Securitization and the Fixed-Rate Mortgage

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Abstract

Fixed-rate mortgages (FRMs) dominate the U.S. mortgage market, with important consequences for household risk management, monetary policy transmission, and systemic risk. In this paper we show that the availability of liquid securitization markets is a key driver of FRM supply. Our analysis compares the government-backed agency mortgage-backed securities (MBS) market to the private nonagency MBS market, exploiting the freeze in the nonagency MBS market in the third quarter of 2007. Using exogenous variation in loan size which determines access to the agency MBS market, we find that when both market segments are liquid, they perform similarly in terms of supporting FRM supply. However, after the freeze of the nonagency market, access to the still-liquid agency MBS market sharply raises the market share of FRMs, by 25–30 percentage points. We highlight policy implications for ongoing reform of the U.S. mortgage finance system.

JEL classification: G21, G18, E44

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How might home buying change if the federal government shuts down the housing finance giants Fannie Mae and Freddie Mac? The 30-year fixed-rate mortgage loan, the steady favorite of American borrowers since the 1950s, could become a luxury product, housing experts on both sides of the political aisle say.

New York Times, March 3, 2011

1 Introduction

The U.S. residential mortgage market is dominated by prepayable 30-year fixed-rate mortgages (FRMs), a type of home loan that exists in few other countries (Campbell 2012; Green and Wachter 2005). FRMs comprise more than 93 percent of mortgages originated since 2009 and 82 percent of the total stock of loans.[1] While experts disagree about the merits of FRMs relative to alternative contract designs, it is widely agreed that the high FRM share has important consequences for household risk management (Campbell and Cocco 2003; Van Hemert 2010), monetary policy transmission (International Monetary Fund 2004; Miles 2004), and systemic risk (Khandani, Lo, and Merton 2012).

In this paper, we analyze why FRMs are so prevalent in the U.S., and in particular, whether securitization is an important determinant of FRM supply. Even in the wake of the subprime crisis, most U.S. mortgages are securitized into mortgage-backed securities (MBS), primarily via the quasi-governmental agencies Fannie Mae and Freddie Mac (F&F). It seems plausible that access to liquid securitization markets should improve the supply of FRMs, since these mortgages generate interest rate risk and non-diversifiable prepayment risk which is difficult for mortgage originators to hedge on-balance sheet in the absence of securitization.[2] There is, however, little hard evidence about the magnitude of these supply

[1]These statistics are author calculations computed as of December 2011, based on data from LPS Applied Analytics. The respective shares for FRMs with a term of at least 30 years and no (or unknown) prepayment penalties are 76 percent and 66 percent. Shares are value-weighted by origination amount (flow) and outstanding balance (stock). As discussed later, a caveat to these numbers is that the LPS data do not cover the entire U.S. mortgage market.

[2]This is consistent with Gabaix, Krishnamurthy, and Vigneron (2007), who find that nonsystematic prepayment risk is priced in equilibrium. The FRM prepayment option has lead to an active industry in modeling prepayment risk (see e.g. Schwartz and Torous 1989 and Stanton 1995 for academic contributions), and the creation of financial instruments to hedge and redistribute prepayment risk, such as collateralized

effects. There is also little agreement amongst experts on whether public credit guarantees for securitized mortgages, like those currently provided by F&F, are necessary to support the continued supply of FRMs. Illustrating the unsettled nature of this debate, in a recent U.S. Senate hearing on housing reform, two of four expert witnesses argued that the 30-year FRM would decline or disappear without public guarantees, while the other two argued that a purely private mortgage finance system could support FRMs.[3]

We consider two research questions: 1) are liquid securitization markets important for the supply of FRMs, and 2) are the government-backed credit guarantees currently provided via F&F necessary to create this liquidity; or alternatively, are purely private securitization markets sufficient?

Our analysis is based on a large mortgage-level dataset over the period 1996–2009, described in section 2. We study differences in mortgage contracts between the "conforming" or "agency" market, and the non-conforming "jumbo" market. The two are separated by the "conforming loan limit," a regulatory threshold limiting the size of mortgages that F&F are permitted to purchase and securitize.[4] Conforming loans for amounts below this limit may be securitized in the agency MBS market via F&F, securitized by a private issuer in the nonagency MBS market, or retained as a whole loan. For jumbo mortgages above this limit, only the latter two options are available—since these loans cannot be sold to F&F, the nonagency market is the only possible way to securitize them.

We study variation in mortgage contracts around the conforming loan limit in periods when both the agency and nonagency market are liquid, as well as periods when the nonagency MBS market becomes illiquid, particularly after the onset of the financial crisis in

mortgage obligations (CMOs). The risks associated with FRMs will be further discussed in section 5.

