the previous restriction that $a \geq \overline{\overline{a}}$ may become redundant under this assumption, as $\overline{\overline{a}}$ may become negative.

which implies that $P_L < 1$[20]. So in separating/screening equilibria, if securitizers believes that a loan is from a low type[21], they are never willing to pay more than the value of the loan itself, 1, so no equilibrium can exist where screening takes place and low types receive loans, as either originators would have to hold on to the loans, which we've excluded from happening due to risk aversion, or they would have to sell these loans, and the price would be lower than the cost of the loan.

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 interest rates $(\overline{r_L}, \overline{r_H})$ are different, which means a originator could profitably deviate by posting a Λ' where they offer to grant loans to low types and set $r_L = \overline{r_H}$, masking low types as high types. Low types will choose to approach the originator who deviates (the only one who grants a loan) and this originator would have higher payoff, as $P_H \geq 0$. And if $\overline{r_L} = \overline{r_H}$, then the equilibrium would not be sustained as not screening would strictly dominate screening for originators.

So no separating/screening equilibrium can exist where loans are sold and the equilibrium outcome is the same as when there is no securitizer market. That is to say, originators screen borrowers and only extend loans to high types at interest rate $\overline{r_H} = \frac{C}{(1-\gamma)}$, and they hold-on to these loans, and borrowers approach any originator offering this package. We sustain this equilibrium by setting beliefs of securitizers such that any loan put on sale is a low type loan ($\Omega = 1$) for any interest rate, as this will mean that the price for any loan put on sale will be less than 1, so no originator would want to deviate and sell a loan, making these beliefs consistent, as they are off the equilibrium path beliefs.

2.6.3 Pooling equilibrium

If the cost of screening is not incurred, then originators would never want to extend loans to simply hold-on to them due to risk aversion, as we discussed previously. As such, if there's no screening taking place, a equilibrium can only exist if originators sell loans to securitizers.

We find that the equilibrium actions will be for originators to not screen, and offer interest rates of $\overline{r_P} = \frac{\gamma(1-q)\tau}{(1-\gamma)+q\gamma}$ 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 loans with an interest rate of $\overline{r_P}$ (such that they believe that the loan is composed of γ low types) and have beliefs that any loan with a different interest rate is composed of low types.

This will hold under two conditions, 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

[20] As even under the highest possible interest rate that can be charged, $r_L = \tau$, $P_L = (2q-1)\tau < 1$ for $\frac{q}{1-q} < 1$.

[21] In a PBE, securitizers beliefs must be consistent with the actions taken by originators, so their beliefs would have to coincide with the actual compositions of loans.

'skim the cream'. A proof for our results is shown in the Appendix.

2.7 Summary and discussion

Under the conditions that $a > \overline{\overline{a}}$ (sufficient risk aversion), $\frac{q}{1-q} < 1$ (low-types present a bad risk), $\frac{C}{(1-\gamma)} \leq \tau$ (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)[22], we find that in the absence of a securitization market, originators screen borrowers and only grant loans to high type borrowers, but once a securitization market is introduced, two possible equilibrium outcomes may result, one which is identical to the no-securitization market (as no loans are sold by originators), and one where originators stop screening, thus allowing both types to have access to loans, and sell loans to the securitization market.

So for this version of the model, we find that in the second period, when prices fall, in the absence of securitizers in the model, no defaults will happen, but when the securitization market exists, in the equilibrium where loans are sold to securitizers, defaults will happen; this parallels what we find in our general equilibrium model.

This result illustrates the basic mechanism that will drive our results in the general equilibrium set-up. Much like in this case, 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 separating equilibrium wherein loans to low and high types are sold and identified at separate interest rates, resulting in originators no longer screening and low types receiving loans.

As we discuss further below, we believe that the equilibrium we find in our model when there is no securitization may describe the state of the world before the securitization boom of the 2000s, whereas the equilibrium where no screening takes place and loans are sold to securitizers may delineate how the market started operating once securitization increased.

However, the predictions of our model depend crucially on loans being non-recourse, which means that they can only describe the outcome in markets where the law for mortgage loans is as such. In the case of the US, this is true for only some states, but not all. We do not, however, need to model the equilibrium outcomes when loans are recourse to be able to compare these states, as when loans are recourse, prices cannot deviate from fundamentals; there is no option value when mortgage law is recourse and prices must be equal to their fundamental value.

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

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[23]. We assume the same settings for this model as in our partial equilibrium model, unless noted, and a discussion of our model choices may be found in Appendix A.

The model is of finite duration and finishes at period 5[24]. House owners, prospective or otherwise, remain divided into two types, with similar utility functions to their previous ones, $U_\zeta^\rho = \sum_{t=\rho+1}^{5}(c_t) + \kappa_\zeta$, where ρ corresponds to the period they arrive, ζ their type, and κ_ζ the utility they get from owning a house at the end of period 5, with $\kappa_H = \kappa$ and $\kappa_L = 0$.

We assume that there exists a housing stock at $t = 1$ such that Ψ of houses are owned by low types and that all current high types own houses, this supply of housing being fixed[25]. To simplify our analyses, we assume there does not exist a renters market for this housing market[26] 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, conditional on a cohort having arrived in the last one[27], with $(1-\gamma)$ of them being high types. As such, new low types, much like before, will wish to buy houses with the intent of reselling them in the future to new high types, as they have no other value of owning a house otherwise and will default on loans if they no longer have such a opportunity due to the failure of a new cohort arriving.

We have two necessary conditions on the housing stock, that $2(1-\gamma) < \Psi \leq 2-\gamma$[28], and for analitical convienience, we assume that $\Psi = 2-\gamma$. The loan structure is is such that loan repayments occur over a two periods of time, such that for a loan originated in t, half of the total loan payment of $A_{i,t}(1+r_{i,t})$, where $A_{i,t}$ is the price for a house bought in period t in equilibrium i and $r_{i,t}$ is the interest rate, 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

[23]For this model, we use the term buyers and borrowers interchangeably.

[24]We could make our model have an infinite-horizon as in B&F, but this would not change our results significantly.

[25]As is discussed in B&F, we could 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 Glaeser, Gyourko, and Saiz (2008).

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

[27]I.e., if a cohort fails to arrive at period 2, no new buyers will arrive in 3, 4 or 5.

[28]The first guarantees that the housing stock is smaller 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.

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[29] and their income is such that they can always cover their loan payments in every period. Borrowers can make an early repayment of loans without 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 prices[30] for houses via a Walrasian auctioneer; in the third subperiod, new buyers can then approach originators to try to acquire a loan to buy a house, if they succeed, they proceed to buy houses[31] from old types[32] with new high types moving first in acquiring houses from existing owners[33]; and in the forth sub-period, originators can sell loans to securitizers, if the securitization market exists.

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; if a cohort fails to arrive before then, then the housing stock will exceed the number of high types. In both situations, will can determine what the equilibrium price must prevail.

In periods 4 and 5, if cohorts have arrived in all periods, such that the number of high types exceeds the number of houses owned by low types, the equilibrium price must be equal to the valuation of the marginal buyer, κ, the value of high types[34]. 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.

If instead, the housing supply exceed the number of high types, the equilibrium price for houses will be equal to 0, the value of the marginal seller. First note that there's no chance of being able to re-sell the house in the future for a greater price, as no new cohorts can arrive. If the equilibrium price was some $A' > 0$, then any low

[29]This is not necessary in a model with more lengthy loan payment schedules, as it is then more easily possible to have the price of houses always be above the income of buyers, making it necessary to acquire loans to buy a house.

