Lender Screening and the Role of Securitization: Evidence from Prime and Subprime Mortgage Markets

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This article examines the link between mortgage securitization and lender screening during the boom and bust of the U.S. housing market. Using comprehensive data on both prime and subprime securitized and bank-held loans, we provide evidence that securitization affected lenders' screening decisions in the subprime market for low-documentation loans through two channels: the securitization rate and the time it takes to securitize a loan. The change in decision-making by subprime lenders occurs on dimensions that are unreported to investors. Examining the time-series evolution of the securitization market further reinforces these findings. We exploit heterogeneity across subprime and prime markets to illustrate that the potential for moral hazard may be reduced with greater collection of hard information and increased monitoring of lenders. Our results suggest that the policy debate regarding securitization and lenders' underwriting standards should separately evaluate the agency and non-agency markets, with special attention toward the extent of soft information in assets being securitized. (*JEL* G21)

1. Introduction

Securitization in the mortgage market has transformed the traditional role of financial intermediaries from "buying and holding" to "buying and selling." The perceived benefits of this financial innovation, such as reduced cost of

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capital and improved risk sharing, are widely recognized (see, e.g., Keys et al. 2010a). However, with subprime mortgages playing a central role in the recent crisis, whether the ability to securitize mortgage loans affected lenders' diligence in evaluating the creditworthiness of potential borrowers is a fundamental question (Stiglitz 2007). Concerns with the "originate-to-distribute" model's performance during the crisis stems from theories of financial intermediation that suggest that by increasing loans' liquidity, securitization may have reduced lenders' incentives to carefully screen and monitor borrowers (Calomiris and Kahn 1991; Aghion, Bolton, and Tirole 2004). It is possible, of course, that regulatory oversight, reputational considerations, or sufficient balance sheet risk may have prevented moral hazard on the part of lenders. Understanding the effects of existing securitization practices on screening is thus an empirical question.

Answering this question empirically, while critical for understanding what went wrong during the crisis, has proved challenging. Making a causal claim requires isolating differences in channels that impact lender behavior and loan outcomes that depend on securitization but are independent of contract and borrower characteristics. While prior research has suggested a link between securitization and screening (see Mian and Sufi 2009; Keys et al. 2010a; Purnanandam forthcoming), the exact channels through which this link operates are not fully understood.[1] In this article, we use comprehensive data on securitized and bank-held loans from the U.S. mortgage market to establish the channels through which easy access to securities markets affected lenders' decision-making.

We overcome empirical challenges associated with the endogeneity of securitization and loan outcomes by exploiting a specific rule of thumb that induced exogenous variation in the ease of securitization among loans with similar characteristics. This rule of thumb is based on the summary measure of borrower credit quality known as the FICO score. For various historical reasons, explained in detail in Keys et al. (2010a), loans made to borrowers that fall just above the 620 credit cutoff had a higher unconditional likelihood of being securitized and were therefore more liquid relative to loans below this cutoff.

The idea behind our identification strategy can best be understood through an example. Consider two borrowers, one with a FICO score of 621 (620+), the other with a FICO score of 619 (620−), who each approach the lender for a loan. In order to evaluate the quality of the loan applicant, screening involves collecting both "hard" information, such as the credit score, and "soft" information, such as a measure of the borrower's future job stability.

[1] Mian and Sufi (2009) use HMDA data to show that incidence of defaults is larger in zip codes where more subprime loans were securitized. Purnanandam (forthcoming) uses variation in the types of loans held on banks' balance sheets at the time of the liquidity crisis in early 2007 to examine the quality of loans that would otherwise be sold. Keys et al. (2010a) establish the connection between securitization and screening using only subprime securitized loans. In contrast, we elaborate on the channels, how they vary with loan-level characteristics such as the extent of soft and hard information, and whether or not the loan is securitized in the agency or non-agency market.

Hard information is something that is easy to contract upon (and transmit), but the lender has to exert an unobservable effort to collect soft information (Stein 2002). Because investors purchase securitized loans based only on hard information, the cost of collecting soft information is internalized by lenders to a lesser extent when screening borrowers at 620+ than at 620−. Therefore, by comparing loan portfolios on either side of the credit score threshold, we can assess whether differential access to securitization led to changes in lenders' decisions to offer loans to consumers with nearly identical risk profiles.

We first clarify the exact channels that change the liquidity of loans from the perspective of a lender. We then design a test to uncover whether these channels are measurable around the threshold of 620. In particular, we show that easy access to securities markets manifests itself, among other things, through securitization rates (i.e., the probability of sale conditional on origination) and the time it takes for loans to be securitized. Using several strategies, we first document a large and significant discontinuity in the low-documentation non-agency securitization rate at FICO=620. This magnitude is large—relative to 620− loans, a 620+ accepted loan is 10% more likely to be securitized. We confirm this result by using independent loan-level data from two anonymous lenders who ranked among the top lenders in terms of subprime origination volume during the housing boom.

Next, we show that the ease of securitization above 620 is reflected in another dimension that impacts the lender's payoffs: the time it takes to securitize a loan. This measure reflects the "inventory" risk associated with holding the loan on the balance sheet before it can be sold. We identify a discontinuity that suggests that an accepted 620−, low-documentation, subprime loan stays on a lender's balance sheet for nearly two months longer than an accepted 620+ loan. This difference creates additional illiquidity for 620− loans relative to 620+ loans in the low-documentation subprime market that may impact lenders' screening effort.

We then show that the portfolio of low-documentation non-agency loans with greater ease of securitization—as measured by greater securitization rates and faster time to securitize—defaults by around 20% more than a similar-risk-profile group with a lesser ease of securitization. The discontinuity in defaults arises despite no differences in loan terms around the threshold. This evidence directly connects differential ease of securitization to differential screening.

Next, we argue that securitization also introduces other dimensions, in addition to conditional securitization rates and time to securitize, that may impact lenders' payoffs—and hence their screening effort. These factors could include the securitization-induced post-sale probability that a given loan is returned to the lender, driven by the audit intensity of investors. Alternatively, other aspects could include changes in acceptance procedures internalized by lenders that are driven by securitization. We suggest that these factors are likely to be captured in another broad measure of ease of securitization—the

unconditional securitization rate—that we employed previously in Keys et al. (2009) and Keys et al. (2010a). The measure has a downside in that it may also capture factors that are not driven by securitization. Accordingly, we validate that this measure indeed captures "ease of securitization" by showing that it systematically changes as the market for non-agency low-documentation loans expanded and then collapsed. Remarkably, the default differences around the threshold follow a similar pattern over time. Thus, using temporal variation in the non-agency market, we confirm that (i) the unconditional securitization rate captures the ease of securitization, and (ii) the discontinuity in screening varies with lenders' relative access to the non-agency securities market.[2]

We then explore how these effects vary across different segments of the mortgage market. Specifically, we examine ease of securitization as measured by the three measures for loans in the non-agency full documentation and the government-sponsored enterprise (GSE) markets. While there are no significant discontinuities in securitization rates or time to securitize a loan, we do find differences in the unconditional rate of securitization for loans in these segments. For the loans made in the GSE market, this difference could reflect in part lenders' internalization of ease of securitization via the use of the GSE underwriting system. Alternatively, for both GSE and non-agency full-documentation loans, this difference could reflect the intensity of post-sale audits conducted by the GSEs or by the investors in the subprime market, respectively. Notably, there are no differences in default rates around the 620 threshold in the sample of agency loans or in the sample of non-agency full-documentation loans. Thus, our findings of differential screening induced by ease of securitization may be confined to the low-documentation part of the subprime market while being absent from the full-documentation part of the subprime market as well as in the GSE-operated prime markets.[3]

We explain that these results may suggest that the screening differences driven by ease of securitization manifest themselves only in segments of the mortgage market where the potential for moral hazard is large—due to the absence of hard information and decreased monitoring of lenders (see, e.g., Passmore, Sherlund, and Burgess 2005; Keys et al. 2010a, 2010b). For the lenders operating in the GSE market, the underwriting process in securitization involves increased monitoring of lenders that differs substantially from the non-GSE market (see Passmore and Sparks 2000; Kling 2009; Bubb and Kaufman 2009). Originating loans with the intent to sell to the GSEs involves collecting substantially more hard information about the borrower before

[2] This test has a similar flavor to time-series variation exploited in Keys et al. (2010a) in their tests using the passage of anti-predatory laws in New Jersey and Georgia.

[3] Alternatively, the differences in behavior of defaults around the 620 threshold may be driven by the fact that the exogenous variation is relatively smaller for the GSE and full-documentation subprime markets as compared with the low-documentation subprime market. Although the increase in the number of securitized loans at the cutoff may seem comparable across different markets, the unconditional probabilities—which reflect the ease of securitization—may still differ in the distribution of prospective borrowers across markets (i.e., the denominator in the unconditional probability calculation).

the lender grants the borrower a loan (e.g., total debt-to-income ratio of the borrower). Moreover, the GSEs' threat to exclude lenders is credible because they are the only buyers in the prime market (see Passmore, Sherlund, and Burgess 2005; Bubb and Kaufman 2009). In contrast, while subprime markets do not have such monitoring by any single entity, relative to low-documentation loans, full-documentation loans involve collecting additional hard and verifiable information about the borrower (e.g., information on employment, income, and assets). Consequently, differential lender screening induced by ease of securitization may be absent among loans with increased monitoring of lenders and/or greater collection of hard information (Keys et al. 2010a, 2010b).

We conclude our analysis by providing further evidence that lenders relax screening of low-documentation loans in the subprime market on dimensions that are easily manipulated because they are unreported to investors. Our analysis shows, for instance, that borrowers whose income is more variable and easier to overstate are more likely to end up in the 620+, low-documentation subprime loan pool. This evidence highlights the importance of liquidity in maintaining the incentives of lenders to screen borrowers where alternative mechanisms such as monitoring or additional hard information may not be available.

The articles closest in spirit to our study are Keys et al. (2009) and Keys et al. (2010a), but our study differs in several significant ways. First, we use information on both securitized and portfolio loans across both prime and subprime markets, which allows us to address selection issues more directly. More importantly, it allows us to tease out two channels through which ease of securitization affects lender behavior: the securitization rate and the time it takes to securitize a loan. In addition, we are able to argue that the measure of ease of securitization (unconditional securitization rate) used in Keys et al. (2009) and Keys et al. (2010a) captures many dimensions that securitization induces in lenders' payoffs that may not be captured in these two channels. Second, we exploit heterogeneity across prime and subprime markets to illustrate the mechanisms that might substitute for incentive provision through the illiquidity of loans. Third, we present novel corroborating evidence that shows that lenders change screening behavior by manipulating dimensions that are unreported to investors. Finally, we highlight the challenges that confront researchers when dealing with data that involve loans supplied to both prime and subprime markets by different lenders. In doing so, we provide a methodology to correctly calculate the securitization rate and time to securitize for different markets.[4]

[4] Bubb and Kaufman (2009) argue that the Keys et al. (2010a) results relating securitization to lenders screening are in fact driven by a lender rule of thumb that is independent of securitization. This alternative was already considered, tested, and rejected in Keys et al. (2010a) using the passage of anti-predatory laws as a natural experiment to vary access to non-agency securities markets. Nonetheless, Keys et al. (2010b) closely examines the critique and shows that the conclusion linking securitization to differential screening holds even in the data

2. Data

The primary mortgage data used in our analysis come from the McDash/LPS database, which combines characteristics of the loan and borrower at the time of origination with monthly payment information. The McDash/LPS data contain loan-level information on unsold loans, loans securitized by GSEs, and loans securitized through private investors. The data set includes all standard loan application variables, such as the loan amount, loan-to-value (LTV) ratio, FICO credit score, and interest rate.