[3]This hearing, titled "Housing Finance Reform: Should There Be A Government Guarantee?" was held in September 2011. Richard Green (University of Southern California) and Adam Levitin (Georgetown University) argued that government support is likely necessary for continued widespread availability of FRMs, while Dwight Jaffee (UC Berkeley) and Peter Wallison (American Enterprise Institute) argued against this claim. Written testimony of these experts is available here: http://banking.senate.gov/public/index.cfm?Fuseaction=Hearings.Hearing&Hearing_ID=a7b4b965-7291-4741-8507-f1dbbb860ac0.

[4]Loan characteristics other than size can also make a loan non-conforming; thus jumbo mortgages are only a subset of the non-conforming market. However, these other underwriting criteria are not as sharply defined as the size limit.

August 2007. Since the agency MBS market remains liquid throughout our sample, it acts as a stable comparison group, allowing us to isolate the effect of the private securitization freeze on mortgage contract structure in the jumbo market. It furthermore enables us to measure the causal effect of agency securitization on contract structure during the pre-crisis period when private markets are also liquid.

As a first pass at understanding differences across the two market segments, raw summary statistics indicate that the FRM share is generally 20–30 percentage points lower in the jumbo market than the conforming market, with the difference widening in summer 2007 and also in an earlier episode in 1999–2000 (see section 2). These statistics are difficult to interpret, however, given that jumbo and conforming mortgage borrowers have very different characteristics. To control for these differences, in section 3 we use two complementary approaches, a regression discontinuity design (RDD) focusing on variation in mortgage size close to the conforming loan limit (CLL), and a difference-in-differences (DiD) analysis, exploiting time-series changes in the CLL. One important concern with these methods is that loan size itself is endogenous, and is likely to respond to lower mortgage rates in the conforming market in ways that are correlated with borrower characteristics.[5] For this reason, we use home values as a plausibly exogenous source of variation in mortgage size, along similar lines to Kaufman (2012) and Adelino, Schoar, and Severino (2012). This strategy makes use of the fact that many borrowers select a mortgage amount close to 80 percent of the home value. Thus, we analyze variation in mortgage contracts for homes with appraised values around 125%(= 1/0.8) of the CLL. This strategy minimizes selection effects due to borrowers adjusting their downpayment in order to qualify for a conforming loan.

We first study the pre-crisis period, with a focus on 2004 to mid-2007. Our first key result is that the *causal* effect of F&F on the FRM share is economically small and generally indistinguishable from zero during this period, based on either the RDD or DiD approach.

[5]Numerous papers have investigated the rate differential between the two market segments, the so-called "jumbo-conforming spread," and generally find it to be around 10–30 basis points in the period before the financial crisis (e.g. McKenzie 2002; Sherlund 2008). It is generally thought that this spread is primarily driven by F&F's (formerly implicit) government guarantee.

The intuition of our discontinuity design can be explained in a simple example. In 2006, the national CLL is \$417,000. Consider two borrowers who purchase homes with values close to $\$417,000 \div 80\% = \$521,250$; the first borrower buys a home appraised slightly above this amount, the second just below it. We show that the first borrower is significantly (around 15 percentage points) more likely to finance their purchase with a non-conforming jumbo mortgage. However, there is no economically or statistically significant difference in the likelihood of selecting an FRM between these two borrowers.

In section 4, we examine shocks to the nonagency market used to securitize jumbo mortgages, focusing on the collapse in nonagency MBS liquidity around the onset of the financial crisis in August 2007. Securitization of jumbo loans, even those of high credit quality, drops sharply to essentially zero around this time. In contrast, there is robust continued securitization and trading activity in the agency market throughout the crisis (Vickery and Wright 2011). We study two distinct events during this period: the market freeze itself, and the later policy response which involved sharply raising the CLL in high-cost housing areas, effective in May 2008.

We show that the market freeze in the nonagency MBS market reduces the supply of all jumbo mortgages, but *disproportionately* reduces the supply of jumbo FRMs. These effects are economically as well as statistically significant—the FRM share incrementally declines by about 25 percentage points above the CLL, relative to the pre-crisis differential. Furthermore, applying our DiD approach, we show that the FRM share sharply increases amongst "newly" conforming loans after the local CLLs are raised in 2008. Causally, exclusion from the liquid agency securitization market during this period reduces the FRM share by 23–33 percentage points, a result similar to the "market freeze" estimates.

To summarize our key findings: 1) Securitization is important for the supply of FRMs. During the financial crisis, when private MBS markets are shut down, access to the liquid agency securitization market causally increases the market share of FRMs by 25–30 percentage points. 2) When private markets are liquid and well functioning, however, as they are prior to the crisis, private and government-backed securitization markets perform similarly in supporting the supply of FRMs.