[30]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.

[31]If they fail, no costs are incurred by any party.

[32]A low type who sells a house and has an outstanding loan will then proceed to repay the loan early to the originator.

[33]This allows us to more easily establish how the relative housing supply decreases compared to the number of high types entering the market at each period.

[34]As we establish below, in all cases, high types receive loans.

type seller who isn't 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 must equal to 0 from that period onwards, if not, then the price will be equal to κ for periods 4 and 5. In particular, as there is never any uncertainty for periods 4 and 5, the price must either be κ or 0, as either enough cohorts have arrived or not.

Following Allen et al. (1993), we define the fundamental value of an asset as being 'Value of an asset in normal use as opposed to (...) as speculative instrument'[35]. As in B&F, this is equivalent to the value if we could marginally relax the supply of housing. For the cases discussed above, as there is no 'speculative' element, the price we've established is equal to the fundamental value. For periods 1 to 3, the fundamental value is equal to the expected price at that time period for what the price should be from period 4 onwards, as this is the value of a house if buyers could buy houses outright, without loans. See Appendix B for a proof. So in period 3, the fundamental value after the arrival of new cohort is equal to κ, in 2 the value is $q\kappa$ and in 1, it's $q^2\kappa$. As we will demonstrate below, this will be equal to the price that prevails without a securitization market.

Although fundamental values do behave in boom/bust manner, should at least one, but not all cohorts arrive before 4, this is a reflection of the greater probability, as each period passes, that the final price of houses will be, in fact, κ and the fundamentals should reflect this.

3.2 Equilibrium without securitization

We solve the model via a PBE, much like in the partial equilibrium model, via backwards induction. From our previous discussion, we need only find the equilibrium actions that prevail in periods 3, 2 and 1 assuming that cohorts have arrived in every such period, as, otherwise, we know what the equilibrium action is. We'll be using analagous results from our partial equilibrium model where applicable.

3.2.1 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 further ahead. 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, as there will be $3 - \gamma$ new high types[36], who will have

[35] That 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'.

[36] And we've established that $\Psi = 2 - \gamma$.

thus exhausted the supply of housing, so 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 associated with low types, there is no need to screen borrowers by originators. As a consequence, originators will post a single interest rates, 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 $A_3 = \kappa$.

3.2.2 Period 2

We first establish what will be the equilibrium price that will prevail if only high types receive loans. 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, which is the expected value that houses may appreciate next period, $A_2 = q\kappa$[37]. As we show below that the risk aversion condition that makes originators wish to screen and deny loans to low types is decreasing in the price of houses, we will not need to establish what price will prevail if both types receive loans, which could only increase (non-strictly) house prices.

We show in Appendix 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, such that the unique equilibrium action will be for originators to screen borrowers and only lend to high types. So under $a \geq a''$, no lending to low types takes place and originators will wish to screen out low types, so that 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.

3.2.3 Period 1

As we show in the Appendix, the conditions $a > a''$ and $\gamma < \frac{1}{2}$, such that low types are a minority in every arriving cohort, are sufficient so 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, such that $A_1 = qA_2 = q^2\kappa$ and the equilibrium interest rate will be the same as in period 2, $r_{H,1} = \frac{C}{(1-\gamma)q\kappa}$.

To summarize, we find that in general equilibrium without where a securitization market does not exist, 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, $C < q\kappa(1-q)(1-\gamma)$, 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

[37]That is, as low types have no intrisinc value of owning houses themselves, the only value they derive from it comes from selling the house, and if they wait, they expect to receive $q\kappa$.

ever happen. If, however, a new cohort fails to arrive at any point, then house prices immediately collapse to 0 and remain there; no new loans are extended, but no defaults happen as only high types have received loans.

3.3 Equilibrium with securitization

Firstly, we describe the results and how they differ from the non-securitized results, providing some intuition behind them, and then proceed to derive the equilibrium. To distinguish our variables from the non-securitization case, we denote them with a tilde.

Much like in partial equilibrium, the addition of securitizers creates the possibility of many different equilibria. The equilibrium of interest will such that both types of new buyers receive loans by non-screening originators in all periods. This means that in, period 2, the marginal seller of houses will be a low type with a loan contract. Crucially, and unlike the low types who already own houses, this seller will not wish to sell the house for just $q\kappa$, as they have the option to wait and see what happens in period 3, where they can always choose to default, creating an option for which they are compensated for, and which increases their value of the holding-on to the house above the fundamental value, 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, and we have a housing bubble that starts from period 1. 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.

Crucially, we'll be assuming here that there is no equilibria switching between the equilibrium where no loans are sold, and the one where loans are sold to the securitization market. This will greatly simplify our analysis and we deem it to be more realistic, as it would otherwise require a change in both the equilibrium and out of the equilibrium path beliefs.

In periods 4 and 5 the same results as in the no-securitization case apply, such that if a cohort has failed to arrive in a preceding period, then prices are 0, any high-types who received loans proceed to repay and/or have repaid their loans and any low-types who have yet to fully repay their loans default on them. Otherwise, the price is at κ, no defaults have happened from any loans and high-types own all of the housing stock.

3.3.1 Period 3

As in the exogenous price case, 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, as in the exogenous price case, we establish their beliefs 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, since only high-types

will end up with houses, by virtue of moving first. As a consequence, this is the belief that securitizers will have, 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 sell their loans, they will have a payoff of $\tilde{U}^O_{H,3} = P_{H,3} - \tilde{A}_3 = \tilde{A}_3\tilde{r}_{H,3}$, which, in equilibrium, due to Bertrand-like competition, will mean $\tilde{r}_{H,3} = 0$, because as 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.

If originators do not sell their loans to securitizers, we achieve an identical outcome, as we discussed in the no-securitization case. We could sustain this as an equilibrium outcome by setting beliefs of securitizers that any loan put on sale consists exclusively of low types. In such a scenario, as these low types would have wait until the next period to sell their newly acquired houses, the price that secturtizers would pay would be less than the equilibrium price, for which originators only achieve 0 utility, so they would not wish to sell their loans and this belief would be sustained as an off the equilibrium path belief.

3.3.2 Period 2

If a low type borrower receives a loan and buys a house in this period, they will default with probability $(1-q)$ next period or, if a new cohort arrives, they immediately sell their house to the new arrivals and repay the loan completely. 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 the Appendix, if securitizers believe a loan to consist exclusively of high types, $P_{H,2} = \tilde{A}_2(1+\tilde{r}_{H,2})$ and for low types, $P_{L,2} = \tilde{A}_2 q(1+\tilde{r}_{L,2})$.

Originators will not choose actions leading to a separating equilibria where low-types are sold if $P_{L,2} \leq \tilde{A}_2$[38], that is, if the cost of loan $\tilde{A}_2$, is higher than the amount they receive for the loan, $P_{L,2}$. This is true if $1+\tilde{r}_{L,2} \leq \frac{1}{q}$ and in the Appendix, we show that this holds 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 a consequence, only two possible equilibrium can exist, as either originators screen, and don't sell their loans, resulting in an equilibrium similar to the previous, no-securitization case, or if originators don't screen, they sell loans to securitizers.