We assess borrower creditworthiness using two measures. First, FICO scores provide a ranking of potential borrowers by the probability of having some negative credit event in the next two years, with nearly all scores between 500 and 800 (see Avery et al. 1996). Second, borrower quality can also be gauged by the level of documentation collected by the lender when taking the loan. Documentation in the market (and reported in the database) is categorized as full, limited, or no documentation. Borrowers with full documentation verify both income and assets. Borrowers with limited documentation usually provide no information about their income but do provide some about their assets. "No-documentation" borrowers provide no information about income or assets, which is a very rare degree of screening lenience on the part of lenders. In our analysis, we combine limited and no-documentation borrowers and call them low-documentation borrowers. Our results are unchanged if we remove the very small portion of no-documentation loans.

Finally, the data set contains information about the property being financed by the borrower and the purpose of the loan. Specifically, we have information on the type of mortgage loan (fixed rate, adjustable rate, balloon, or hybrid), the LTV ratio, and the zip code of where the dwelling is located. Typically, loans are classified as either for purchase or for refinance, though in this article we focus exclusively on loans for home purchases. Most of the loans in our sample are for owner-occupied single-family residences, townhouses, or condominiums (single-unit loans account for more than 90% of the loans in our sample). Therefore, to ensure reasonable comparisons, we restrict the loans in our sample to these groups. We also drop nonconventional properties, such as those that are insured or pledged by the Federal Housing Administration (FHA) or the Veterans Administration (VA), and we also exclude buy-down mortgages. We further exclude Alt-A loans, because the coverage for these loans in the database is limited. We use only loans with valid FICO scores in our sample. We conduct our cross-sectional analysis on loans originated between January 2001 and December 2006, but we extend the window before and after the subprime mortgage boom for our time-series tests.

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used by Bubb and Kaufman—and does so only in the low-documentation non-agency market, as was the case in Keys et al. (2010a). Bubb and Kaufman pool loans across agency and non-agency markets, thus confounding their ability to make inferences about any particular segment of the market. As shown in Keys et al. (2010b) and this article, when appropriately separated, the pattern of differential screening emerges in the low-documentation non-agency market but not in the full-documentation non-agency or agency markets.

3. Theoretical Considerations and Empirical Strategy

3.1 Theoretical framework

We closely follow Keys et al. (2009) and Keys et al. (2010a) to develop the framework for our analysis. When a borrower approaches a lender for a mortgage loan, the lender asks the borrower to fill out a credit application. In addition, the lender obtains the borrower's credit report from the three credit bureaus. Part of the background information on the application and report could be considered "hard" information (e.g., the borrower's FICO score), whereas the rest is "soft" (e.g., a measure of future income stability of the borrower, how many years of documentation were provided by the borrower, joint income status) in the sense that it is less easy to summarize on a legal contract. The lender expends effort to process the soft and hard information about the borrower and, based on this assessment, offers a menu of contracts to the borrower.

Subsequently, the borrower decides to accept or decline the loan contract offered by the lender. Once a loan contract has been accepted, the loan can be sold as part of a securitized pool to investors. Notably, only the hard information about the borrower (FICO score) and the contractual terms (e.g., LTV ratio, interest rate) are used by investors when buying these loans as part of a securitized pool. Therefore, although lenders are compensated for collecting the borrower's hard information, the incentive for lenders to process soft information critically depends on whether they have to bear the risk of loans they originate (e.g., Parlour and Plantin 2008; Rajan, Seru, and Vig 2008).

The central claim in this article is that lenders are less likely to expend effort to process soft information as the ease of securitization increases (for more details, see Keys et al. 2010a). Because investors purchase securitized loans based on hard information, our assertion is that the cost of collecting soft information is internalized by lenders when screening borrowers at 620− to a greater extent than at 620+. By focusing on the lender as a unit of observation, we attempt to learn about the differential impact that ease of securitization had on the behavior of lenders around the cutoff. We hope to capture this differential lender behavior by comparing the performance of portfolios of loans on either side of the credit score that have nearly identical risk profiles.

3.2 Exogenous variation in "ease of securitization"

We exploit a specific *rule of thumb* at the FICO score of 620 that makes the securitization of loans more likely if a certain FICO score threshold is attained. This score was established as a minimum threshold in the mid-1990s by Fannie Mae and Freddie Mac in their guidelines on loan eligibility. Guidelines by Freddie Mac suggest that FICO scores below 620 are placed in the *Cautious Review Category*, and Freddie Mac considers a score below 620 "as a strong indication that the borrower's credit reputation is not acceptable" (Freddie Mac 2001, 2007). This is also reflected in Fair Isaac's statement that "those agencies

[Fannie Mae and Freddie Mac], which buy mortgages from banks and resell them to investors, have indicated to lenders that any consumer with a FICO score above 620 is good, while consumers below 620 should result in further inquiry from the lender.“ Although the GSEs actively securitized loans when the nascent subprime market was relatively small, this role has shifted entirely to investment banks and hedge funds (the non-agency sector) in recent times.

Adherence to this cutoff by subprime mortgage-backed security (MBS) investors, following the advice of GSEs, could generate an increase in demand for securitized loans that are just above the credit cutoff relative to loans below this cutoff (see Keys et al. 2010a for more discussion).

3.3 Measuring “ease of securitization”

To understand what we mean by “ease of securitization,” consider the following decomposition of the unconditional probability that a given loan is securitized, $P(S = 1)$, as discussed in Bubb and Kaufman (2009):

$$P(S = 1) = P(A = 1)^* P(L = 1|A = 1)^* P(S = 1|A = 1, L = 1),$$

where $P(A = 1)$ is the application rate, $P(L = 1|A = 1)$ is the acceptance rate of the lender, and $P(S = 1|A = 1, L = 1)$ is the conditional securitization rate. We expect greater ease with which lenders can access securitization markets to potentially show up on three fronts. First, we expect these changes to show up in the conditional securitization rates, $P(S = 1|A = 1, L = 1)$. Second, we expect any increase in liquidity of a loan due to easy access to securitization market to show up in the time it takes to securitize a given loan. This is an aspect that may not be captured in the conditional securitization rate.

Third, and finally, there are additional factors that securitization introduces into lenders’ payoffs—such as the post-sale probability that a given loan is returned to the lender driven by audit intensity of investors. This aspect, in addition to conditional securitization rates and time to securitize a given loan, is likely to be captured in the unconditional securitization rate, $P(S = 1)$. The differences in this probability around the threshold could be proxied by the differences in number of securitized loans $N(S = 1)$ around this threshold. The underlying assumption behind this assertion is that the number of potential applicants at 620− and 620+ is similar, which seems reasonable.

In our empirical analysis, we use these three measures—the conditional securitization rate, time to securitize, and unconditional securitization rate—to capture the “ease of securitization” around the 620 threshold. Using the first two measures gives us clear channels through which ease of access to securities markets may impact the liquidity of the loan. We primarily use the time-series evolution of the third measure to assess if there was a systematic change in the ease of securitization as the market for subprime securities first expanded and then collapsed.

Furthermore, given that agency and non-agency markets differ substantially in the incentive provisions for lender underwriting (see Passmore and Sparks

2000; Kling 2009), it is important that we calculate securitization rates, time to securitize, unconditional securitization rates, and default rates separately for loans originated with the intent to sell privately in the non-agency market versus loans intended for sale to the GSEs (Keys et al. 2010b). Moreover, even among non-agency loans we must separately analyze the securitization rates of low- and full-documentation loans because the value of screening soft information in these markets varies dramatically (Keys et al. 2010a). Consequently, in our results below, we account for the heterogeneity in these markets (agency/non-agency, full documentation/low documentation) by analyzing them separately.

3.4 Empirical methodology

Our discontinuity tests are designed to empirically identify jumps in the securitization rates or time to securitize of loans across the FICO distribution. We examine the change in the conditional securitization rate, time to securitize, and unconditional securitization rate of low-documentation non-agency loans along the FICO distribution from 620− to 620+, and contrast this result with similar estimates from the agency market and the "pooled" mortgage market as a whole. We use the same approach to estimate differences in default rates around the FICO cutoff of 620 for loans in different markets.

We estimate the extent of the jump with techniques that are commonly used in the literature on regression discontinuity. Specifically, we collapse the data on each FICO score (500–800) i and estimate equations of the form

$$Y_i = \alpha + \beta T_i + \theta f(\text{FICO}(i)) + \delta T_i \cdot f(\text{FICO}(i)) + \varepsilon_i,$$

where Y_i is the average outcome at FICO score i, T_i is an indicator that takes a value of 1 at FICO $\geq$ 620 and a value of 0 if FICO $<$ 620, and ε_i is a mean-zero error term. f (FICO) and $T \cdot f$ (FICO) are flexible seventh-order polynomials, with the goal of these functions being to fit the smoothed curves on either side of the cutoff as closely to the data presented in the figures as possible. f (FICO) is estimated from 620− to the left, and $T \cdot f$ (FICO) is estimated from 620+ to the right. The magnitude of the discontinuity, β, is estimated by the difference in these two smoothed functions evaluated at the cutoff. The data are recentered such that FICO=620 corresponds to "0"; thus, at the cutoff, the polynomials are evaluated at 0 and drop out of the calculation, which allows β to be interpreted as the magnitude of the discontinuity at the FICO threshold. This coefficient should be interpreted locally in the immediate vicinity of the credit score threshold.

Our maintained claim is that any differences in performance of loans on either side of the cutoff, after controlling for hard information, should be only due to the impact that securitization has on lenders' behavior. This claim relies on two main identification assumptions:

First, as we approach the cutoff from either side, any differences in the characteristics of prospective borrowers are assumed to be random. This

implies that the underlying creditworthiness and the demand for mortgage loans (at a given price) is the same for prospective buyers with a credit score of 620− or 620+. This seems reasonable, as it amounts to saying that the calculation Fair Isaac performs (using a logistic function) to generate credit scores has a random error component around any specific score—and that the FICO distribution across the population is smooth.

Second, we assume that screening is costly for the lender. The collection of information—hard systematic data (e.g., FICO score) as well as soft information (e.g., joint income status) about the creditworthiness of the borrower—requires time and effort by loan officers. If lenders did not have to expend resources to collect information, it would be difficult to argue that the differences in performance we estimate are a result of ease of securitization around the credit threshold affecting banks' incentives to screen and monitor.

4. Empirical Evidence

4.1 Descriptive statistics

Our analysis uses more than two million mortgage loans originated between 2001 and 2006. As noted earlier, the McDash/LPS data contain information on unsold loans, loans sold to the GSEs, and loans sold to non-agency investors. In contrast to research using securitized subprime loans (such as the LP data used in Keys et al. 2010a), the sample consists of much more observably creditworthy borrowers (higher FICO scores) and lower LTV ratios. In Panel A of Table 1, we present the number of loans in our sample, separately for low and full documentation. During our sample period, the mortgage market experienced an increase in the number of loans with reduced hard information in the form of limited or no documentation. With the subprime boom, the composition of new loans shifted to lower-quality borrowers, as seen by a decline in average FICO scores for both low- and full-documentation loans in 2005 and 2006.

Panel B compares the low- and full-documentation segments of our sample on a number of the explanatory variables used in the analysis. Low-documentation loans are on average larger and given to borrowers with higher credit scores than loans where full information on income and assets is provided. However, the two groups of loans have relatively similar contract terms, such as interest rate, loan-to-value, prepayment penalties, and whether the interest rate is adjustable or not. Our analysis below is careful to analyze these two types of loans separately, as well as splitting the sample based on whether the loan is unsold, sold to GSEs, or sold privately.