Our findings have specific implications for the ongoing policy debate about reform of F&F and the U.S. mortgage finance system more generally. In the debate over F&F reform, availability of long-term FRMs is one of the key metrics used to compare different policy options, as evidenced for instance by the U.S. Treasury's recent white paper on housing finance (Department of Treasury 2011). Our main policy conclusion is that government backing of the mortgage market as in its present form is *not* necessary to support the continued supply of FRMs, but only so long as private MBS markets are liquid (which is not the case at the present moment). Additionally, our finding that securitization itself is important implies that excessive regulation of MBS markets, such as stringent risk retention rules or other restrictions, would likely constrain FRM supply—even if government backing of the market was maintained.

Perhaps the most significant caveat on these conclusions is that we conduct a partial rather than general equilibrium analysis, using local variation in the likelihood of securitization by F&F. It is possible that our results would not translate directly to a large change in market structure. We explore this issue and discuss other caveats in detail in section 5.

2 Institutional Background and Data

Before turning to our analysis, we describe some necessary institutional details, particularly regarding the evolution of the conforming loan limit, which is at the core of our identification strategy. We also discuss related literature, describe our data, and present some descriptive statistics and evidence.

As already mentioned, our identification strategy exploits discontinuous variation in loan contracts generated by rules governing whether a loan is "conforming," that is, whether it is eligible to be purchased and securitized by Fannie Mae or Freddie Mac. Historically, the CLL adjusted periodically to reflect movements in the general level of home prices. Currently, the national CLL for one-unit homes is $417,000. Higher dollar limits apply for mortgages secured by homes that are: (i) located in high-cost housing areas, (ii) multifamily dwellings, and (iii) located in Alaska, Hawaii, Guam and the U.S. Virgin Islands. (Thus, while we generally refer to a single CLL, there are in fact a set of loan limits that vary by property type and location, with the national CLL being a lower bound.)

Table 1 shows how the CLL for one-unit properties changed over the sample period we will use. During the housing boom period, the CLL was raised each year (effective on January 1 of each calendar year), often by significant amounts, reflecting rising home prices.[6] The national limit reached $417,000 in 2006. It has subsequently been held at that dollar level, reflecting the fact that home prices have subsequently declined, rather than increased.

Prior to mid-2007, jumbo mortgages larger than the CLL could be securitized relatively easily through the nonagency MBS market.[7] However, reflecting rising mortgage defaults, the nonagency MBS market froze as a source of mortgage funding around the onset of the financial crisis in August 2007, as did a number of other securitization markets and the asset-backed commercial paper market. Primary nonagency MBS liquidity rapidly declined after this point: there has been almost no issuance of jumbo MBS since the third quarter of 2007, and in particular, no jumbo MBS backed by newly-originated mortgages were issued

[6]Note that the national CLL in a given year applies to mortgages originated in any year, not just the current calendar year. This is notable, because this rule creates an incentive for lenders to be forward looking, and take known future increases in the limit (usually announced around November) into account when originating mortgages, even before the new limit has taken effect. As a concrete example, the CLL in 2005 was $359,650, and was raised to $417,000 on January 1, 2006. A lender originating a mortgage in late 2005 with a principal balance between these two dollar amounts knows that, even though it cannot immediately securitize the loan through the agency MBS market, it will be able to do so after January 1 (as long as it is willing to hold the loan in portfolio until then). Thus, the future increase in the limit is likely to affect contract terms for mortgages originated just prior to the increase. For this reason, in most of our analysis we drop loans originated in the last few months of a calendar year.

[7]The nonagency MBS market is also known as the "private-label" market. This term refers to the fact that the issuer pooling the loans and creating the MBS is a private financial institution, rather than a government-sponsored enterprise (GSE) like F&F. Note that F&F themselves were privately owned for-profit corporations during most of our sample period. However, because of their systemic importance and public charters, these firms were widely viewed as government-backed by market participants. Consistent with this presumption, F&F were indeed taken into government conservatorship in September 2008, as their financial position deteriorated sharply.

in 2008 and 2009. In contrast, liquidity in the agency MBS market has remained relatively robust during this period (Vickery and Wright 2011), as evidenced by $2.89 trillion of agency MBS issuance in 2008 and 2009.

Figure 2 shows the securitization status of loans in our dataset (described in more detail below). As the top half of the figure shows, the percentage of jumbo loans that were securitized dropped rapidly over the course of 2007, and by the end of the year, less than 20% of jumbo mortgages were securitized. At the same time, in the conforming segment (bottom half of the figure), the securitization share went up, supported by F&F's presence in that market, even though private securitization all but disappeared.