Separating / screening equilibrium We apply a similar line of reasoning as in the partial equilibrium model. As the price that a loan believe to consist of low types has is too low to compensante 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

[38]This holds strictly if low type borrowers choose to default when indifferent between defaulting and selling their loans.

low types denied loans, as originators could once again mask low types as high types, which would be a profitable deviation for both originators, as $P_{H,2} \geq 0$, and for low type borrowers, who 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 was done to a low type. In which case, originators post that they'll be screening, denying loans to low types and setting $\tilde{r}_{H,2} = \frac{C}{(1-\gamma)q\kappa}$, as the interest rate to high types, high types are screened and receive loans and no loans are put on sale on the securitization market.

As we're assuming there is no equilibrium 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 find without securitization, that is to say, 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 as in the no securitization case, that is to say, $a > a''$ and $C < q\kappa(1-q)(1-\gamma)$, so that house prices will be equal to $\tilde{A}_{S,2} = q^2\kappa$.

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

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

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 extend loans to both types, whilst screening and only selling loans extended to low types. In the Appendix, we show that originators will not wish to do so.

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, the value of the marginal sellers. These low types have 3 possible actions they can take this period: they can default at no cost, they can pay the instalment 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, $q[\kappa - \frac{\tilde{A}_1(1+\tilde{r}_{P,1})}{2}] + (1-q) \times 0$, minus the cost of the installment today, $\frac{\tilde{A}_1(1+\tilde{r}_{P,1})}{2}$. And the return from selling the house this period is equal to $\tilde{A}_2 - \tilde{A}_1(1+\tilde{r}_{P,1})$. As, in equilibrium, we know they will sell, we have to have that $\tilde{A}_2 - \tilde{A}_1(1 + r_{P,1}) \geq q\kappa - (1+q)\frac{\tilde{A}_1(1+\tilde{r}_{P,1})}{2}$ which implies that $\tilde{A}_2 \geq q\kappa + \frac{1-q}{2}\tilde{A}_1(1 + r_{P,1})$, a deviation from the fundamental value of houses.

As in period 2 we still have more sellers than buyers, the equilibrium price will be exactly equal to that of the marginal seller, and $\tilde{A}_2 = q\kappa + \frac{1-q}{2}\tilde{A}_1(1+r_{P,1})$. As we see from our results in period 1, this implies that equilibrium prices will be $\tilde{A}_2 = q\kappa + q^2\kappa\frac{1-q}{2(1-\gamma(1-q))-q(1-q)} > q\kappa$[39].

So in a pooling equilibrium, originators choose not to screen borrowers, and set interest rates $\tilde{r}_{P,2} = \frac{1}{1-\gamma(1-q)} - 1$, and sell these loans to securitzers, who 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 low type who bought a house in period 1 and has an option value to default, house prices deviate from fundamentals.

3.3.3 Period 1

Low types who buy in period 1 will have identical actions to low types who buy in period 2, that is to say, if no cohorts arrive, they default on their loans, but if a cohort arrives, all of the low types 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.

From our discussion of period 2, a separating / no-selling 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, only high types receive loans and no loans are put on sale in the securitization market, and prices are the same as in the period 1 prices when there is no securitization, $\tilde{A}_{S,1} = q^2\kappa$.

A pooling/selling equilibrium, can also be sustained by setting identical conditions to that of period 2, and as we show in the Appendix, we have that originators will not wish to 'skim the cream'. In which case, originators choose not to screen and extend loans to both types, and then sell these loans to securitizers.

As the marginal seller, a low type without a loan, has no 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 $\tilde{A}_2 = q\kappa + \frac{1-q}{2}\tilde{A}_1(1+r_{P,1})$, to find that $\tilde{A}_1 = q^2\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q))-q(1-q)}$[40].

3.4 Summary and discussion

So, under the assumptions that $a > a''$ (sufficiently high risk aversion), $C < q\kappa(1-q)(1-\gamma)$ (sufficiently low costs) and $\gamma < \frac{1}{2}$ (low types are a minority), we find that without a securitization market, assuming cohorts arrive every period, originators screen borrowers, so that high types are the only ones to receive loans, house

[39] Note that if $\tilde{A}_2(1+\tilde{r}_{P,2}) \geq \kappa$, 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 $\tilde{A}_2 < \kappa$.

[40] 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.

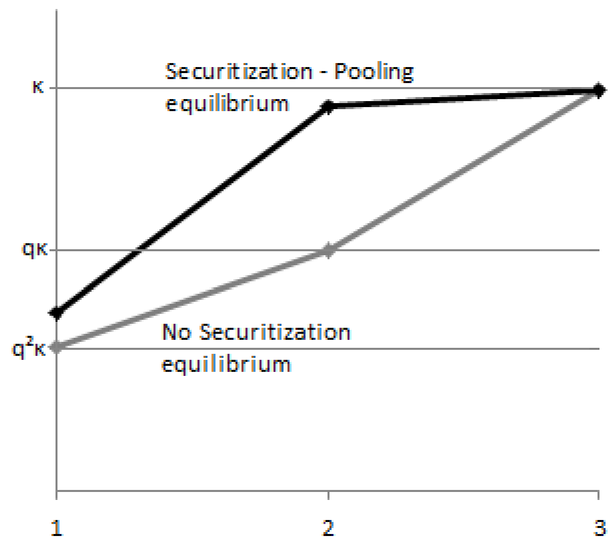

Figure 1: House prices in a sustained boom.

prices follow $A_1 = q^2\kappa$, $A_2 = q\kappa$, $A_3 = \kappa = A_4 = A_5$, and if a cohort fails to arrive before period 4, house prices collapse immediately to 0, and no defaults happen.

With a securitization market, we have two possible equilibrium, which we solve under the assumption that there is no equilibria switching. In the separating/screening equilibrium, beliefs of securitizers are such that no loans are sold and the equilibrium actions and outcomes are identical to the previous case.

In the pooling/no-screening equilibrium, assuming cohorts arrive every period, originators don't screen borrowers, both types receive loans, which are sold to the securitization market every period, and, as consequence of the option value of low types, house prices deviate from fundamentals, starting from period 1, such that $\tilde{A}_1 = q^2\kappa\frac{2(1-\gamma(1-q))}{2(1-\gamma(1-q))-q(1-q)}$, $\tilde{A}_2 = q\kappa + q^2\kappa\frac{1-q}{2(1-\gamma(1-q))-q(1-q)}$, $\tilde{A}_3 = \kappa = \tilde{A}_4 = \tilde{A}_5$. Finally, if a cohort fails to arrive before period 4, house prices collapse immediately to 0, and defaults happen from low types who received loans.

From our results above, we have a clear prediction for how house prices should evolve over time, during a period of increased demand, depending on whether or not there is a securitization market. In both cases, house prices experience a 'boom-like' behaviour, but when the securitization market exists, the option value of defaulting from low-type borrowers who become the marginal sellers pushes up house prices above the level experienced when there is no such market. Note, however, that if cohorts arrive until the housing stock is exhausted, in both cases prices will be equal at a new high point κ, and a market without securitization would experience a much larger increase at the end. This can be seen in Figure 1.