4.2 Main tests

4.2.1 Ease of securitization: Conditional securitization rates. In this section, we begin by establishing whether a difference exists in ease of securitization around the FICO threshold of 620 by analyzing the first measure

Table 1
Summary statistics

Panel A: Summary Statistics by Year

	Low Documentation			Full Documentation		
	Number of Loans	Mean Loan-To-Value	Mean FICO	Number of Loans	Mean Loan-To-Value	Mean FICO
2001	17,911	77.9	704	42,713	82.1	699
2002	44,270	77.4	708	108,937	79.8	711
2003	115,651	77.6	710	292,168	79.3	715
2004	177,930	77.5	708	470,300	79.5	700
2005	204,099	78.1	704	423,926	79.1	694
2006	191,899	79.6	702	405,464	80.3	693

Panel B: Summary Statistics of Key Variables

	Low Documentation		Full Documentation	
	Mean	Std. Dev.	Mean	Std. Dev.
Average loan size ($000)	245.9	242.0	208.0	201.2
FICO score	705.6	55.8	700.1	66.4
Loan-to-Value ratio	78.2	13.5	79.6	14.5
Initial Interest Rate	5.7	1.8	6.1	1.4
ARM (%)	39.5	48.9	32.6	46.9
Prepayment penalty (%)	16.6	37.2	21.9	41.4

This table presents average characteristics of the sample of owner-occupied first-lien mortgage loans intended for purchase, originated between 2001 and 2006. All such loans that are not insured by the VA or FHA, and are not buydown loans, with valid FICO scores between 500 and 800 are included in our sample. Loans in the sample are securitized to the GSEs, privately securitized, or held on banks' portfolios. Data on home purchase loans come from LPS. During the sample period, average LTV ratios of mortgages rose slightly, while average FICO scores fell, indicative of a shift toward increased subprime activity. Low-documentation loans were larger on average, but associated with higher FICO scores. See the text for more details.

we discussed in Section 3: the conditional securitization rate of an accepted loan.

In each month of the data, one observes whether a given loan is sold to agencies, sold to non-agencies, or held on a bank's balance sheet.[5] Our objective with these data is to compute the securitization rate for the non-agency and agency markets. For the moment, let us focus on non-agency loans. For these loans, the securitization rate is

$$\text{Securitization Rate of non-agency loans} = \frac{\#\text{ of loans sold to non-agencies}}{\#\text{ of loans sold to non-agencies} + \#\text{ of loans on books.}}$$

The relevant "loans on the books" for this calculation are those that are originated with an intent to sell to non-agencies. As highlighted in Section 3, because the agency and non-agency markets differ dramatically, we want to analyze these markets separately. Moreover, even within non-agency markets

[5] The ownership status of loans (sold to agency, sold to non-agency, or bank-held) is dynamic over time as loans transition across states frequently. We take the ownership status as fixed at six months from origination, except where we focus on variation in the time to securitize. The results are robust to alternative cutoffs (e.g., twelve months).

we want to analyze the low-documentation and full-documentation markets separately. Doing this requires us to know whether the loans on banks' books were originated with an intent to sell to non-agency markets. Because this information is not available in the LPS data, reasonable assumptions are necessary to calculate a securitization rate for non-agency loans.

Our approach to separately analyze the incentives of agency and non-agency markets is to calculate the securitization rate by considering which low-documentation loans on banks' books "look like" non-agency loans. To characterize which loans look like agency loans, we run a probit regression only on sold loans that identifies which mortgage characteristics are associated with whether or not a loan is sold to the GSEs or to private investors.[6] Private loans are especially more likely to have larger loan amounts, a prepayment penalty, a non-fixed-payment structure, and higher interest rates than GSE loans. We then use the predicted values (that is, to what extent the loan is predicted to be sold to agencies or non-agencies, based on its characteristics) out of sample and apply them to the distribution of loans held in the bank's portfolio. In other words, the probit regression constructs an index (propensity score) of which characteristics make a loan more or less likely to be sold on the agency market.

Do the loans in the low-documentation sample look more like those loans sold to GSEs or loans sold to non-agencies? We plot the distribution of predicted values in Figure 1b. The distribution of "predicted GSE" characteristics for unsold low-documentation loans looks nearly identical to the distribution for non-GSE loans. A simple summary measure of these distributions further supports the results in the figure. For the loans that are in fact sold to the agency market, the predicted rate of sale to the agency market is 86% (the average of the predicted values). However, the predicted rate of sale to GSEs for loans not sold to the agency market is 26%.[7] The rate for unsold loans is 36%, which is much more similar to the non-agency distribution than the agency distribution.

We apply these predicted values as weights to the portfolio sample to recompute non-agency securitization rates. This is equivalent to a semi-parametric propensity-score reweighting approach to address the compositional issues with the unsold segment of loans (see, e.g., DiNardo, Fortin, and Lemieux 1996). In contrast to the pooled securitization rate in Figure 1a, Figure 1d documents a clear discontinuity in the low-documentation non-agency securitization rate using those unsold loans that are likely to be non-agency. The unsold loans in this segment are heavily weighted toward

[6] Specifically, the regression includes FICO score, loan-to-value ratio, interest rate, loan size, debt-to-income ratio, ARM (adjustable-rate mortgage) status, presence of a prepayment penalty, year of origination, a dummy for whether the loan was made in a high-cost state (California, Arizona, Nevada, or Florida), and whether the loan is interest only or negative amortization. As mentioned above, our sample selection criteria are non-FHA/VA, non-buydown, owner-occupied, single-family, first-lien purchase loans.

[7] If the model was perfectly predictive, these values would be 100% and 0%, respectively.

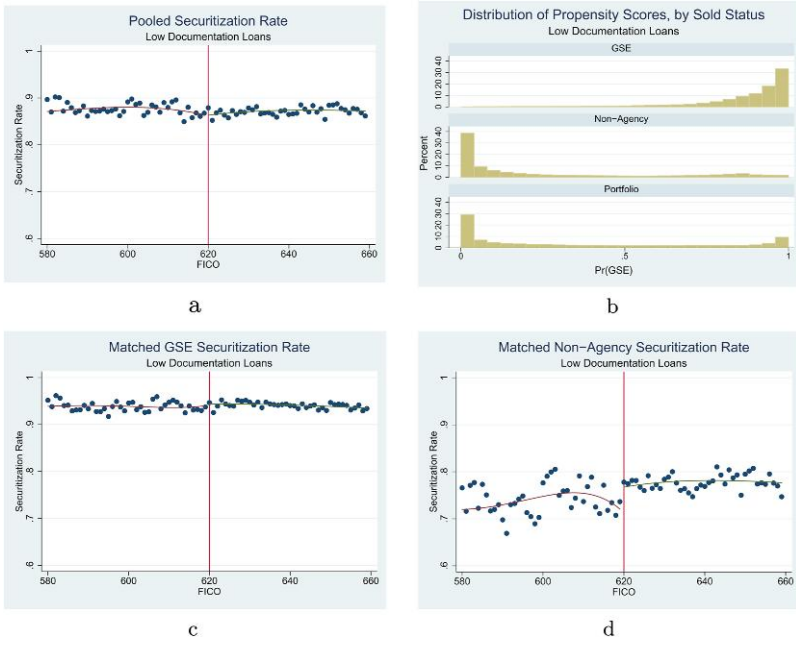

Figure 1
Pooled (non-GSE and GSE together) and separated securitization rates for low-documentation loans in the LPS database originated between 2001 and 2006
The pooled securitization rate in (a) exhibits no discontinuity around 620. Propensity score matching is used to attribute unsold loans to GSEs or to non-GSEs (Method 1). The distribution of loans based on their likelihood of being sold to the GSEs is shown in (b). Portfolio loans are unsold loans on books of banks, and their distribution is very similar to that of non-agency loans. When these propensity scores are applied to separately calculate agency (c) and non-agency (d) securitization rates, the figures show that there is no jump in GSE securitization rates at 620, while there is a large and significant jump in the non-agency securitization rate at the threshold.

the non-agency market, and the estimated discontinuity in the securitization rate is 5.5%, as shown in Panel A of Table 2.[8] Once unsold loans are appropriately classified, a large discontinuity in the low-documentation non-agency securitization rate is apparent. This suggests that low-documentation loans being sold to the non-agency market are confronted with discontinuous access to the secondary market at the FICO=620 threshold.

At the same time, we observe no discontinuity in securitization rates for low-documentation loans sold to GSEs at the 620 cutoff. Figure 1c shows the reweighted securitization rate for the GSEs, with no estimated difference around FICO=620. Moreover, the securitization rates for GSE loans are high, as might be expected (see Chomsisengphet and Pennington-Cross 2006), an average of 92% compared with 74% in the non-agency market. Finally, this also explains why we do not observe a jump in the securitization rate when

[8] All estimated regression discontinuity coefficients mentioned in the text and figures are unreported for brevity. These results are available upon request.

Table 2
Estimated regression discontinuities

Panel A: Conditional Securitization Rates

	Low Documentation Loans			
	Pooled	Non-agency	Matched Non-agency	Matched GSE
$\beta_{FICO=620}$	0.001	0.074***	0.055***	0.002
(SE)	(0.009)	(0.022)	(0.017)	(0.007)

	All Loans (low, full, missing)			
	Pooled	Matched Lowdoc Non-agency	Matched Fulldoc non-agency	Matched GSE
$\beta_{FICO=620}$	0.008	0.044***	−0.002	0.020
(SE)	(0.004)	(0.017)	(0.005)	(0.007)

	Jumbo		Non-Jumbo	
	Pooled	Non-agency	Pooled	Non-agency
$\beta_{FICO=620}$	0.061***	0.062***	0.008***	0.010***
(SE)	(0.017)	(0.017)	(0.004)	(0.005)

Panel B: Months to securitize non-agency low documentation loans

	Non-agency	Agency
$\beta_{FICO=620}$	−1.17***	−0.40***
(SE)	(0.21)	(0.10)

Panel C: Default Rates

	Low Documentation Loans			
	Pooled	Non-agency	Matched Non-agency	Matched GSE
$\beta_{FICO=620}$	0.052***	0.080***	0.071***	0.007
(SE)	(0.012)	(0.021)	(0.021)	(0.013)

	All Loans (low, full, missing)			
	Pooled	Matched Lowdoc Non-agency	Matched Fulldoc non-agency	Matched GSE
$\beta_{FICO=620}$	0.019***	0.063***	0.003	0.009
(SE)	(0.006)	(0.021)	(0.006)	(0.008)

	Jumbo		Non-Jumbo	
	Pooled	Non-agency	Pooled	Non-agency
$\beta_{FICO=620}$	0.049***	0.053***	0.017***	0.028***
(SE)	(0.020)	(0.020)	(0.006)	(0.006)

This table presents estimates of the magnitude of the discontinuity at FICO=620 for securitization rates, delinquency rates, and average time to privately securitize. All reported coefficients are estimated using fifth-order polynomials on either side of the discontinuity. The "pooled" category combines loans sold to GSEs and non-agency investors. Propensity score reweighting (based on the likelihood of being sold to the GSEs) is used in the columns denoted "Matched" to attribute unsold loans to GSEs or non-GSEs. Separate estimates for non-agency markets are calculated with the assumption that all mortgages that meet the GSE loan requirements are sold to the GSEs. Heteroscedasticity-robust standard errors are reported in parentheses. Data are from the LPS/McDash database. See the text for the sample selection. ***, **, and * represent significance at 1%, 5%, and 10%, respectively.

we analyze the agency and non-agency loans together in Figure 1a—the lack of differential access to securities in the GSE market around the FICO cutoff swamps the differences in access to securities in the low-documentation non-agency market.