The liquidity freeze in the nonagency market led to a sharp rise in jumbo mortgage rates, dating to August 2007. The spread between jumbo and conforming mortgage rates, normally around 10–30 basis points, spiked sharply to as much as 150 basis points.[8] To increase mortgage supply in the wake of the private market freeze, the Economic Stimulus Act of 2008 (ESA) temporarily raised the CLL in designated "high-cost" areas to as much as $729,750 from a previous national level of $417,000. The ESA was passed on February 13, 2008, although it did not become fully effective until May 2008, in part because of issues regarding the pooling and trading of this new class of "super-conforming" mortgages.[9] The higher temporary CLLs were then extended a number of times, finally expiring on September 30, 2011.[10]

Our identification strategy exploits these limits in two ways. First, we examine variation

[8]Figure A.1 in the appendix shows the evolution of the jumbo-conforming spread over time. It also presents issuance volumes of nonagency MBS since 2000.

[9]Agency MBS are primarily traded in a large liquid forward market known as the "to-be-announced" or TBA market. Initially, SIFMA ruled that MBS backed by super-conforming mortgages would not be eligible for TBA delivery, significantly reducing the liquidity of such mortgages. In May 2008 Fannie Mae announced that it would temporarily purchase super-conforming mortgages at par to TBA pricing; later, SIFMA allowed super-conforming mortgages to be included in TBA pools, with some restrictions. In addition, some delays were experienced due to the practical logistics of rolling out the new higher limits. See Vickery and Wright (2011) for more details.

[10]Even after the expiration of these temporary limits, the CLLs have remained above the national limit in high-cost housing areas. This is because in mid-2008, permanently higher CLLs were established for high-cost areas, under the Housing and Economic Recovery Act (HERA). These higher permanent limits were not originally binding (because they lay below the temporary limits). However, they did become binding in October 2011, after the temporary limits expired, and remain binding today.

in loan size near the limit in a given year using a regression discontinuity design. Second, we use a difference-in-differences approach around time-series *changes* in the CLL, comparing loans that were not conforming in one year to loans in the subsequent year that become conforming due to an intervening change in the limit. In both these approaches we use variation in home values as a source of plausibly exogenous variation in loan amount.

The first strategy is closely related to Kaufman (2012), who uses a regression discontinuity design to analyze the effect of F&F on a number of mortgage contract features as well as delinquencies and foreclosures.[11] We instead focus on a more in-depth analysis of a particular contract element, namely the FRM feature. In particular, unlike Kaufman, we exploit securitization market shocks and time-series shifts in the CLL. Also related is work by Loutskina and Strahan (2009), who use changes in secondary market liquidity around the CLL to examine the impact of banks' financial conditions on mortgage originations, and argue that higher liquidity reduces the importance of financial conditions for credit supply. Calem, Covas, and Wu (2011) build on that study to examine the effects of the nonagency market collapse in 2007, as we do, and find that after the collapse, lenders that were previously more dependent on the secondary market exhibit a more pronounced decrease in their jumbo lending. Neither Loutskina and Strahan nor Calem et al. distinguish between fixed- and adjustable-rate mortgage supply.[12] Finally, our DiD strategy builds on Adelino, Schoar, and Severino (2012), who study how time-series changes in the CLL affects home prices (but do not consider mortgage contract structure).

2.1 Data

Our main analysis relies on a loan-level dataset provided by LPS Applied Analytics (formerly called "McDash"). These data have been extensively used by researchers in recent years, in particular to study mortgage delinquency (e.g. Foote et al. 2010; Elul 2011). The LPS

[11] Other work has used regression discontinuity approaches based on credit scores to investigate whether securitization leads to lax screening by mortgage originators (Keys et al. 2010; Bubb and Kaufman 2011).

[12] Both papers use mortgage-level data from the Home Mortgage Disclosure Act (HMDA), which do not contain information about the contract structure of the loans.

data have a high coverage of the overall market since 2005, as nine of the top ten servicers contribute their data. However, as is well known among mortgage researchers, the LPS coverage for prior years is somewhat less extensive. For instance, while over the period 2005–2007, the number of first-lien conventional mortgage originations in LPS represents about 64% of the originations in HMDA, the corresponding number is approximately 60% for 2000–2004 and 46% for 1996–1999.[13]

Furthermore, the mortgages from these earlier years that are in the data are often highly "seasoned," meaning that only mortgages that remained open (no prepayment or foreclosure) over a number of years ever make it into the dataset. We find that this problem is most severe for mortgages originated prior to 1996, where the median seasoning is 15 months or higher. After 1996, the annual median seasoning never exceeds 6 months (and is mostly equal to zero). Consequently, we use the LPS data from 1996 onwards only.

While we do not expect the potential non-representativeness of the LPS data to introduce systematic bias in our analysis, we note that for our main results we rely on post-2004 data, which have a better coverage or the overall market than for the earlier years. We have also reproduced our main analysis using an alternative dataset, the Monthly Interest Rate Survey (MIRS), and find very similar patterns (results available on request).