Should a cohort fail to arrive at, say, period 3, then prices in both markets would

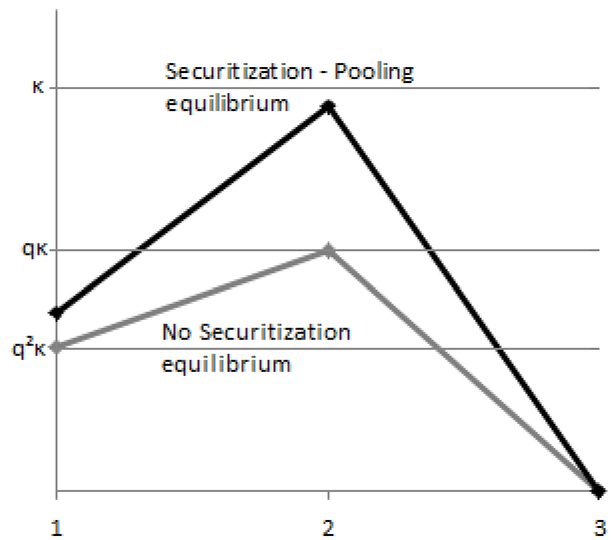

Figure 2: House prices in a boom and bust.

immediately fall to zero, but in such a case, a market with securitization would fall from a higher price level and, subsequently, experience a greater boom and a greater bust. This is illustrated in Figure 2.

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

Taken literally, our model predicts that if a securitization markets exists, then 100% of loans would be sold off by originators and securitized, but 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 low types, conditional on the characteristics that we have omitted.

That is to say, in US states mortgage loans are non-recourse, we would expect that with higher levels of securitization, the probability that low type/investor borrowers have managed to buy houses and, in subsequent periods, become the marginal seller in a given propriety market is increased. Given their option value, we would expect this effect to push up house prices markets, on average, in these states.

As such, we expect that there is a positive interaction effect between percentages of loans securitized in US states and whether that state has non-recourse law on mortgage loans, and house prices, beyond the positive effect that securitization has been found to have (Keys et. al. (2010), among others), and this is the primary prediction of our paper that we wish to test. In addition, it should also be possible to find if this interaction effect subsequently lead to greater drops in house prices during the bust period, and to higher levels of defaults, in non-recourse states.

Note also that we expect that many of the other mechanisms that the literature has suggested as a cause for the housing bubble, from moral hazard issues to overoptimism to increase in loan supply, we surmize would most likely interact with our own model in such a way as to enhance each other. For example, in the case of 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 would make our conditions for an equilibrium less stringent, whilst simultaneously providing an additional reason for why house prices might have increased besides more demand. In similar fashion, if an increase in 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 surmise that by setting up the model as we do, we're most likely finding a lower bound for under what conditions our mechanism might contribute to a housing bubble.

4 Data

To test the predictions of our model, we require micro level securitization data, and this has proven surprisingly hard to get access to[41]. Fortunately, a public alternative exists in the form of the HMDA. The HMDA was originally created to collect data to check for discrimination in the US housing market, by requiring some loan originators, which now covers around 80% of the mortgage loans according to Fishbein and Essene (2010), to report certain types of information on any loan request, successful or not, which it then makes available, in aggregated datasets of annual data.

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 to was changed in 2004, and has remained the same ever since. This change aggregated two categories, and, crucially for us, added the category 'Private Securitization', which consists of any sale to a non-GSE entity where the originator believes the loan will be securitized[42]. We restrict our attention to successfully originated loans that were intended for houses purchases, and use the percentage of this loans that were sold on in this category.

We have, however, two issues when using this data, that need to be addressed. Firstly, as the category 'Private Securitization' only began to be collected from 2004 onwards, we have a limited amount of data points available, and we would ideally wish to have data from 2000 or earlier. The second, more prominent concern, is that the

[41] There are two main private databases for securitization data, the CoreLogic and LPS datasets, the former of which restrict their sales to those residing in the US, and we have been unable to negotiate with CoreLogic at this time.

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

category 'Private Securitization' only reports originators beliefs on how sold loans will be put to use, not on whether securitization actually took place.

In other words, this data could be misreporting the actual securitization levels of loans within states as originators might report that loans as having been securitized when they were not, and, symmetrically, it is possible that loans reported as sold to other types of purchasers were, subsequently, securitized and not reported as such[43]. We suspect that the latter effect is taking place, 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 our data reports around 10%.

Fortunately for the intents of this paper, we are mainly concerned with relative, not absolute measures of securitization, as we wish to observe securitization's interaction effect on different states, and unless there's systematic differences in the way originators in each state reported this category, which we cannot think of any good reason would be the case, then it should provide an accurate measure of relative securitization taking place between states, serving our purposes, although biasing upwards the estimates of the effects of securitization.

4.1 Recourse in the US

The question of whether mortgages are non-recourse in practice in the US, an issue that is, surprisingly, tricky to answer. State laws dictate what are the procedures after mortgage repayments stop, and there is a great deal of heterogeneity as to how each state deals with this, as do the possible ways borrowers and lenders can proceed once a default happens[44]. For the purposes of this paper, what matters is if the state permits deficiency judgments to made on defaulted mortgages during a foreclosure procedure; 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 a 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. 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 below, the most recent evidence seems to suggest that non-recourse status matters significantly in this aspect.

We now face the questions of how to classify states and whether being recourse

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

[44]According to Ghent and Kudlyak (2011), borrowers may give the house deed to the lender in exchange for no further actions, they may find 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.

matters in practice; the former we discuss further ahead, the latter question is dealt sparsely by the literature. Ghent and Kudlyak (2011) find that a state being non-recourse increases default rates and the way borrowers default, which they take as evidence of strategic defaults on part of borrowers. Pennington-Cross (2003) similarly finds significant evidence that being recourse increases the amounts recovered by lenders in case of defaults, as "(...) the right of deficiency judgment has a 3.73 percent positive impact on recovery rates. In short, state foreclosure laws can have a significant impact on the ability of a lender to recoup losses by selling a foreclosed home". Most recently, Dobbie and Goldsmith-Pinkham (2014) find evidence that from 2007 to 2011, 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.

Pence (2003) produces conflicting evidence of the importance of recourse status. They surmise that the literature up to this point, had found ambiguous effects of recourse / deficiency judgments on mortgages, but they themselves dismiss it, as "lenders rarely pursue deficiency judgments", and they find no empirical evidence of it's importance (on a test of weak power). They do suggest, however, that investors and 'non-hardships' cases were situations were deficiency judgments may be pursued, and suggesting that their existence can be used as leverage against borrowers.

Thus, the most recent evidence for the importance of a state's recourse status in how borrowers and lenders behave seems to indicate that it is significant, but there is some earlier, pre-boom evidence to the contrary.

Regarding how to classify the recourse status of a state, Ghent et al. and Pence propose a very similar list that has a high degree of concurrence, with Arizona, California, Iowa, Minnesota, Montana, North Dakota, Oregon, Washington and Wisconsin being considered non-recourse; they differ only that Alaska and North Carolina are also considered non-recourse by Ghent et al. However, both papers also state that the literature has no consensus on this issue, and cite authors that offer slightly different lists to their own.

In lieu of this, we opt to use Ghent et al. classification as the basis for our regressions, and use Pence as a robustness check.