To underscore the importance of looking at low-documentation loans in the non-agency sector, we perform a similar reweighting exercise with all of

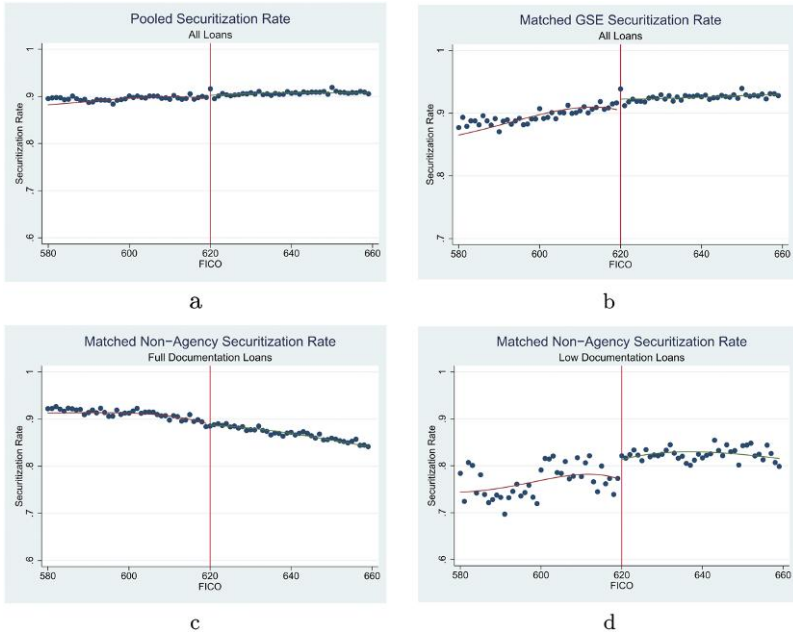

Figure 2
Pooled (non-GSE and GSE together) and separated securitization rates for all loans in the LPS database originated between 2001 and 2006
The pooled securitization rate for all loans is shown in (a) and is smooth through FICO=620. Propensity score matching is used to attribute unsold loans to GSEs or to non-GSEs (Method 1). When propensity scores are applied to separately calculate securitization rates, the GSE loans (b) and full-documentation non-agency loans (c) have no differences around 620, while there is a large discontinuity in securitization rates for low documentation non-agency loans (d).

the loans in the LPS/McDash purchase sample, regardless of documentation status. The results are shown in Figure 2. This decomposition method shows that there are no differences in securitization rates for GSE loans around the 620 threshold (Figure 2b). Moreover, within non-agency loans, there is no difference in securitization rate around the cutoff for full documentation loans (Figure 2c). It is only in the non-agency low-documentation sample of loans that we find a difference in the willingness of investors to purchase loans on either side of the 620 threshold (Figure 2d). The formal estimates corresponding to these figures are presented in Panel A of Table 2.

4.2.2 Ease of securitization: Time to securitize. As mentioned in Section 3, a lender's ex ante screening effort depends both on the securitization rate and on the payoffs conditional on securitization. An additional aspect of securitization that lenders may consider is the time it takes to securitize a loan. The longer it takes for a loan to be securitized, the costlier it may be for the bank. This cost could come from the opportunity cost to the bank of not being able to invest elsewhere. In addition, if the loan becomes delinquent before it is

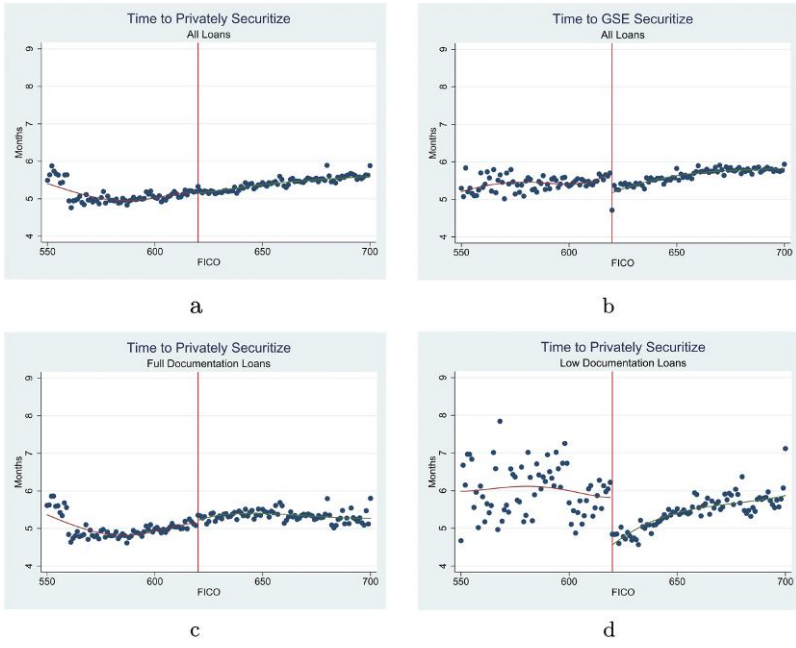

Figure 3
Average time for loans in the LPS database originated between 2001 and 2006 to be securitized
The longer it takes for a loan to be securitized, the costlier it may be for the bank. This cost could come from the opportunity cost to the bank of not being able to invest elsewhere. In addition, if the loan becomes delinquent before it is securitized, the likelihood of subsequent securitization is reduced dramatically. For the pooled (non-GSE and GSE together) sample (a), and full documentation non-GSE sample (c), there are no differences in the time to securitize around the 620 threshold. For the GSE sample (b), there is a small decrease in the time to securitize at FICO=620. In contrast, there is a large discontinuity in the average time to securitize for the low documentation non-agency sample (d).

securitized, the likelihood of subsequent securitization is reduced dramatically (see Piskorski, Seru, and Vig 2009). If so, this would further tie up the bank's capital on its balance sheet. In other words, a longer time to securitize carries with it inventory (or "warehouse") risk, and this inventory risk could provide the appropriate incentives for lenders to screen borrowers carefully. More importantly, these costs could vary with loan characteristics (such as FICO) and impact the payoff a lender faces even if the loan is eventually securitized.

To illustrate how the time to securitize varies around the 620 threshold, we plot the variable constructed from time of origination to time of first securitization for non-agency low-documentation loans.[9] As shown in Figure 3d, there is a large decrease in the time it takes to securitize a low-documentation non-agency loan around the FICO threshold in the LPS data. In particular, it

[9] To capture the heterogeneity in the timing of securitization, we allow the time of first securitization to be anytime in the first forty-eight months after origination, although qualitatively similar results hold with shorter time horizons.

takes about one month longer to securitize a loan that is just below 620 than a loan just above 620 (on a base of six months). In sum, the loans just below 620 take roughly 16% longer on average to be sold. Notably, there is very limited evidence for differential time to securitize in the agency market (there is a small jump for GSE loans at FICO=620 in Figure 3b) and in the full documentation non-agency market (no jump in Figure 3c).[10]

How costly is it for lenders to keep low-documentation non-agency loans for an extra 25% longer on their balance sheet? Using the data from McDash/LPS on defaults by month of origination, we can compare the differences in defaults from the average time to securitize for 620+ (roughly five months after origination) to the average time to securitize for loans with FICO scores at 620− (roughly six months). Between month 5 and month 6, an average of 3.6% of low-documentation non-agency loans enter some stage of delinquency (thirty days or more delinquent). On a base of 21% thirty-day delinquency rates five months after origination for this sample, this is an increase of 17%. For sixty-day delinquencies, the increase is even larger, 23.7% (an increase of 2.2% on a base of 9.3%). The lender directly bears the cost of these additional defaults, as it makes it difficult for these loans to be subsequently sold (or, in some cases, sold at a discount). This calculation shows that there is a significant cost to additional time to securitize from the lender's perspective, which could directly affect their origination and screening decisions. Note that these losses are in addition to the opportunity cost that lenders bear for having their capital tied up for an additional month.

4.2.3 Differences in screening: Default rates. Following the methods above, we examine default rates and find dramatic differences in underwriting standards across loans in the agency and non-agency markets. The pooled low-documentation default rate across the FICO distribution presented in Figure 4a obscures the differences between the two markets. When unsold loans are attributed to the appropriate market, the data in Figure 4c clearly show that the jump in default rates at FICO $=$ 620 in pooled data is driven solely by low-documentation non-agency loans. The estimated difference in low-documentation non-agency default rates around 620 is 7.1 percentage points (see Panel C of Table 2). In contrast, in the GSE market, there is no difference in default rates at FICO $=$ 620 (Figure 4b).

These patterns obtain in any comparable cut of the LPS data and show how pooling can obscure the differences in non-agency and agency markets. This pooling of data across markets was the central driver of confounded

[10] As is shown in the next section, the jump for GSE loans is not large enough to induce differences in default rates across the threshold. As an additional check on the differences in warehouse risk around the FICO threshold, we obtained data from a competitor of LPS on the time to securitize mortgages found in subprime private pools (this data set corrects for the "imputed origination date" problem that plagues several data sets). Results suggest a similar striking decrease in the time to securitize for low-documentation loans at FICO=620. Loans just below 620 stay on lenders' balance sheets for 25% longer than loans just above 620.

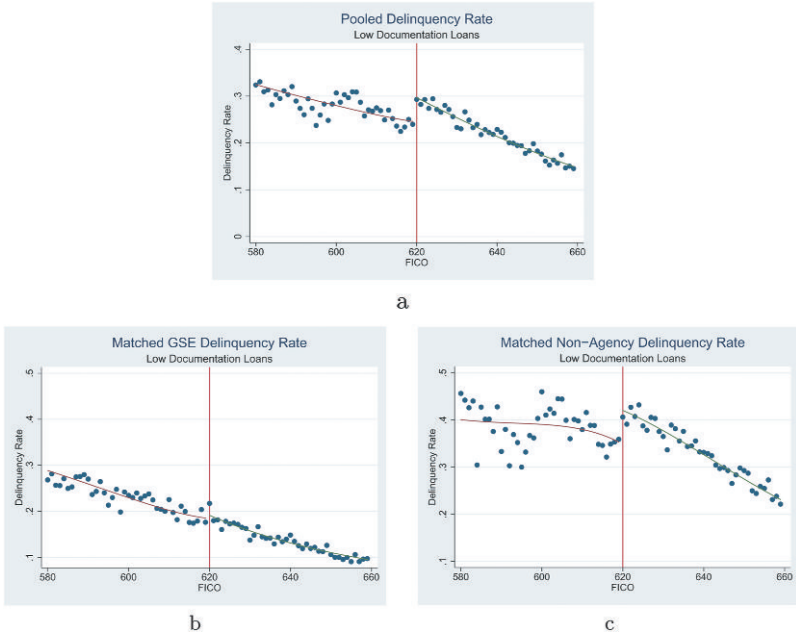

Figure 4
Pooled (non-GSE and GSE together) and separated 60+ day delinquency rates for low-documentation loans in the LPS database originated between 2001 and 2006
The pooled delinquency rate in (a) exhibits a large discontinuity around 620. Propensity score matching (using the distribution shown in [b]) is used to attribute unsold loans to GSEs or to non-GSEs (Method 1). When these propensity scores are applied to separately calculate agency (b) and non-agency (c) delinquency rates, the figures show that there is no jump in GSE delinquency rates at 620, while there is a large and significant jump in the non-agency delinquency rate at the threshold.

inferences made in Bubb and Kaufman (2009)—as was clarified in Keys et al. (2010b). Reweighting loans on the basis of their ex ante characteristics exposes differences in the ease of securitization and loan performance around the 620 threshold in the low-documentation part of the non-agency market, while revealing no such pattern in the agency market or full-documentation part of the non-agency market.[11]

4.2.4 Robustness: Alternative method for computing securitization rate and default rates. We now provide an alternative method of attributing unsold loans to a particular market that is simpler to implement than the first method (and does not require any parametric assumptions), though it also makes some limiting assumptions. In a given low-documentation segment of the market dominated by non-agency sales, this method (Method 2) designates

[11] Also see Keys et al. (2010b) for detailed discussion on the reason why pooling of loans across markets leads to more dampening of discontinuities around the 620 threshold for conditional securitization rates than it does for default rates.

all unsold loans to the non-agency market. This unweighted assignment exploits the fact that a large share of the lending in agency and non-agency markets is done by specialized lenders, and that for virtually all mortgages that meet the agency loan requirements, it may be advantageous for lenders to sell the loans to the GSEs.[12] However, one has to be careful to apply this method to low-documentation segments that are non-agency-dominated—otherwise the issues with pooling across markets (agency and full-documentation non-agency loans) reemerge.

We use this method to compute the non-agency securitization rate for low-documentation loans. As Figure 5a shows, there is no discontinuity in the total low-documentation securitization rate. However, as shown in Figure 5b, when the securitization rate is recomputed for low-documentation non-agency loans by removing those loans sold to the GSEs, we observe a large and significant discontinuity at the FICO score of 620. This evidence is consistent with the estimate reported in Krainer and Laderman (2009), who use LPS data from home purchase loans originated in California and find a discontinuity of 4.5 percentage points at FICO=620, the only significant jump in the non-agency securitization rate distribution. Correspondingly, as is shown in Figures 5c and 5e, all of the discontinuity in pooled default rates is driven by the discontinuity in default rates for non-agency loans (roughly 8%). Consistent with the results reported using propensity score reweighting, there is no estimated discontinuity in agency loan performance at 620 (Figure 5d).