Our analysis focuses on first-lien conventional mortgages (i.e. we drop FHA/VA and affordable housing loans) on single-family residences, condos or townhouses. We drop observations from Alaska, Hawaii, U.S. Virgin Islands and Guam, which have higher CLLs. We also drop mortgages with origination amounts below 0.25 times or above 2.5 times the CLL for the origination year. Finally, we drop mortgages where the initial LTV is recorded as below 20 or above 100 percent, as these could be signs of data errors (e.g. second liens being recorded as first liens, or a wrong loan amount).

We will focus our analysis on purchase-money mortgages, that is, mortgages used to

[13]Prior to 2004, the HMDA data did not record the lien status of a mortgage. For the reported calculation, we thus assume that the fraction of first lien mortgages prior to 2004 was equal to the average fraction over 2004–07.

finance a home purchase rather than to refinance an existing mortgage. This choice was made primarily because purchase transactions are arguably somewhat less endogenous to the availability and pricing of different mortgage contracts than refinancings. Furthermore, the MIRS data only contain purchase transactions. In total we have about 18.5 million loans in our sample, 8 million of which were originated between 2004 and 2007. The years with the lowest number of loans in our sample are 1996 and 2000, where we have about 770 thousand loans each.

Our main dependent variable of interest is whether a borrower selects a long-term prepayable FRM, rather than an alternative contract type, such as a hybrid or adjustable-rate mortgage (ARM). We define two variables: "FRM30noPPP" equals 1 if a borrower selects a mortgage of maturity 30 years or more, where the prepayment penalty flag is "no" or "unknown."[14] We also examine an alternative variable,"FRM," set equal to 1 if a borrower selects an FRM of any maturity, with or without prepayment penalty. Our main results are similar across these two dependent variables.

In some of our analysis, we also study the securitization status of loans, as reported in the LPS data. In particular, we classify a loan as non-securitized if six months after origination, the loan is held in portfolio. Note that this means that we can only use this variable, which we will denote "Non_sec6," for loans that are present in the dataset six months after origination.[15]

[14] In the early years of our sample, information on prepayment penalties is missing for a large fraction of loans—e.g., more than 50% in 1996 and 1997. The fraction of loans with missing prepayment penalty information then rapidly declines, to below 20% by 2000 and to below 3% for 2004–2007.

[15] There is a tradeoff when selecting the point in time at which securitization status is measured: looking at securitization status at a higher loan age allows one to observe more seasoned loans, but in turn loses the loans that have prepaid or defaulted, which may introduce selection. Also, securitization status can change multiple times over the life of a loan, and for our purposes we are most interested in the "initial" status after allowing sufficient time for securitization to occur. Unless stated, using securitization status at 12 months instead does not materially change the findings reported later.

2.2 Descriptive Evidence

Before turning to our formal analysis, Figure 1 plots the raw FRM share for mortgages above and below the national CLL (currently \$417,000).[16] The FRM share is consistently much higher amongst the loans below the CLL, which were generally eligible to be securitized by F&F—e.g., between 2004 and 2007, the difference in FRM share between the two groups is is stable at around 30 percentage points. Moreover, the differential in FRM share responds to movements in MBS liquidity; it widens after the nonagency market freezes in August 2007, and also in an earlier, less severe episode of market disruption in 1999–2000 following the collapse of Long Term Capital Management (LTCM). The differential also contracts sharply after May 2008, when some mortgages above the national CLL become eligible for agency securitization, due to the introduction of higher temporary limits in high-cost housing areas. Notably, however, there is still significant origination of FRMs in the jumbo market even prior to 2008, including the 30-year prepayable FRM. This demonstrates that the absence of F&F does not entirely preclude the availability of long-term fixed-rate contracts.[17]

3 The Causal Effect of Agency Securitization on Contract Structure

In this section we apply two approaches for estimating the causal treatment effect of jumbo status (i.e. being in the non-conforming segment of the market) on the likelihood of obtaining a (long-term prepayable) FRM. Here we focus only on the pre-crisis period, up to July 2007, and particularly the period 2004–07 when private MBS markets are most liquid. Finding a negative treatment effect even during this period would suggest that F&F's presence in the

[16] We identify these groups by comparing the original mortgage principal to the national loan limit in the origination year. As in our econometric analysis, we focus on purchase-money mortgages. The graph looks similar if refinancings are included, although there is a level shift, since the FRM share is lower amongst refinancings.

[17] Koijen, Van Hemert, and Van Nieuwerburgh (2009) and Moench, Vickery, and Aragon (2010) study the determinants of time-series variation in the overall FRM share.

conforming segment disproportionately facilitates the availability of FRMs at all times. A null (or positive) effect instead suggests that a liquid private MBS market performs similarly to the government-backed agency market in terms of supporting FRM supply.

3.1 Regression Discontinuity Design

Our first approach is a "fuzzy" regression discontinuity design (RDD). Specifically, we use variation in the appraisal amount of a property as an instrument for whether or not a borrower takes out a jumbo loan.