4.2 Other data

We obtain our main variable of interest, state-wide housing price levels, from the FHFA. This uses the standard weighted-repeat sales methodology and applies it for data coming from Freddie Mac and Fannie Mae. The main advantage of using this is that it provides us with prices for all 51 states, something that the main alternative we have contemplated at this point, the Case-Shiller indices, does not. We believe that the limitation of using data stemming only from GSEs transactions not to be a great one, as there should be no significant segmentation between the house market for houses guaranteed by GSEs and the other houses.

Nevertheless, it is possible to do a robustness check using the Case-Shiller index, although with some important limitations. Firstly, we'll have to use a single city as a proxy for each state[45], which may or may not be a good representative sample of the state, secondly, several cities indices, Boston, Charlotte, New York, Portland and Washington, are created from measures from counties that stem from more than just their nominal state; thirdly, the cities which Case-Shiller choose to sample might be correlated with some of our variable of interest, such as house prices; finally, as there's only 17 states, our limited sample size might affect our results more severely.

For our controls, following literature standards, we use data on population, 'Resident Population' from the US census, and income, 'Per Capita Personal Income' from the U.S. Department of Commerce. We also use state-level interest rates for 'conventional loans'[46] from the FHFA as a proxy for relative financing conditions in each state.

We normalize these 4 measures to be 100 in 2004.

5 Empirical strategy and results

5.1 'Boom period'

We first wish to test our model predictions for the 'boom' period, and to do this, we should regress house prices over the interaction effect between securitization and the non-recourse status of a US state:

$HPrice_{i,t} = Sec_{i,t} + NonRec_i + SecNonRec_{i,t} + \gamma_{i,t} + \varepsilon_{i,t}$

Where $HPrice_{i,t}$ are house prices in state i at time t, $Sec_{i,t}$ is the percentage of loans securitized in i, t, $NonRec_i$ is a dummy for whether a state is Non-Recourse, $SecNonRec_{i,t}$ is the interaction effect, $\gamma_{i,t}$ are the controls, income, population and interest rates for each state i at time t.

We do this for the 2004-2006 and via a pooled OLS regression, using robust Huber-White standard errors. As a robustness check, we vary the end-date to 2005 and 2007, and we also include all permutations for state and time fixed-effects[47], and use state-level clustered standard errors and GLS estimation, as can be seen in Table 1.

As we're likely underestimating the actual levels of securitization in states, we should expect the associated coefficient to be biased upwards, thus the effect of every additional percentage point of securitization on house prices should be interpreted with care. With this in mind, the coefficient for both securitization and the interaction effect are both positive and significant, and remain of similar magnitude through the various specifications. This suggests that securitization played a significant role in pushing up house prices, as the literature has found previously, but that non-recourse status of a

[45] With the exceptions of California, with 3 cities, and Florida, with 2.

[46] Single-family, fully amortized, purchase-money, non-farm loans.

[47] Although we have to exclude the non-recourse dummy if we include state fixed-effects, due to it not varying over time.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	HPrice	HPrice	HPrice	HPrice	HPrice	HPrice
Sec	1.133***	1.175***	1.194***	1.447***	1.133***	1.133***
	(0.228)	(0.288)	(0.283)	(0.476)	(0.284)	(0.205)
NonRec	-0.698		-0.674		-0.698	-.698
	(1.025)		(1.049)		(1.214)	(1.706)
SecNonRec	0.948***	1.330**	0.945***	1.388***	0.948*	0.948
	(0.357)	(0.509)	(0.362)	(0.507)	(0.479)	(0.381)
Observations	153	153	153	153	153	153
R-squared	0.779	0.904	0.779	0.905	0.779	NA
State Dummies	NO	YES	NO	YES	NO	NO
Year Dummies	NO	NO	YES	YES	NO	NO
Method	Robust	Robust	Robust	Robust	Clustered	GLS

Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 1: House prices: 2004-2006

given state also played an important role; as is seen, the effect of being non-recourse is large enough that it nearly doubles the effect of every additional percentage point of securitization.

The non-recourse dummy, on the other hand, is negative for all but one, and is insignificant in all our different specifications, which suggests that, at least where it concerns house prices, non-recourse status by itself is not an important, but only affects house prices via a specific mechanism, such as our own. Tables with results for the control variables in all regressions may be found in the appendix.

There is, however, a critical issue of causality in this regressions, as it is not clear that more securitization leads to higher house prices, and not the other way round[48]. It might be the case that in states where house prices have increased more, buyers of securitized mortgages become more confident in buying such securities originated in those states as the increased house prices increases the buffer margin against defaults, for example. As we cannot exclude that this, or other mechanisms that might create a reverse causality, the issue of whether pooled OLS is a consistent regression procedure remains and we are currently seeking out instruments to be able to deal with this.

As an additional robustness check, we also use two different variations for our main variables, house prices and non-securitization status, using the Case-Shiller index for house prices (which has a 0.91 correlation with the FHFA measure of house prices) and the classification of Pence, which can be seen as Table 2.

[48]It might be possible to argue along similar lines for interest rates and house prices; running the same regressions excluding interest rates results in virtually the same coefficients, as can be seen in Table 11 in the appendix, which we take to be a sign that this is not a major issue.

VARIABLES	Case-Shiller HPrice	Case-Shiller HPrice	Case-Shiller HPrice	Case-Shiller HPrice	Pence HPrice	Pence HPrice	Pence HPrice	Pence HPrice
Sec	0.314	-0.110	0.394	3.234	1.105***	1.153***	1.142***	1.390***
	(1.057)	(0.979)	(1.382)	(1.992)	(0.227)	(0.287)	(0.287)	(0.480)
NonRec	0.677		1.632		-0.507		-0.495	
	(3.694)		(3.913)		(1.119)		(1.149)	
SecNonRec	1.354	2.612**	1.330	3.025*	0.988***	1.537***	0.985***	1.569***
	(0.943)	(1.101)	(1.054)	(1.478)	(0.369)	(0.536)	(0.374)	(0.538)
Observations	51	51	51	51	153	153	153	153
R-squared	0.691	0.830	0.710	0.870	0.782	0.905	0.782	0.906
End Date	2006	2006	2006	2006	2006	2006	2006	2006
State Dummies	NO	YES	NO	YES	NO	YES	NO	YES
Year Dummies	NO	NO	YES	YES	NO	NO	YES	YES
Method	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2: House prices: 2004-2006 with Case-Shiller and Pence

We find that Pence's classification does not significantly alter our results, indeed, we observe a very similar pattern with our coefficients.

However, using Case-Shiller house prices does result in substantial changes to our coefficients, particularly for securitization and the non-recourse status, and most of our variables stop being significant; fortunately, the interaction effect remains positive and is significant under some specifications, which we take to be as (limited) evidence of our mechanism. As such, this robustness check leaves us in tricky position to disentangle whether our main results currently stand due to the limitations of using the FHFA dataset or one of the several reasons we discuss above why Case-Shiller might find be problematic[49]; we are currently seeking out alternative datasets for house prices to try to solve this.

5.2 '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. Although there's some degree of heterogeneity, most states in our sample experience the peak of their house prices in either 2006 (9 states) or 2007 (25 states)[50], we thus opt for the

[49]In particular, altering the end date results in even greater changes than the ones reported below, so we assume that the issue of sample size might be the most salient.