Next, we use Method 2 to examine the market for jumbo loans, a segment that is dominated by loans sold to non-agencies. Because of its detachment from the oversight of the GSE market, the jumbo market has been studied extensively (see, e.g., Loutskina and Strahan 2009). Using the FICO=620 methodology of Keys et al. (2009) and Keys et al. (2010a), Bubb and Kaufman (2009) also explore the dynamics of the jumbo market., but they pool loans across documentation types. As reported in Table 1, less than 3% of all jumbo loans in the LPS database are sold to the agency market (and even these are likely misclassified). More importantly, the low-documentation jumbo loan segment has fewer than 2% of loans sold to the agency market. Consequently, examining the low-documentation jumbo loan segment offers a subsample that is essentially free of pooling across agency and full-documentation non-agency loans. Figure 6 shows the securitization and default rate for this segment, documenting a large and significant discontinuity in the low-documentation jumbo non-agency securitization rate of 22.7% (Figure 6b) and default rate

[12] An alternative justification for the assumption that bank-held loans are largely originated with an intent to sell to the non-agency market is the role of the automated underwriting system in lender decision-making. In particular, since most GSE purchases occur only if the loan satisfies the criteria in their automated underwriting system, lenders can check whether a given loan meets the GSE criteria even before it is originated. For loans that do not meet the criteria, the lender would then screen based on the ease with which the loan eventually would be sold to the non-agency market. Using this idea, one could potentially apply the arguments above to the low-documentation market (with a sufficient sample of non-agency loans) without relying on lender segmentation.

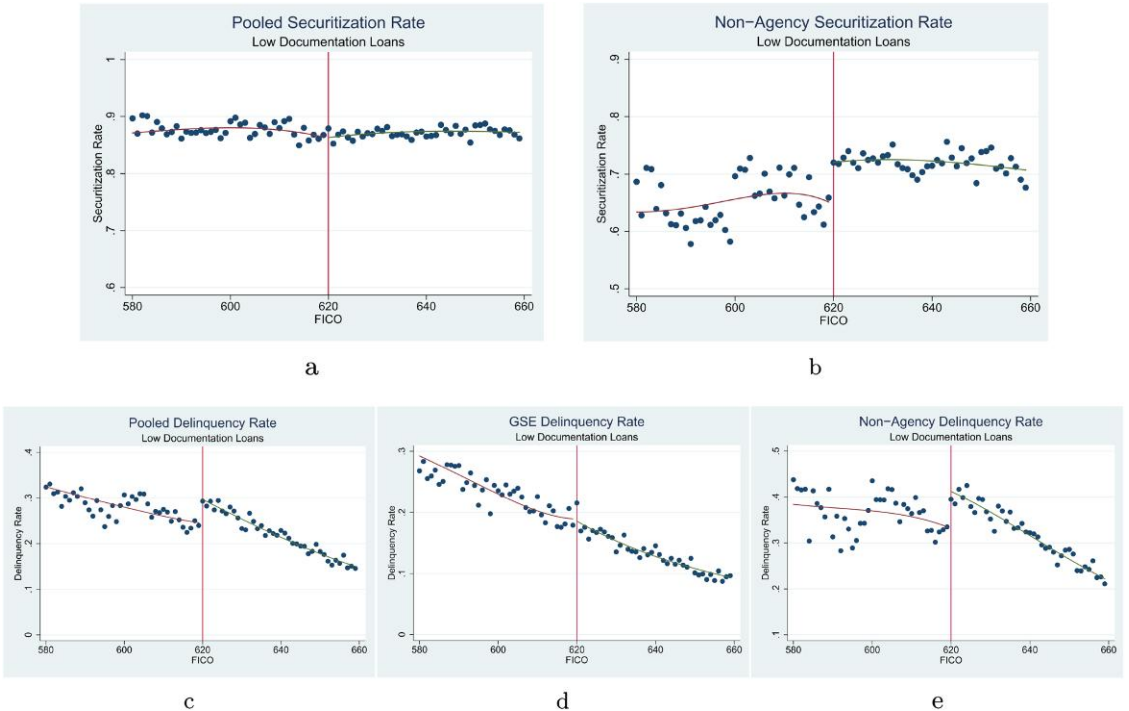

Figure 5
Pooled (non-GSE and GSE together) and separated securitization and default rates for low-documentation loans in the LPS database originated between 2001 and 2006
The separated securitization and delinquency rates are constructed assuming that all mortgages that meet the GSE loan requirements are sold (Method 2). Figure 5(b) shows that the pooled securitization rate obscures a large jump in the low-documentation non-agency securitization rate, while (d) and (e) present the smooth agency delinquency rate and discontinuity in non-agency delinquency rates.

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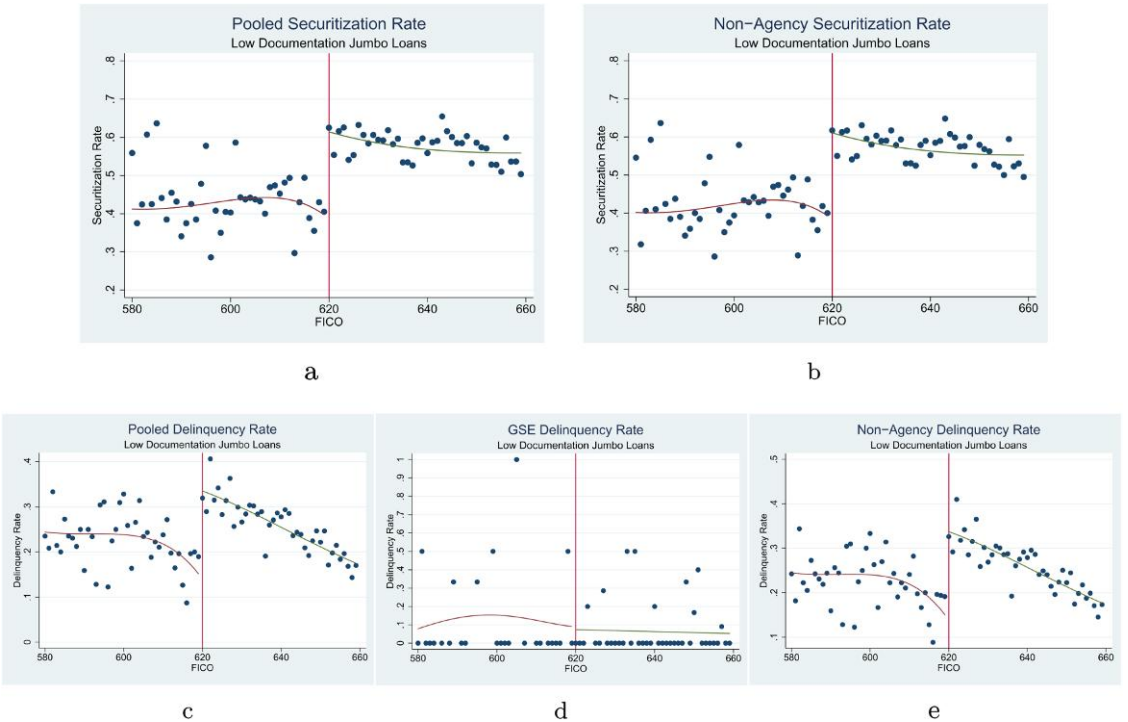

Figure 6

Pooled (non-GSE and GSE together) and separated securitization and default rates for low-documentation jumbo loans in the LPS database originated between 2001 and 2006

The pooled graphs, (a) for securitization, (c) for delinquency, show that combining loans across markets can be misleading. The separated securitization and delinquency rates are constructed assuming that all mortgages that meet the GSE loan requirements are sold (Method 2). Figure 6(b) shows a large jump in the low-documentation non-agency securitization rate, while (d) and (e) present the smooth agency delinquency rate (albeit noisily measured due to extremely low sample size) and sharp discontinuity in non-agency delinquency rates.

of 19.5% (Figure 6e) at the FICO score of 620. In contrast, there is no such discontinuity in the full-documentation jumbo loan segment (Figure 6d).

We can extend the same methodology to other subsamples that are dominated by low-documentation non-agency loans. For instance, we can analyze low-documentation loans with adjustable interest rates (ARMs), because very few of these loans seem to be intended for the agency market (Table 1). We observe a sharp discontinuity in the willingness of investors to purchase these loans around FICO=620 as well as in the default-rate differences around the cutoff (not shown for brevity). Similar results obtain in other subsamples with similar features (e.g., low-documentation loans with option ARMs or low-documentation loans with a prepayment penalty are predominantly non-agency; see Table 1).

Finally, to illustrate the confounding effects of pooling across markets, we can further contrast the findings in the low-documentation non-agency segment of the market with results from segments that are dominated by agency or non-agency full-documentation loans. In Figures 7a and 7c, we plot the pooled securitization and default rates in the non-jumbo "conforming" market (about 68% of loans in this segment are agency loans; see Table 1).[13] The pooled data suggest a jump in default rates but no jump in securitization rates. However, these patterns are driven by pooling of low-documentation non-agency loans with agency and non-agency full-documentation loans. In particular, using Method 2, we find that the usual pattern emerges when we separate the non-agency low-documentation loans from the pooled "conforming" market data. The agency market shows no difference in the default rate (Figure 7d), while the non-agency low-documentation loans exhibit a sharp discontinuity in the non-agency securitization rate of 6.6% and 4.8% in the default rate (Figures 7b and 7e, respectively).[14] Correspondingly, the full-documentation non-agency loans show no discontinuities in securitization rates or default rates (not shown). These findings again confirm that the aggregate jump in defaults is driven entirely by low-documentation non-agency loans. Formal estimates corresponding to analysis in this section are presented in Table 2 (Panels A and C).

4.2.5 Additional evidence using loan-level data from two large subprime lenders. To provide additional evidence on the connection between securitization rates and default rates among low-documentation non-agency loans, we obtained data from two large subprime lenders (who requested anonymity) to estimate their securitization rates and default rates across the FICO distribution. These two lenders made up roughly 10% of the non-agency

[13] Note that these loans are not truly "conforming" in other dimensions of the loan and may still be intended for sale in the non-agency market.

[14] These estimates are based on a sample that combines both purchase and refinancing loans, as sample sizes for low-documentation non-jumbo loans assigned to non-agency are relatively small. Nonetheless, the results are qualitatively similar for purchase loans only.