One might think that it is straightforward to study the effects of jumbo status by simply comparing mortgages with loan amounts just below the CLL to others with loan amounts just above the CLL. However, as Kaufman (2012) points out, this strategy is subject to significant endogeneity problems, as the loan amount is a choice variable for borrowers. This is illustrated in Figure 3. The figure plots in turn the FRM share, and the average FICO score, as a function of loan size normalized relative to the CLL, during the period January 2004 to July 2007. We see that the FRM share drops sharply at the CLL, and in particular that there is an "overshooting" effect at the limit, suggestive of selection effects.[18] Furthermore, there is a sharp shift in the FICO score at the limit. This shows that loan amount is not well suited as the running variable for an RDD, since the assumption underlying this approach is that only one variable, the probability of selecting a jumbo loan, jumps at the threshold, while other variables (observed and unobserved) vary continuously across the threshold. This assumption is clearly violated in Figure 3.

The appraisal amount instead provides plausibly exogenous variation in a borrower's probability of selecting a jumbo loan. At least in the later years of our sample, this probability discretely jumps up at an appraisal amount of CLL/0.8. The reason why is that a significant fraction of mortgage loans in the U.S. are made at a loan-to-value ratio (LTV) of exactly

[18]The fact that borrowers who sort just below the CLL have a higher propensity to get FRMs could be indicative that F&F's presence disproportionately facilitates FRMs. However, it is also possible that borrowers who have the ability to make a sufficiently large downpayment to get below the CLL have unobserved characteristics that correlate with a preference for FRMs (e.g. high risk aversion).

80%. This occurs in part by convention, but also because 80% is the maximum LTV such that loans can be purchased by the GSEs without requiring the borrower to take out private mortgage insurance (PMI). To illustrate, consider a borrower purchasing a property with a value assessed at $CLL/0.8. She can finance this purchase with an LTV of 80% to get a mortgage of exactly $CLL. If instead her property were assessed at $CLL/0.8 + $10,000, getting an 80% LTV loan puts her above the CLL; if she wants to qualify for a conforming loan, she must either pay for PMI, or increase her downpayment by $10,000. Both of these strategies may be more expensive than the increase in the interest rate she faces by getting a jumbo mortgage. Therefore, her probability of matching with a jumbo loan is discretely higher than if the value of the property was $10,000 lower.

Figure 4, again using data from January 2004 to July 2007, illustrates the identification strategy and the key result of our RDD analysis. Panel A of the figure plots the fraction of borrowers who select a jumbo mortgage against the property appraisal amount, scaled by CLL/0.8. We observe a sizeable discontinuous jump in the probability of selecting a jumbo mortgage at the appraisal cutoff (= CLL/0.8), of around 15 percentage points. However, as shown in the other two panels of the figure, this shift has little or no effect on the market share of 30-year prepayable FRMs (Panel B) or all FRMs (Panel C). According to both measures, the FRM share is trending downward with appraisal amount, reflecting that larger mortgages tend to be more likely to feature an adjustable interest rate. However, there is no discernible discontinuity around the appraisal cutoff.

Unfortunately, the discontinuity in the probability of obtaining a jumbo loan is much weaker prior to 2004, since a smaller fraction of borrowers financed their homes with an LTV of 80% in this earlier period. Similarly, after the breakdown of the nonagency market in the summer of 2007, jumbo loans became sufficiently expensive so that for a large number of borrowers with houses appraised at more than CLL/0.8, it became attractive to put down a larger downpayment in order to obtain a lower rate, rather than to try and obtain a jumbo loan. Consequently, we only use this identification strategy for January 2004 to July 2007.

Although our identification strategy is in principle still valid outside this time period, it is not statistically powerful.

Below we present results using local linear regression, which formalize the results of Figure 4, and also allow us to attach standard errors to the estimated treatment effect of being in the jumbo segment. Before discussing these results, however, we note that the data show no evidence of any "manipulation" or sorting around the appraisal amount CLL/0.8 (which would be a problem for the validity of our RDD). Panel A of Figure 5 shows that, for 2006 and 2007, where CLL/0.8 equals \$521,250, there are no conspicuous spikes in loan volumes right below or above the cutoff. There is a spike in the histogram at \$520,000; however this is to be expected due to rounding of appraisals (as the figure shows, these spikes in the frequency of appraisals also occur at other multiples of \$5,000). Panel B of the figure shows the mean FICO scores around the CLL/0.8 cutoff, and demonstrates that there does not seem to be significant sorting of borrowers with different credit quality around the threshold.[19]

3.1.1 Results

To quantify the treatment effect on contract structure of being in the jumbo segment, we use local linear regressions (see e.g. Imbens and Lemieux 2008 for an introduction) around the CLL/0.8 threshold. We do this both for the pooled data from 2004 to 2007 and year-by-year.