[50]The exceptions are states where house prices being to fall in 2005, Massachusetts and Michigan, continue to grow throughout our sample, North Dakota, or experience falls in house prices post-2007, Oklahoma, South Dakota, Texas and Wyoming.

latter date as our starting point for the bust. The lowest point of the bust is trickier to ascertain, as the mode for which house prices have their smallest value in the post-boom period is 2011 (38 states), but the difference between that price and the price in 2009 is less than 10% for 36 states, although most states experience significant price fluctuation in that period, as 21 states have at least one annual price change above 5%, and 34 states experience at least one change above 3%. Given this uncertainty, we use both 2009 and 2011 as end dates for the bust period in prices, to test the bust-period predictions.

We also need to create a new variable, $Sec0406_i$, which is simply the sum of our securitization variable from 2004 to 2006 in each state, from which we can derive the interaction effect between the accumulated securitization and the non-recourse status, $SecNonRec0406_i$. With this, we can test our prediction by running the following regression using robust standard errors:

$$HPrice_{i,t} = Sec0406_i + SecNonRec0406_i + \gamma_i + \upsilon_i$$

where γ_i is the our controls. Note that, unlike before, we cannot include the non-recourse status of a state nor state fixed-effects, as we would have multicollinearity with $SecNonRec0406_i$. We run this regression for both end dates of 2009 and 2011, and we include a time dummy as robustness check. Although our model would predict that securitization would have no contemporaneous effect during the bust period, as a further robustness, we include $Sec_{i,t}$ and $SecNonRec_{i,t}$ in some our regressions. Note that our regressions where we exclude our securitization measure should have no endogeneity problems, as we'll only be including a lagged measure of it. Our results can be seen in table 3.

Our results go against the predictions of our model. Crucially, our interaction effect for past securitization, $SecNonRec0406_i$, has a coefficient that varies from positive to negative (depending on our regression specification), and is non-significant in most of these. Past securitization is slightly more robust, as it negative (as expected) in all but one specification, even if significance (and the size of the coefficient) varies considerably depending on our specification. Nevertheless, as the 2011 results are fairly robust, we take this as evidence accumulated securitization in the period of 2004 to 2006 played a role in the longer-term decline of house prices.

The interaction effect between contemporaneous securitization and non-recourse status is non-significant, as our model would predict, but we find that contemporaneous securitization has a positive and significant effect in this time period. This might be due to our start date of 2007, wherein securitization was still large and house prices were at their peak, and if we run the same regressions with a start date of 2008, we find that this result largely disappears, with our other coefficients largely unchanged, as can be seen in table 4.

We thus find some evidence that past securitization was an important determinant in the fall of houses prices during the bust period, but fail to find evidence of our specific mechanism.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	HPrice	HPrice	HPrice	HPrice	HPrice	HPrice
Sec0406	-0.348	-0.675***	0.0189	-0.177	-0.533**	-0.682***
	(0.212)	(0.168)	(0.190)	(0.151)	(0.208)	(0.163)
SecNonRec0406	0.0349	-0.0890	0.137	0.0172	-0.0595	-0.436*
	(0.276)	(0.203)	(0.252)	(0.180)	(0.397)	(0.257)
Sec					5.673***	2.318*
					(1.616)	(1.188)
SecNonRec					-1.207	3.478
					(3.336)	(2.537)
Observations	153	255	153	255	153	255
R-squared	0.357	0.424	0.488	0.585	0.434	0.462
End Date	2009	2011	2009	2011	2009	2011
Year Dummies	NO	NO	YES	YES	NO	NO

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3: House prices: 2007-2009/2011

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	HPrice	HPrice	HPrice	HPrice	HPrice	HPrice
Sec0406	-0.450*	-0.845***	-0.136	-0.332*	-0.416*	-0.773***
	(0.245)	(0.186)	(0.246)	(0.173)	(0.240)	(0.184)
SecNonRec0406	-0.0859	-0.180	0.0368	-0.0733	-0.173	-0.453*
	(0.308)	(0.212)	(0.308)	(0.189)	(0.359)	(0.246)
Sec					-1.285	-1.034
					(4.348)	(1.873)
SecNonRec					2.141	4.883
					(5.113)	(3.080)
Observations	102	204	102	204	102	204
R-squared	0.430	0.414	0.476	0.584	0.432	0.428
End Date	2009	2011	2009	2011	2009	2011
Year Dummies	NO	NO	YES	YES	NO	NO

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: House prices: 2008-2009/2011

VARIABLES	(1) MDefaults	(2) MDefaults	(3) MDefaults	(4) MDefaults	(5) MDefaults	(6) MDefaults
Sec0406	0.231***	0.283***	0.242***	0.286***	0.271***	0.274***
	(0.0528)	(0.0438)	(0.0432)	(0.0369)	(0.0456)	(0.0353)
SecNonRec0406	-0.0171	-0.0314	-0.00941	-0.0221	0.0116	-0.0191
	(0.0499)	(0.0354)	(0.0364)	(0.0272)	(0.0330)	(0.0289)
HPriceLag					-0.115***	-0.0935***
					(0.0251)	(0.0145)
Observations	153	255	153	255	153	255
R-squared	0.300	0.330	0.553	0.526	0.437	0.483
End Date	2009	2011	2009	2011	2009	2011
Year Dummies	NO	NO	YES	YES	NO	NO

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Defaults: 2007-2009/2011

5.2.1 Defaults

In addition to our prediction for house prices, our model also predicts that defaults are affected as a consequence of higher levels of securitization in non-recourse states, as granting low types access to loans during the boom should lead to higher levels of defaults during the bust period, although as we need γ, the proportion of low types to be small, it might be difficult to capture this effect in our model.

For defaults, we use the FRBNY Consumer Credit Panel data which specifies the percent of mortgage debt balance that is 90 days or more delinquent in each state, $MDefault_{i,t}$. As before, we need to set a date for which start and finish, from our previous discussion we choose to start from 2007 and use both end dates of 2009 and 2011 (although mortgage delinquencies remains above their historical average of around 1% even in 2012). We then proceed to run the following regression using robust standard errors:

$MDefault_{i,t} = Sec0406_i + SecNonRec0406_i + \widetilde{\gamma}_i + \theta_{i,t}$

where $\widetilde{\gamma}_i$ are our controls without interest rates[51]. As before, we run a robustness check by including time fixed-effects and lagged house prices[52], the results of which are found in table 5.

As can be seen, we find strong evidence that past securitization was an important mechanism for explaining subsequent defaults in the bust period, a result that is very robust, and the higher the amount securitized, the higher the subsequent defaults. Similarly, lagged house prices is both significant and has right sign for it's coefficient

[51] The causality link between interest rates and defaults is even more troubling than that between house prices and securitization.

[52] To avoid causality issues.

(lower house prices would, all else equal, lead to higher defaults). However, our interaction effect is non-significant in any period, and it's sign varies from positive to negative, so again we fail to find evidence of our mechanism in the bust period.

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 nature 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 beyond their fundamental value during the boom, and that during the subsequent bust period, this may have resulted in greater falls in house prices and higher levels of defaults.

Our model generates a housing bubble as in Allen and Gorton (1993), where the asymmetry of payoffs between loan originators and borrowers creates an option value for the latter, which pushes house prices beyond their fundamental 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.

Our model takes place during a period of increasing housing demand of uncertain duration, and our key result comes from the introduction of securitization. This alters the incentives of loan originators, who, by selling loans to the securitization market, no longer bear the risks associated with these loans, whereas previously, these risks would lead them to screen borrowers. Furthermore, as these loans are non-recourse, originators cannot credibly signal that a loan has been extended to a low type borrower (who may default) or a high type borrower (who never defaults in either scenario), so with securitization, originators extend loans to both types.