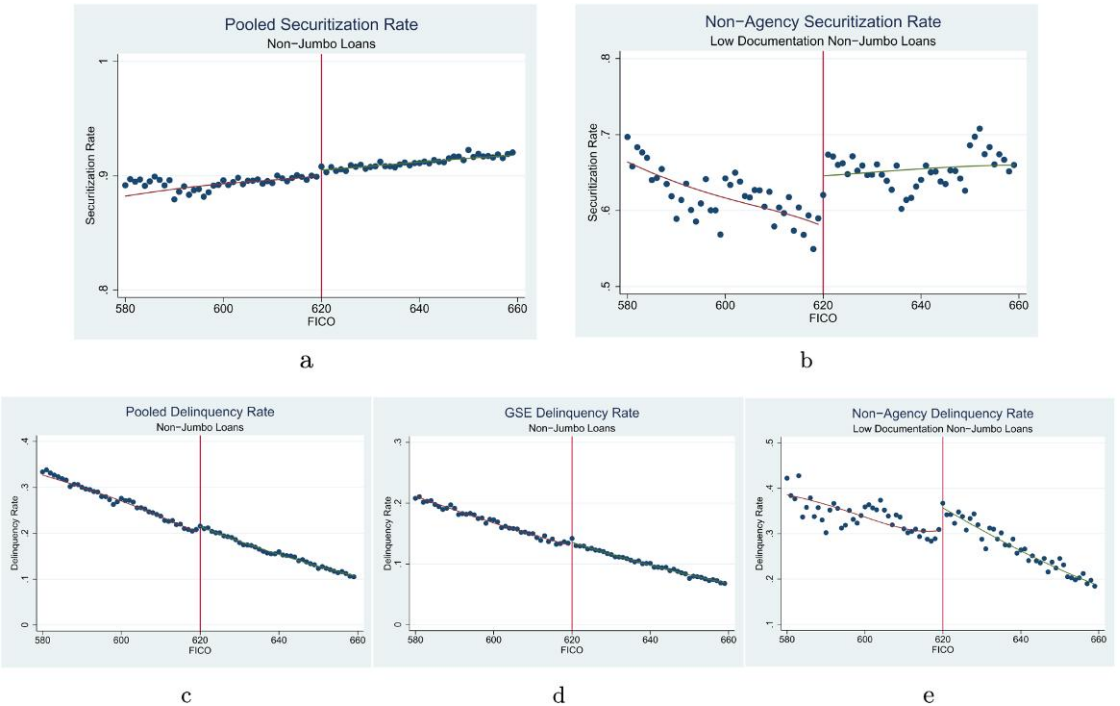

Figure 7

Pooled (non-GSE and GSE together) and separated securitization and default rates for non-jumbo loans in the LPS database originated between 2001 and 2006

The separated securitization and delinquency rates are constructed assuming that all mortgages that meet the GSE loan requirements are sold (Method 2). Figure 7(b) shows a large and significant difference in non-agency securitization rates around the threshold. For delinquencies, there is no discontinuity for agency loans (d), whereas there is a large jump in the delinquency rate for non-agency low-documentation loans around the threshold (e). Non-agency full-documentation loans show no jump in default rates (unreported).

market and were almost exclusively focused on subprime originations. We use the "alternative" method highlighted in Section 4.2.4 to assign unsold loans to the subprime market. Note that we do not have to make any assumptions because there is no ambiguity on the market for which these loans are largely intended.

As shown in Figure 8, we observe a discontinuity in the low-documentation securitization rate of 2.8% in the loans that Lender Y originated around a FICO score of 620, and a 1.7% discontinuity in the rate of low-documentation securitization at FICO=620 for Lender X (Figures 8a and b). This result is also confirmed in the analysis of Jiang, Nelson, and Vytlacil (2009), who use data from an anonymous large subprime lender. In fact, the graphs look very similar to the non-agency low-documentation securitization rates calculated using LPS/McDash data when the pooling of agency and non-agency loans is taken into account. Correspondingly, there is also a jump in default rates for these lenders around the 620 threshold, as shown in Figures 8c and 8d.

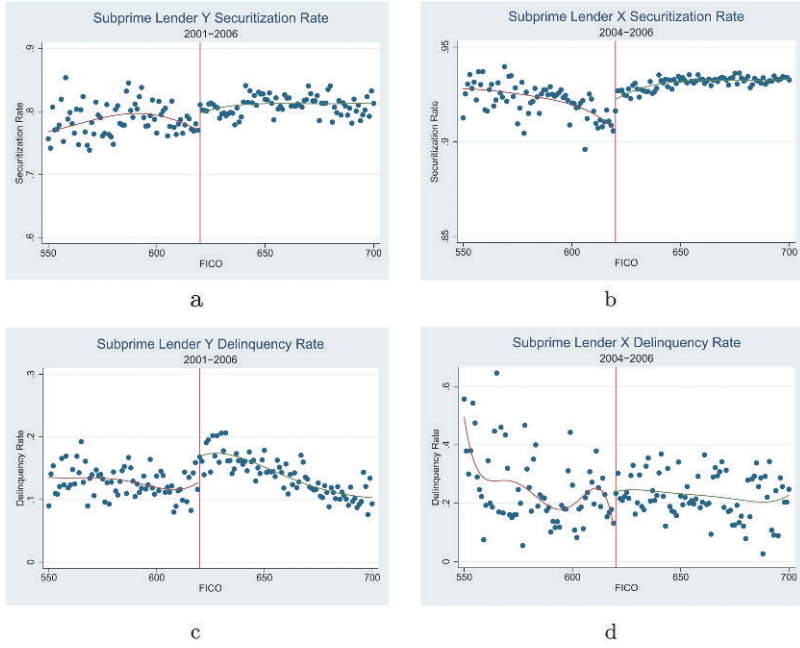

Figure 8
Securitization and sixty-day-plus delinquency rates for low-documentation loans of two large subprime lenders (names withheld)
Both the lenders were among the top twenty largest subprime lenders in the United States as of 2006. The sample consists of loans originated between 2001 and 2006 for Lender Y, and 2004 and 2006 for Lender X. Figures 8(a) and (b) show that both lenders securitized a greater fraction of their loans just above the 620 threshold. Figures 8(c) and (d) show that loans just above the 620 threshold were more likely to default than just below it, a pattern that holds for both lenders.

4.2.6 Robustness: Accounting for lender heterogeneity. Though the previous section already highlights that the results hold for two large lenders, one might worry that our other results are influenced by lender heterogeneity. Though LPS does not have information on individual lenders, we use information on loan observables (such as loan issuance date and location) to match the information obtained through the Home Mortgage Disclosure Act (HMDA), which includes lender IDs.

Once lenders are linked to each loan, we can analyze whether our results can identify lender heterogeneity by sorting lenders by the "ease of securitization" in the low-documentation non-agency market and examining if the differences in screening vary monotonically with "ease of securitization." We next present analysis showing that this is indeed the case.

We first sort lenders into groups based on the magnitude of the discontinuity in the number of securitized low-documentation non-agency loans around 620 (unconditional securitization rate). We choose the third measure to sort the lenders because, as argued in Section 3, the unconditional securitization rates capture potentially all the elements through which securitization may impact lenders' screening behavior. When the lenders are sorted into two groups along these lines (Figure 9a), the relationship among unconditional loans originated, securitization rates, and default rates for these loans is clear. In Figures 9b and 9c (estimates reported in Table 3), we show that there are large discontinuities in securitization rates, time to securitize, and default rates of low-documentation non-agency default among precisely those lenders with the largest discontinuities in the number of low-documentation loans securitized.

5. Unconditional Securitization Rate

As we argued earlier, securitization introduces other dimensions, in addition to conditional securitization rates and time to securitize, that may impact lenders' payoffs—and hence their screening effort. These factors could include the securitization-induced post-sale probability that a given loan is returned to the lender, driven by investors' audit intensity. Alternatively, other aspects could include changes in acceptance procedures internalized by lenders that are driven by securitization. We suggest that these factors are likely to be captured in another broad measure of ease of securitization—the unconditional securitization rate—that we employed previously in Keys et al. (2009) and Keys et al. (2010a). The measure has a downside in that it may also capture factors that are not driven by securitization. Accordingly, we begin this section by first validating that this measure indeed captures "ease of securitization."

We do so by showing that the unconditional securitization rate systematically changed as the market for non-agency low-documentation loans expanded and then collapsed. In particular, we analyze periods when there were limited opportunities for lenders to securitize to the non-agency sector and show that during this period there were no or small discontinuities in the

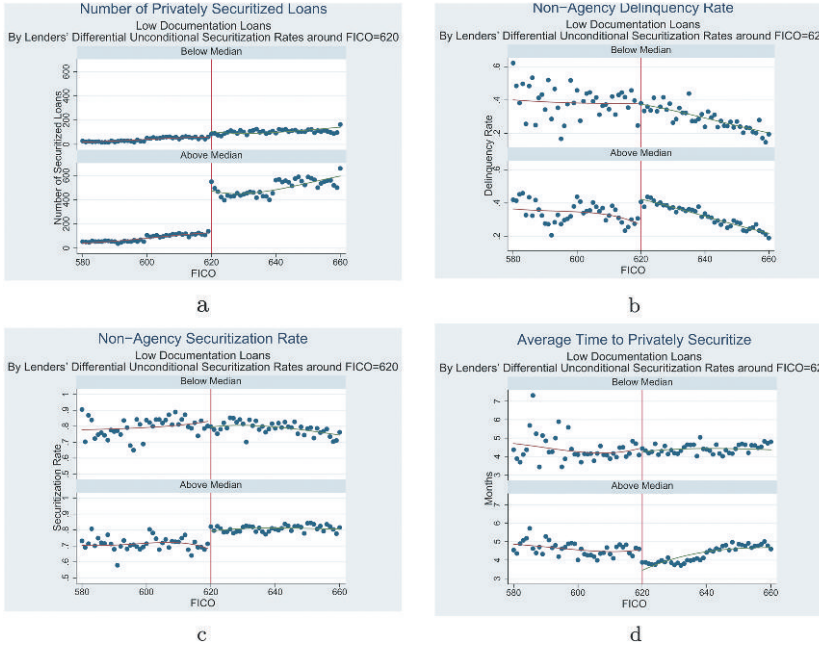

Figure 9
Number of securitized loans for low-documentation loan subsamples formed on the basis of differential unconditional securitization rates around FICO of 620
The figure depicts the number of (a) securitized loans (i.e., unconditional securitization rates), (b) default rates, (c) conditional securitization rates, and (d) time in months it takes to securitize loans for low-documentation loan subsamples formed on the basis of differential unconditional securitization rates around FICO of 620. Group 1 (2) consists of loans originated by lenders that have below (above) median differential unconditional securitization rates around the 620 cutoff. Propensity score matching is used to attribute unsold loans to GSEs or to non-GSEs. The discontinuity in delinquency rates around the cutoff increases as the ease of securitization (measured by conditional securitization rates and the time it takes to securitize a loan) increases across the two samples. The figure uses loans from the LPS database originated between 2001 and 2006.

number of loans securitized (i.e., in the unconditional securitization rate). We document this empirical regularity both before and after the subprime boom. In contrast, during the ramp-up of securitization, one observes progressively larger jumps in securitized loans—reflecting increasing ease of securitization from 2001 to 2006.

This temporal variation in the non-agency market also allows us to confirm that lender screening responded to "ease of securitization" as measured by unconditional securitization rates. We do so by showing that the default differences around the threshold follow a similar pattern as unconditional securitization rates. Note that because the primary data set used in our analysis does not have a reliable coverage of subprime loans going back in time, we employ an alternative data set (LoanPerformance) to capture the coverage of subprime loans. This data set has been used previously by Keys et al. (2010a) and is described in more detail there.

Table 3
Discontinuities in default and securitization rates in subsamples by lenders' differential number of securitized low-documentation loans around FICO=620

	(1) Low Unconditional Securitization Rate (below median)	(2) High Unconditional Securitization Rate (above median)
Number of Loans	47.8***	346.3***
	(9.7)	(20.0)
Default Rate	−0.006	0.155***
	(0.066)	(0.029)
Securitization Rate	−0.039	0.116***
(conditional rate)	(0.050)	(0.022)
Time to Securitize	−0.220	−1.14***
	(0.526)	(0.224)

This table presents discontinuity estimates in subsamples formed using lenders' differential number of securitized loans (i.e., unconditional securitization rates) around FICO of 620. Individual lenders are sorted based on the magnitude of the discontinuity in the number of loans securitized around 620. Lenders are identified by matching LPS to HMDA using loan characteristics. Propensity score matching is used to attribute unsold loans to GSEs or to non-GSEs. The sample consists of loans originated between 2001 and 2006. For lenders who have the largest differential behavior in securitized loans around FICO=620, they also have the largest differences in securitization rates and default rates. ***, **, and * represent significance at 1%, 5%, and 10% respectively.

5.1 Validation of unconditional securitization measure

5.1.1 Pre-subprime boom, 1997 to 2000, and growth years, 2001 to 2006.

In the years prior to the housing boom, the subprime market was in its infancy. Although increases in homeownership rates began in the mid-1990s, there was relatively little demand for subprime asset-backed securities (ABS) in the investor market (see Gramlich 2007). In this pre-boom period, securitizing loans in this market was relatively difficult and, as Figure 10a shows using the LoanPerformance data, relatively few subprime loans were sold on the secondary market.