As shown by Hahn, Todd, and van der Klaauw (2001), the treatment effect τ in a fuzzy RD can be estimated by the "Wald estimator" in a 2SLS setting:

$$\tau = \frac{\lim\limits_{\varepsilon \to 0^+} \mathrm{E}[Y|X = c + \varepsilon] - \lim\limits_{\varepsilon \to 0^+} \mathrm{E}[Y|X = c - \varepsilon]}{\lim\limits_{\varepsilon \to 0^+} \mathrm{E}[D|X = c + \varepsilon] - \lim\limits_{\varepsilon \to 0^+} \mathrm{E}[D|X = c - \varepsilon]} \tag{1}$$

[19]In the figure, one can see a slight spike below the cutoff, which however looks more like random noise than indicative of a change in the underlying relationship around CLL/0.8. Consistent with this interpretation, formal local linear regressions do not yield significant estimates of the discontinuity when appropriate bandwidths (as determined by a cross-validation procedure) are used. Similarly, none of the other characteristics we use as controls in some of our regressions (condo, investor, and subprime dummies) change significantly around the threshold. Kaufman (2012) discusses the institutional details of the appraisal process in more detail.

where X is the "running variable" (the appraisal amount in our setting), c is the threshold (CLL/0.8), Y is the outcome of interest (e.g. FRM30noPPP), and D is the treatment indicator (jumbo).

To choose the bandwidth for the local linear regressions, we use a cross-validation procedure similar to that in Almond et al. (2010)[20]: we estimate local linear regressions of our outcome variable of interest on appraisal value over a window of 0.7 to 1.3 times CLL/0.8 using a variety of bandwidths, and compare the results to a fourth-order polynomial model (estimated separately above and below the threshold). For the pooled regressions, the bandwidths that minimize the sum of squared errors are around 0.08 for Pr(FRM30noPPP) and 0.03 for Pr(jumbo); for the individual years, the optimal bandwidths are slightly larger. For simplicity, we use 0.08 as our baseline bandwidth for all variables, and report the sensitivity of our results to alternative choices in the appendix.

For our main estimates, we only use mortgages originated between January and September. As already documented, jumbo mortgages originated late in the calendar year frequently end up being sold to F&F in the following year (when they become conforming due to the rise in the limit). We do not want this to influence our estimated treatment effects. Additionally, we include a vector of year-month dummies in all regressions in order to control for time-series variation in the overall market share of FRMs relative to ARMs and thereby improve the precision of our estimates. We have also experimented with adding additional covariates, such as state dummies, FICO scores, and so on, and find that this has little effect on our results.

Table 2 shows the results from our analysis, starting with the pooled data over 2004 to mid-2007.[21] In Panel A, we see that the estimated treatment effect of jumbo status on the probability of matching with a prepayable 30-year mortgage is in fact positive, meaning that borrowers just above the CLL/0.8 threshold are, if anything, *more* likely to get a long-term

[20]We thank Heidi Williams for sharing their Stata code with us.

[21]For 2007, we only include data up to July, as the nonagency market comes to a halt afterwards, as discussed earlier.

prepayable FRM. The standard errors do not allow rejection of the null hypothesis that the treatment effect is zero, but they do allow us to reject the hypothesis that the effect of jumbo status on Pr(FRM30noPPP) is negative of economically significant magnitude—e.g., -0.1. As shown in the second column, this holds even more strongly if we use FRM (without restrictions on maturity and prepayment penalty) as our dependent variable. Also, Table A.1 in the appendix shows that these results are not very sensitive to our choice of bandwidth. The final column of Panel A examines the effect of jumbo status on the probability of securitization. The estimated treatment effect of 0.02 suggests that the causal effect of jumbo status on the probability of the loan being retained in portfolio (measured six months after origination) is only very slightly, and insignificantly, positive.

Panel B repeats the exercise for FRM30noPPP year-by-year, to show that the previous results are not driven by aggregation across time periods. Except for 2004, where the estimated treatment effect is slightly negative (but imprecisely estimated and sensitive to the bandwidth—see Table A.2 in the appendix), the estimated treatment effects are again positive.

Taken together, these results imply that over 2004–07, private securitization provided a close substitute for the government-backed agency MBS market as a means of diversifying the prepayment and interest rate risk associated with FRMs. This enabled lenders to offer long-term prepayable FRMs to jumbo borrowers to the same extent that those loans were available in the conforming segment.[22]

3.2 Difference-in-Differences Analysis

While the RDD approach described in the previous section provides a very clean way to test for treatment effects of jumbo status on contract structure, it only allows us to do so for years in which the "first stage" is powerful, i.e. from 2004 to mid-2007.

[22]Note that this finding is not inconsistent with there being a positive interest rate spread between the two segments, as widely documented in previous research (see footnote 5). Our findings suggest, however, that over this period the spread was similar for FRMs and ARMs, or that borrowers' contract choice was not particularly sensitive to small differences in rates.