Low type borrowers only buy houses to try to profit from potential capital gains on the housing market, by selling a bought house in a subsequent period. If demand continues for long enough, the initial housing stock is exhausted, and these low type borrowers become the marginal sellers. As non-recourse loans have an option value associated with the possibility of waiting and defaulting, their value of selling the house will be above the fundamental value, increasing house prices and, with rational expectations, this increases the price of houses happens even before these low types become sellers.

Both when loans are recourse and when they are non-recourse, if period-by-period increase in housing demand ends before the whole housing stock is owned by high types, our model predicts that a bust will happen, and houses will subsequently be priced at the value of a low type, which implies that non-recourse states should experience a greater fall. Similarly, defaults only happen in non-recourse states, as we predict that in recourse states, no low type should receive a loan.

We find some empirical evidence for our boom prediction, where the positive effects of securitization on house prices are nearly doubled in US states that have non-recourse

laws. We acknowledge, however, that this is tentative evidence, as we have not yet been able to take into account possible inconsistencies in our regression technique of a pooled OLS, due to causality issues between house prices and securitization. We do not find evidence for our predictions during the bust period. We do find evidence that securitization played an important role in determining house prices and defaults in the 2000s, as is consistent with the literature.

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 *de facto* or *de jure* non-recourse, to make these rules binding and, perhaps, proportional to the loan-to-value ratio of a mortgage[53], as we surmise that prices can otherwise deviate upwards from fundamentals.

We highlight the fact that our result is independent of the existence (or not) of subprime mortgages, and 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, we believe that the recent changes[54] by US regulators that relaxed the Dodd-Frank laws that require originators to have a substantial 'skin in the game' by, instead, exempting the vast majority of mortgages in the US from such a requirements, has been counterproductive and might be re-laying the foundations for future housing bubbles, even if subprime mortgages are more tightly controlled and regulated, or non-existent.

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[53]Higher LTV ratios may not only allow for better self-selection of borrowers, but would also dampen the effects of a bubble in our model.

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

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7 Appendix A - Model discussion

7.1 Partial equilibrium

7.1.1 Borrowers

We can think of low type borrowers as being investors as they only wish to buy a house to take advantage of (potential) capital gains by selling it in a later period. There is evidence that house buyers seeking to make capital gains were an important part of the housing market in the US during the recent boom (Haughwout, Lee, Tracy and van der Klaauw, 2011), to the extent 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.[55] In our model, we need not assume such a large number of investors: a small number of low types is sufficient to generate a bubble, as long as they have the opportunity to become the marginal sellers.

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 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 prob-

[55]Unlike our model, Haughwout et al. (2011) find evidence of investor-like buyers by looking at second home purchases, but as they conclude that this was done investors "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.

lems 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."*[56]

Although we've 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 signalling device at the time period of interest to us was limited.

7.1.3 Securitizers

The rise of 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[57]. Many of these agents, as discussed by Lewis (2011), had very little understanding of the US housing market, much less of the mortgage loans they held via the CDOs and MBS they owned[58], in part due to the complexity of the securitization process.

This process is itself quite complex to model, as securitization involves numerous agents and steps[59]. We can summarize it as consisting of aggregating loans from a number of different markets, on the assumption that they exhibit some statistical

[56] *Economist, Nov. 2013.*

[57] 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 originated in the private sector (Angelides and Thomas, 2011), which seems to indicate that lending standards did not change as much as the in the private sector.

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, so we believe that this might require further study.

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

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

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[60]; 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.[61]

7.2 General equilibrium

The choice of 5 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. Consequentely, 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 5 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. Consequentely, and as we have emphisized 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 mortage loans are repayed 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[62].

[60]But not the benefits of tranching.

[61]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.

[62]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

8 Appendix B - Proofs

8.1 Partial Equilibrium

Only two values for interest rates can exist for loans that 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, which we call oLow.

Note that originators make offers that are only conditional on types, such that if a low type is receiving a loan from a given originator, any other low type can approach the same originator and receive an identical loan[63].

As such, a profitable deviation exists for at least one low type, as either the interest that oLow pays is strictly smaller than the interest rate of other low types, in which case the other low types would do better by choosing the originator offering oLow interest rate on loans, or the other interest rate is lower, in which case oLow would do better by choosing a originator who offers the other interest rate and is granting loans to low types.

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

■

In partial equilibrium when there is pooling/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 $\overline{r_P} = \frac{\gamma(1-q)\tau}{(1-\gamma)+q\gamma}$ 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 $\overline{r_P} \leq \tau$, which is true if $\gamma \leq \frac{1}{2(1-q)}$.

What are the possible deviant actions that a originator could contemplate from this equilibrium[64]? 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

prices, as both of which make it cheaper for a borrower to wait.

[63]We're excluding the possibility that originators can use a randomization strategy on the loans they offer, an originator is not allowed to choose a strategy wherein, for example, a low type receives a loan with interest r_j with some probability p_j and some other interest rate r_k with some probability p_k, although this may happen in real life.

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

(and choose to sell or keep these loans)($PD4$); grant loans to both and offer a different interest rate to low types (and choose to sell or keep these loans)($PD5$); grant loans to both and offer a different interest rates to both types (and choose to sell or keep these loans)($PD6$); grant loans to both at the equilibrium interest rate and choose to not sell either one or both of the loans($PD7$).

If they choose to not screen and offer a different interest rate than the equilibrium interest rate, first note from our previous results, due to risk aversion, they would never wish to hold-on to loans. So if they wished to sell loans, the deviation interest rate they would contemplate could only be lower than the equilibrium interest rate, as otherwise they will not attract any borrowers[65], 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 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[66] 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[67]. 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[68], 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've 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, possibly, 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 $\frac{(1-\gamma)\gamma(1-q)}{(1-\gamma)+q\gamma} \leq C$.

[65] Originators are thus constrained by the actions of the borrowers, as any succesful 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.

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

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

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

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.

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.
■

Without securitization, 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 pooling/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 pooling 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[69] and utility is separable between types as there's no risk associated with high types, the expected utility of lending in a pooling 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

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

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

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 pooling 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.

■

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 $\tilde{A}_3 = 0$[70], so $P_{\Omega,2} = \tilde{A}_2(1-\Omega(1-q))(1+\tilde{r}_{\Omega,2})$.

[70] As we've 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

■

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's 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 $(1+r_{L,2}) \leq \frac{1}{q}$[71].

■

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 can be re-written as an second order equation of γ, $\tilde{A}_2\gamma^2 - (C+\tilde{A}_2)\gamma + \frac{C}{1-q} > 0$. As $\tilde{A}_2\gamma^2 - (C+\tilde{A}_2)\gamma$ is a second order equation with two roots, $\gamma' = 0$ and $\gamma'' = \frac{C}{\tilde{A}_2} + 1 > 1$, we must have that for all $\gamma \in [0,1]$, $\tilde{A}_2\gamma^2 - (C+\tilde{A}_2)\gamma \leq 0$, so that the zero order term, $\frac{C}{1-q}$, guarantees that our condition is $C > \frac{\tilde{A}_2(1-\gamma)\gamma(1-q)}{1-\gamma(1-q)}$ is satisfied.