As is shown in the top panel of Figure 10a, during the period 1997–2000, there is no difference in the unconditional number of low-documentation loans securitized around 620, suggesting that the ease of securitization on either side of the 620 cutoff is highly constrained by demand for subprime ABS. At the same time, as shown in the bottom panel of Figure 10a, there is no differential performance of low-documentation loans around 620 during 1997–2000 (see Panel A of Table 4). This evidence suggests that when securitization markets were relatively limited, the 620 cutoff rule did not affect lender behavior in terms of screening standards.[15]

We now extend the LP data to study the time-series movement in jumps of unconditional low-documentation loans as well as the jumps in defaults of loans around the 620 threshold. Figures 10b and 10c plot the progressive discontinuities in the number of loans securitized and in the default rates across

[15] Most large lenders who were active in the non-agency market during the 1997–2000 period were also active in the subprime boom period (2001–2006). Consequently, this pattern is not likely to be driven solely by different lenders entering the subprime market in the post-2000 period.

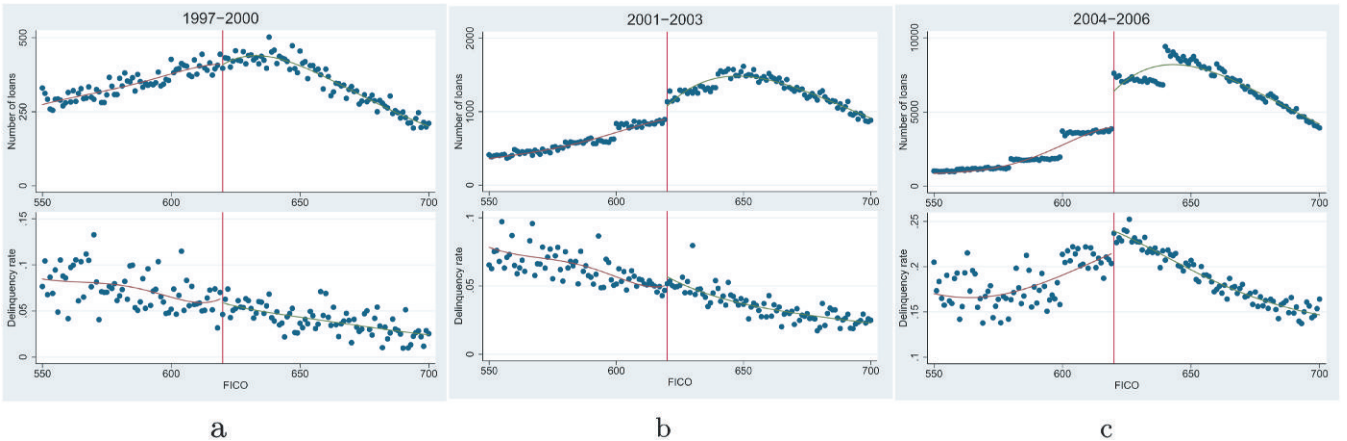

Figure 10
Time-series evidence on the number of securitized loans (i.e., unconditional securitization rates) and delinquency rates in the low-documentation subprime market over time
The graphs use data from the LP database originated during three periods: (a) 1997–2000, (b) 2001–2003, and (c) 2004–2006. The figure shows that the unconditional securitization rate and delinquency jumps around the cutoff started from zero and increased together over time as the low-documentation subprime market grew in size.

Table 4
Estimated regression discontinuities by time period

Panel A: Number of Securitized Loans (Unconditional Securitization Rate)

	1997-2000	2001-2003	2004-2006	2005H2-2006H1	2006H2-2007H1
$\beta_{FICO=620}$	−2.2	178.3***	2424.5***	1409.4***	409.8***
(SE)	(15.8)	(39.3)	(325.3)	(90.3)	(78.3)

Panel B: Delinquency Rates

	1997-2000	2001-2003	2004-2006	2005H2-2006H1	2006H2-2007H1
$\beta_{FICO=620}$	−0.006	0.006	0.024***	0.019**	−0.005
(SE)	(0.012)	(0.006)	(0.009)	(0.009)	(0.016)

This table presents estimates of the magnitude of the discontinuity at FICO=620 in the number of securitized loans and in delinquency rates over five time periods. During the peak of the subprime boom, 2004-2006, both the discontinuities in the number of loans securitized and the delinquency rates are largest. All reported coefficients are estimated using fifth-order polynomials on either side of the discontinuity. Heteroscedasticity-robust standard errors are reported in parentheses. Data are from the LoanPerformance database. See the text for the sample selection. ***, **, and * represent significance at 1%, 5%, and 10%, respectively.

the FICO spectrum. For comparisons with the 1997–2000 period, we consider two subperiods of the boom years, 2001–2003 and 2004–2006. As is evident, one observes progressively larger jumps in loans securitized from 2001–2003 to 2004–2006. Correspondingly, the magnitude of the discontinuity in defaults of low-documentation loans around the 620 threshold also shows an increasing pattern over the period (estimate is 0.006 for 2001–2003 and 0.024 for 2004–2006; see Panel B of Table 4). Thus, the magnitude of default differences increases as the discontinuities in the number of loans around the 620 threshold increases.

Overall, the pattern in the subprime market for low-documentation loans suggests that as the "ease of securitization" captured by the jumps in unconditional loans securitized around the threshold increases, so do the default differences around the threshold. This is consistent with the claims in Keys et al. (2010a) that securitization access led to changes in lenders' underwriting standards as measured by higher defaults above the FICO threshold, and in Purnanandam (forthcoming), who finds that the incentives to screen soft information differed on the basis of lenders' involvement in the secondary market.

5.1.2 Early signs of collapse: Last half of 2006 and first half of 2007. After the first half of 2006, the market for subprime securities began to decelerate. In particular, subprime lending in states such as California and Florida dramatically reduced in size with the general economic slowdown. The impact was widespread for large non-agency lenders such as New Century, which began facing economic pressures around this time (Creswell and Bajaj 2007). This slowdown is visible in the unconditional number of securitized subprime loans, as there are roughly half as many loans securitized in the second half of 2006 relative to the second half of 2005.

Figure 11b shows that the ease of securitization, as measured by the unconditional jump in the number of loans securitized, gradually began to diminish starting in the second half of 2006. Specifically, relative to the last half of 2005 and the first half of 2006 (Figure 11a), the latter part of 2006 and the first half of 2007 saw much smaller jumps in the number of loans securitized around the 620 threshold. Strikingly, the default jumps around the 620 threshold follow the same pattern—they are attenuated in the second half of 2006 and in the first half of 2007 relative to the second half of 2005 and the first half of 2006, precisely when the ease of securitization around the threshold attenuates (see Table 4 for estimates).

Thus, the evidence from before, during, and after the subprime boom evokes a consistent pattern: around the FICO threshold, the differences in the number of loans securitized (reflecting greater ease of securitization) and the differences in default rates are highly correlated over time. This relationship shows that the ease of securitization was directly related to the performance of loans around the FICO threshold in the subprime mortgage market.

5.2 Mitigating forces

We now explore whether ease of securitization leads to differential screening across all segments of the mortgage market. As shown earlier, for the non-agency full-documentation and the GSE market there are no significant discontinuities in securitization rates or time to securitize a loan. However, when we examine the third measure of ease of securitization (unconditional securitization rate), we find a jump in this measure for both non-agency full-documentation loans and the loans in the GSE market. For illustration, Figures 12a and 12b show the number of securitized loans pooled across years in the low-documentation segments of the non-agency and agency markets. The difference in the size of the jump is roughly comparable across the two markets, with nearly one and a half times as many loans being securitized just above the threshold than below it. Similar results (unreported) are obtained for the non-agency full-documentation market.

Why do we find differences only in the unconditional rate of securitization for non-agency full-documentation loans and GSE loans? For the loans made in the GSE market, this difference could reflect in part lenders' internalization of ease of securitization via the use of the GSE underwriting system. Alternatively, for both GSE and non-agency full-documentation loans, this difference could reflect the intensity of post-sale audits conducted by the GSEs or investors in the subprime market, respectively. As a result, we see jumps in the measure (unconditional securitization rate) that captures these factors, while they are absent from the other two measures (conditional securitization rate and time to securitize).

Notably, as the earlier findings on defaults have shown (e.g., Figure 4b), there are no differences in default rates around the 620 threshold in the sample

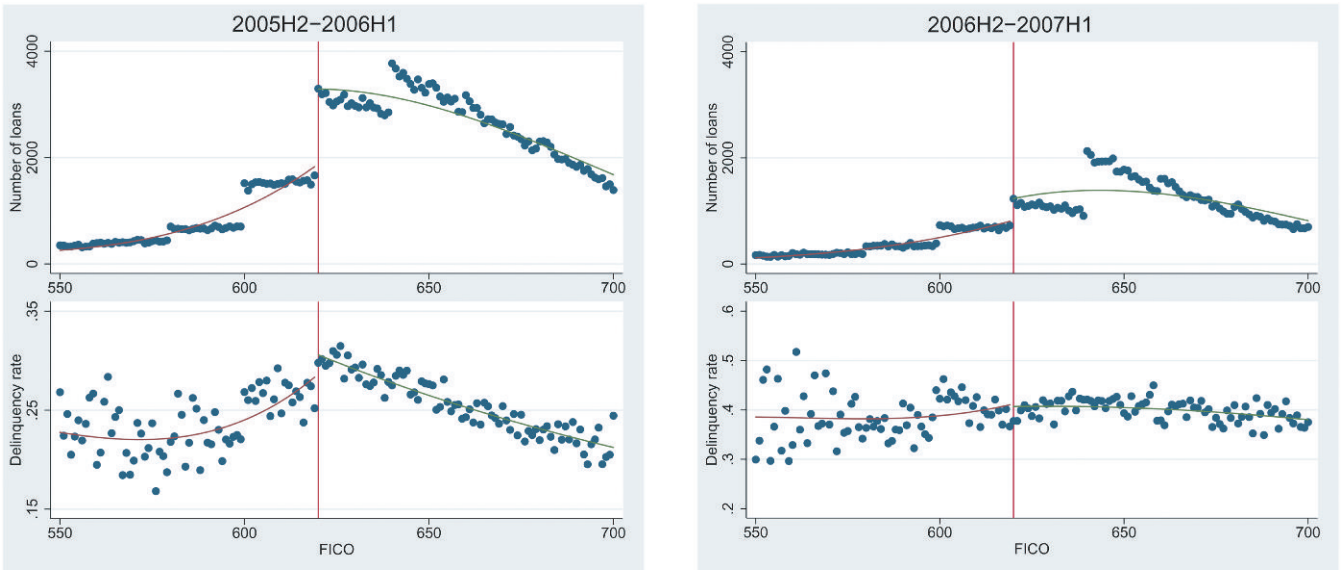

Figure 11
Time-series evidence on the number of securitized loans (i.e., unconditional securitization rates) and delinquency rates in the low-documentation subprime market over time
The graphs use data from the LP database originated during two periods: (a) 2005:H2–2006:H1, and (b) 2006:H2–2007:H1. The figure shows that the unconditional securitization rate and delinquency jumps around the cutoff were large when the subprime market was at its peak (a), and these jumps began to attenuate as the subprime market slowed down (b).