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 $\tilde{A}_1 \leq \tilde{A}_2$, 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.

■

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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.

[71]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 Controls

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	HPrice	HPrice	HPrice	HPrice	HPrice	HPRICE
Inc	0.966***	0.903***	0.976***	1.001***	0.966***	0.966***
	(0.220)	(0.223)	(0.259)	(0.269)	(0.246)	(0.144)
Pop	1.978***	1.856***	1.975***	1.877***	1.978***	1.978***
	(0.524)	(0.544)	(0.527)	(0.536)	(0.605)	(0.310)
IntRate	-0.0408	0.00623	-0.0885	0.0449	-0.0408	-0.0408
	(0.166)	(0.147)	(0.292)	(0.259)	(0.173)	(0.114)
Observations	153	153	153	153	153	153
R-squared	0.779	0.904	0.779	0.905	0.779	NA
State Dummies	NO	YES	NO	YES	NO	NO
Year Dummies	NO	NO	YES	YES	NO	NO
Method	Robust ST	Robust ST	Robust ST	Robust ST	Clustered ST	GLS

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 6: House prices controls: 2004 - 2006

VARIABLES	Case-Shiller HPrice	Case-Shiller HPrice	Case-Shiller HPrice	Case-Shiller HPrice	Pence HPrice	Pence HPrice	Pence HPrice	Pence HPrice
Inc	2.364***	2.395***	2.974***	2.876***	0.973***	0.912***	0.979***	1.005***
	(0.774)	(0.865)	(0.780)	(0.841)	(0.222)	(0.224)	(0.260)	(0.269)
Pop	1.991**	2.549**	2.295**	2.651**	2.027***	1.889***	2.026***	1.914***
	(0.919)	(1.148)	(0.962)	(1.064)	(0.519)	(0.538)	(0.522)	(0.532)
IntRate	-0.793*	-0.905*	0.554	-0.324	-0.0431	-0.000850	-0.0722	0.0452
	(0.402)	(0.448)	(1.340)	(1.268)	(0.165)	(0.146)	(0.295)	(0.258)
Constant	-259.2**	-309.4**	-484.7**	-427.8**	-197.8***	-179.5***	-195.3***	-195.7***
	(112.9)	(134.3)	(220.3)	(206.3)	(47.51)	(49.36)	(58.40)	(61.12)
Observations	51	51	51	51	153	153	153	153
R-squared	0.691	0.830	0.710	0.870	0.782	0.905	0.782	0.906
End Date	2006	2006	2006	2006	2006	2006	2006	2006
State Dummies	NO	YES	NO	YES	NO	YES	NO	YES
Year Dummies	NO	NO	YES	YES	NO	NO	YES	YES
Method	Robust ST	Robust ST	Robust ST	Robust ST	Robust ST	Robust ST	Robust ST	Robust ST

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 7: House prices controls: 2004-2006 with Case-Shiller and Pence

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice	(5) HPrice	(6) HPrice
Inc	0.990***	0.933***	1.186***	1.222***	1.060***	0.959***
	(0.158)	(0.105)	(0.158)	(0.116)	(0.166)	(0.108)
Pop	1.541***	1.067***	1.559***	1.234***	1.370***	1.017***
	(0.380)	(0.250)	(0.344)	(0.202)	(0.366)	(0.246)
IntRate	0.452***	0.682***	-0.843**	-0.883***	0.232**	0.626***
	(0.0852)	(0.0620)	(0.384)	(0.294)	(0.107)	(0.0595)
Constant	-204.8***	-169.6***	-84.03	-47.62	-174.4***	-163.7***
	(44.00)	(28.52)	(66.20)	(45.20)	(43.69)	(28.43)
Observations	153	255	153	255	153	255
R-squared	0.357	0.424	0.488	0.585	0.434	0.462
End Date	2009	2011	2009	2011	2009	2011
Year Dummies	NO	NO	YES	YES	NO	NO

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 8: House prices controls: 2007-2009/2011

VARIABLES	(1) HPrice	(2) HPrice	(3) HPrice	(4) HPrice	(5) HPrice	(6) HPrice
Inc	1.169***	0.893***	1.097***	1.164***	1.165***	0.893***
	(0.191)	(0.109)	(0.171)	(0.120)	(0.193)	(0.111)
Pop	1.501***	0.961***	1.340***	1.131***	1.535***	0.949***
	(0.398)	(0.259)	(0.398)	(0.208)	(0.374)	(0.261)
IntRate	0.0456	0.521***	-1.274**	-1.046***	0.0589	0.512***
	(0.113)	(0.0806)	(0.532)	(0.348)	(0.117)	(0.0858)
Constant	-182.8***	-137.7***	-20.69	-28.62	-187.2***	-136.1***
	(46.02)	(29.89)	(82.62)	(49.89)	(44.32)	(30.22)
Observations	102	204	102	204	102	204
R-squared	0.430	0.414	0.476	0.584	0.432	0.428
End Date	2009	2011	2009	2011	2009	2011
Year Dummies	NO	NO	YES	YES	NO	NO

Robust standard errors in parentheses, *** p$<$0.01, ** p$<$0.05, * p$<$0.1

Table 9: House prices controls: 2008-2009/2011

VARIABLES	(1) MDefaults	(2) MDefaults	(3) MDefaults	(4) MDefaults	(5) MDefaults
Inc	-0.0824**	-0.0547***	-0.0952***	0.0211	-0.00653
	(0.0334)	(0.0207)	(0.0204)	(0.0247)	(0.0173)
Pop	0.170**	0.150***	0.0347	0.354***	0.208***
	(0.0768)	(0.0485)	(0.0415)	(0.0863)	(0.0440)
Constant	-6.770	-7.948*	6.369*	-25.13***	-9.154**
	(6.884)	(4.262)	(3.707)	(7.548)	(3.843)
Observations	153	255	255	153	255
R-squared	0.300	0.330	0.526	0.437	0.483
End Date	2009	2011	2011	2009	2011
Year Dummies	NO	NO	YES	NO	NO

Robust standard errors in parentheses, *** p$<$0.01, ** p$<$0.05, * p$<$0.1

Table 10: Defaults controls: 2007-2009/2011

9.2 Other tables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	HPrice	HPrice	HPrice	HPrice	HPrice	HPrice	HPrice
Sec	1.132***	1.039***	1.244***	1.172***	1.154***	1.470***	1.132***
	(0.228)	(0.236)	(0.196)	(0.258)	(0.268)	(0.450)	(0.286)
NonRec	-0.674	-0.749	0.223		-0.658		-0.674
	(1.025)	(0.630)	(1.493)		(1.050)		(1.213)
SecNonRec	0.940***	0.778***	0.848**	1.331***	0.941**	1.392***	0.940*
	(0.355)	(0.272)	(0.381)	(0.504)	(0.362)	(0.503)	(0.475)
Observations	153	102	204	153	153	153	153
R-squared	0.779	0.794	0.735	0.904	0.779	0.905	0.779
End Date	2006	2005	2008	2006	2006	2006	2006
State Dummies	NO	NO	NO	YES	NO	YES	NO
Year Dummies	NO	NO	NO	NO	YES	YES	NO
Method	Robust ST	Robust ST	Robust ST	Robust ST	Robust ST	Robust ST	Clustered ST

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11: House prices: 2004 - 2006 without interest rates