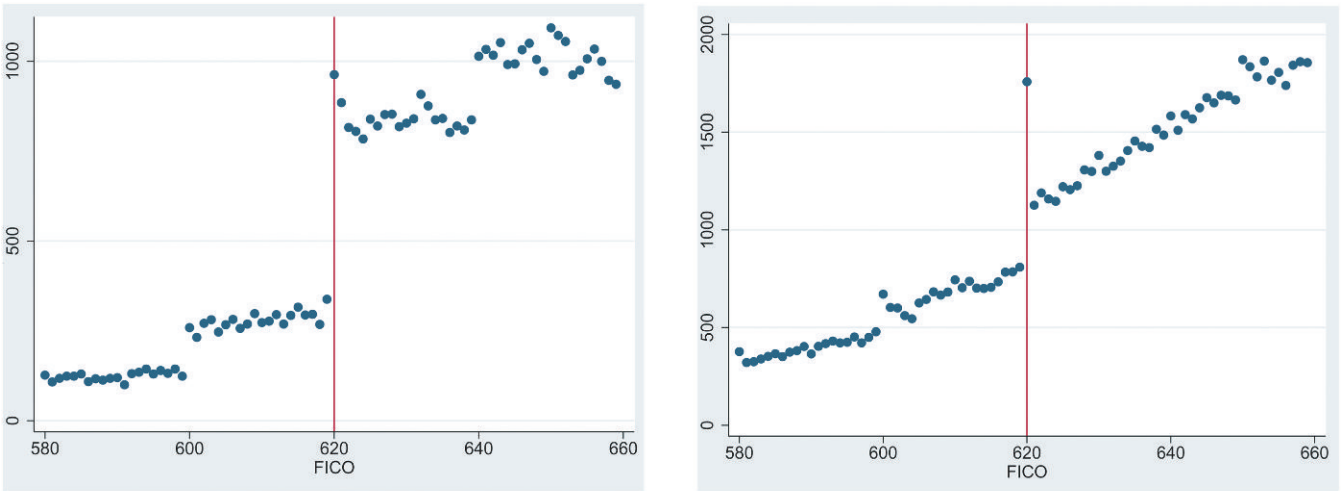

Figure 12

Number of securitized loans for the low-documentation non-agency market and the GSE market

The figure depicts the number of securitized loans for the low-documentation (a) non-agency market, and (b) the GSE market. There is a large jump in both markets at FICO=620. In conjunction with results on GSEs presented earlier, this suggests that the unconditional securitization rate may be capturing dimensions (in addition to conditional securitization rates and time to securitize) through which securitization may impact lenders' payoffs. As explained in the text, these could include factors such as securitization-induced post-sale audit intensity. The figures use loans from the LPS database originated between 2001 and 2006. The scale difference between Figure 10 and this figure may reflect in part the worse coverage of subprime loans in the LPS database relative to LP data.

of agency loans or in the sample of non-agency full-documentation loans (detailed results are discussed in Keys et al. 2010b). Thus, our effects on differential screening induced by ease of securitization may be confined to the low-documentation part of the subprime market while being absent from the full-documentation part of the subprime market as well as in the GSE-operated prime markets. Of course, the differences in the behavior of defaults around the 620 threshold may simply be driven by the fact that the exogenous variation in ease of securitization is relatively smaller for the GSE and full-documentation subprime markets as compared with the low-documentation subprime market. Though the increase in the number of securitized loans across the cutoff may seem comparable across different markets, the unconditional probabilities—which reflect the ease of securitization—may still differ in the distribution of the prospective borrowers across markets (i.e., the denominator in the unconditional probability calculation).

These findings, however, may have an economic basis. For the lenders operating in the GSE market, the underwriting process in securitization involves increased monitoring of lenders that differs substantially from the non-GSE market (see Passmore, Sherlund, and Burgess 2005; Kling 2009). Originating loans with the intent to sell to GSEs involves collecting substantially more hard information about the borrower before the lender grants the borrower a loan (e.g., the total debt-to-income ratio of the borrower). Moreover, the GSEs' threat to exclude lenders is credible because they are the only buyers in the prime market (Passmore, Sherlund, and Burgess 2005; Bubb and Kaufman 2009). Using the Keys et al. (2009) and Keys et al. (2010a) identification strategy around FICO=620, Bubb and Kaufman (2009) make a similar point regarding the GSE market to explain some of their findings. In contrast, while subprime markets do not have such monitoring by any single entity, relative to low-documentation loans, full-documentation loans involve collecting additional hard and verifiable information about the borrower (e.g., information on employment, income, and assets). Consequently, the screening differences driven by ease of securitization may manifest themselves only in segments of the mortgage market where the potential for moral hazard is large due to the absence of hard information and decreased monitoring of lenders—as is the case for non-agency low-documentation loans.

6. In What Ways Do Lenders Relax Screening for Low-documentation Loans?

In this section, we briefly explore what actions lenders might undertake when relaxing their lending standards. As the ease of securitization increases, lenders have an incentive to originate loans that rate high based on characteristics that are reported to investors, even if other unreported variables imply a lower borrower quality.

In order to document this behavior, we rely on a data set of a large lender (Lender Y corresponding to Section 4.2.5). In this data set, we know which variables are reported to investors and which go unreported. Our empirical strategy focuses on documenting meaningful differences in unreported variables among low-documentation loans around 620. Note that, relative to low-documentation loans, full-documentation loans involve obtaining and verifying additional information about employment, income, and assets. Accordingly, we focus on several variables that might be correlated with variables that are collected by the bank but unreported to investors.

We begin with borrowers' self-employment status. As is evident from Figure 13a, among approved low-documentation loans, loans just above 620 are six percentage points more likely to be from self-employed borrowers (15% in relative terms). Under the plausible assumption that the self-employed have highly variable income that is easier to overstate, having more self-employed borrowers in the 620+ pool provides evidence of differentially weaker screening above the cutoff.

We find similar effects when we focus on whether borrowers were first-time homebuyers (who may be less informed or less prepared for homeownership), the number of dependents (where income may be stretched across more individuals), and whether the co-borrower was also self-employed. In each of these cases, we find that borrowers above 620+ were more likely to be first-time home borrowers, had more dependents in their family, and were more likely to have a co-borrower who was also self-employed.[16]

Finally, we also examine if there is an impact on lenders' acceptance rates. Note that from Section 3.3 there may also be an impact of ease of securitization on acceptance rates of lenders as well, because lenders adjust their origination standards in response to easy access to secondary markets. As shown in Figure 13b, low-documentation applications above 620+ are more likely to be accepted by Lender Y (about 12% in relative terms). This is consistent with securitization affecting acceptance rates of lenders in addition to affecting the securitization rate.

Overall, the evidence in this section provides evidence that is consistent with a change in lenders' behavior in response to ease of securitization. Loans that were easier to securitize suffered from more lax screening—as is evident from the relaxation of lending standards along dimensions that are unreported to investors.

7. Conclusion and Discussion

We document significant discontinuities in both the securitization rate and time to securitize around FICO=620 in the low-documentation subprime market.

[16] The estimates for each of these cases are significant and large. For instance, relative to 620– loans, the number of dependents (likelihood that co-borrower is self-employed) are (is) greater at 620+ by 20% (33%). We do not report these for brevity.

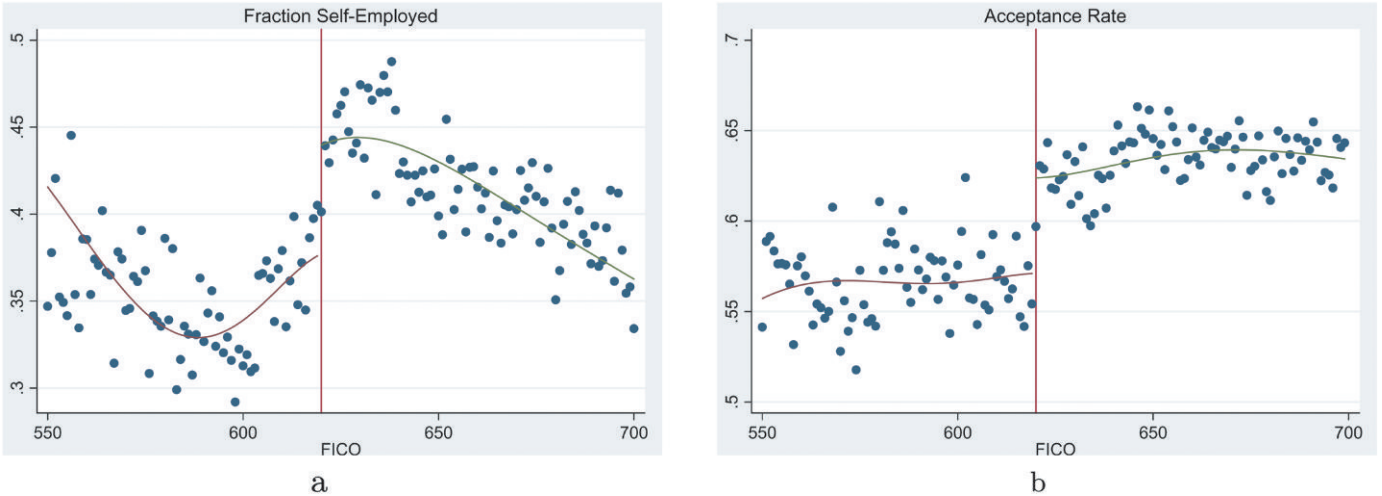

Figure 13
Variables collected by the bank but unreported to investors
The data come from a large anonymous subprime lender (Lender Y in Figure 8) and are for the period 2001–2006. For this lender we have information on all the variables that were collected by the bank and whether these variables were reported to investors of securitized pools. Figure 13(a) depicts the fraction of low-documentation subprime borrowers who are self-employed, by FICO score. There is a clear and statistically significant difference of 6% at FICO=620. Figure 13(b) shows the approval rate of low-documentation applications, by borrower's FICO score. The lender accepted a significantly larger fraction of applications at FICO=620.

Correspondingly, there is a jump in default rates at the threshold in this market—with better-quality loans just above 620 defaulting *more* frequently—which we interpret as securitization-induced differential screening by lenders. Importantly, no such patterns in defaults exist among full-documentation subprime loans or prime loans where the potential for moral hazard may be limited due to greater collection of hard information and increased monitoring of lenders. Examining the time-series evolution of the securitization market for subprime mortgages further establishes the connection between access to securities markets and lending standards.

Our finding of differential screening induced by ease of securitization being confined to the low-documentation part of the subprime market—while being absent from the full-documentation part of the subprime market as well as in the GSE-operated prime markets—may be best explained by differences in the value of screening soft information across the securitized assets in these segments. The GSEs monitor and coordinate strict and uniform underwriting guidelines, which include following a proprietary underwriting system and a credible threat of exclusion from the agency market (see Passmore and Sparks 2000). These stringent guidelines make the value of screening soft information for these loans relatively small. Similarly, for full-documentation non-agency loans, conditional on lenders collecting more hard information, the value of soft information may not be as important. As a result, in markets with sufficient hard information or additional mechanisms for monitoring, one may observe jumps in unconditional loans sold (due to jumps in conditional securitization rates and/or time to securitize, for instance) around the 620 cutoff without any corresponding jumps in default rates.

Because the data available cannot determine whether investors accurately priced lenders' differential screening behavior around the 620 threshold in their payments to lenders or the prices of asset-backed securities, our discussion of the results is necessarily agnostic toward this issue. On the one hand, it is possible that investors could have rationally anticipated and priced the moral hazard into their payments. Lenders in turn may have chosen to respond to this scenario for reasons related to regulatory arbitrage or capturing market share in the short run, among others (see Parlour and Plantin 2008; Rajan, Seru, and Vig 2008). On the other hand, developing an arbitrage strategy for exploiting this opportunity may have been prohibitively difficult for investors, given that loans were pooled into tranches across the FICO spectrum before they were traded. Examining which of these alternatives occurred during the runup to the subprime crisis is a fruitful area of future research.

It is important to note that while we refrain from making any welfare claims, there could have been distortions introduced in the real economy due to the effects we document, even if the effect was rationally priced by investors. In particular, it is possible that regulators and rating agencies may have perceived some securitized assets to be less risky than they actually were if they relied on pre-boom data to evaluate the quality of loans above FICO=620. As a result,

banks' capital requirements may not have adjusted sufficiently for the risk of some securitized assets. Understanding the behavior of regulators and rating agencies in the periods before and during the crisis remains another promising area of research.

Finally, our conclusions should be directed at securitization as practiced in the low-documentation subprime market during the subprime boom, rather than at the optimally designed originate-to-distribute model. We believe securitization is an important innovation and has many merits. The important insight of our article is to establish that the benefits of securitization may be limited in environments when the value of screening on soft information by intermediaries is potentially high.

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