To be able to also test for causal effects in earlier years, we implement an alternative identification strategy that relies on variation in the CLL from one year to the next. As in Adelino, Schoar, and Severino (2012), the idea is to look at mortgages with appraisal amounts in a band above CLL/0.8 in year t, but below CLL/0.8 in year $t+1$. In the first year, these loans are significantly more likely to be in the jumbo segment than in the second year, i.e. they are "treated" in year t but not in year $t+1$. We compare these loans to a control group with appraisal amounts below CLL/0.8 in t (and thus also in $t+1$, as CLLs never decrease from one year to the next)—i.e. they are untreated in both years.

It is easiest to think of this analysis as implemented year-by-year, although we will initially discuss results from a regression in which we pool the data across all or a subset of years. For each pair of years t and $t+1$, we use loans that have appraisal amounts within a band $[\text{CLL}_t/0.8 \pm (\text{CLL}_{t+1}/0.8 - \text{CLL}_t/0.8)]$, and estimate a two-stage least squares linear probability model:[23]

$$\begin{aligned} Pr(FRM30noPPP_i) &= \beta_0 + \beta_1 \cdot \widehat{Pr}(jumbo_i) \\ &\quad + \beta_2 \cdot I(year_i = t) + \beta_3 \cdot I(appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]) + \gamma' \mathbf{X}_i + u_i \\ Pr(jumbo_i) &= \delta_0 + \delta_1 \cdot I(year_i = t \times appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]) \\ &\quad + \delta_2 \cdot I(year_i = t) + \delta_3 \cdot I(appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]) + \lambda' \mathbf{X}_i + v_i \end{aligned}$$

Identification comes from the fact that δ_1 is positive: a loan is more likely to be in the jumbo segment if the appraisal amount of the property ($appr_i$) is above CLL/0.8 in the year in question. We can then use the predicted jumbo status in the second stage to measure the effect of jumbo structure on contract structure. We also add additional controls, denoted by $\mathbf{X}_i$: month dummies, a cubic function of FICO score (or a dummy for missing FICO score), as well as condo, investor, and subprime dummies.[24]

[23] We cap the width of the bands at $25,000 (otherwise, the width of the bands would be very heterogeneous across years); this is omitted from the text for ease of reading.

[24] The investor dummy equals 1 for declared investment properties or second homes. The subprime dummy is set to 1 if the FICO score is below 620, or if the mortgage is rated as grade B or C in the LPS data.

It may be helpful to consider a particular example (without control variables). In 2004, CLL/0.8 equals \$417,125. Among properties with appraisal amount (417,125, 442,125], in 2004 about 29% are financed with a jumbo loan. In 2005, the corresponding jumbo percentage for this property appraisal band is only 5%, since CLL/0.8 now equals \$449,563. In the "control group," properties appraised between \$392,125 and \$417,125, the corresponding percentages are approximately 6% for 2004 and 4% for 2005. The difference-in-differences, corresponding to δ_1, then equals $(0.29 - 0.05) - (0.06 - 0.04) = 0.22$. Next we consider the outcome variable Pr(FRM30noPPP). Among properties appraised in the band (417,125, 442,125], 40% in 2004 and 43% in 2005 get financed by such a mortgage. For the properties appraised in (392,125, 417,125] the corresponding numbers are 41% and 44%. Thus, both groups are somewhat more likely to get an FRM30noPPP in 2005 than in 2004, but even though in 2004 a much larger fraction of the loans in the higher appraisal band were financed by a jumbo mortgage, this difference is no larger for them than for the loans in the lower appraisal band, translating into a treatment effect of basically zero.

The "exclusion restriction" here is that, controlling for other covariates, being in the appraisal amount bin ($\text{CLL}_t/0.8$, $\text{CLL}_{t+1}/0.8$] does not differentially affect a borrower's propensity to select an FRM between the two years, other than through its effect on the likelihood of obtaining a jumbo loan. A necessary condition for this exclusion restriction to hold is that borrowers in that appraisal amount bin do not "time the market" simply in order to get a cheaper mortgage in the following year (such market-timing borrowers might have a different propensity to get an FRM due to their unobserved characteristics). To control for this possibility, in the following analysis we drop the first three months of each year, as the loans originated during those months would be most likely to be affected by such market timing.[25]

[25] However, not dropping those months does not materially alter the results.

3.2.1 Results

Table 3 presents results from the two-stage DiD regression when we pool the data over all years for which the DiD is feasible (1996–2006; Panel A), as well as for the subsample 2002–2006 (Panel B). Column 1 shows that the instrument is strong: over the full sample, properties appraised in the band ($\text{CLL}_t/0.8$, $\text{CLL}_{t+1}/0.8$] in year t are about 14 percentage points more likely to be financed by a jumbo loan than properties appraised in the same band in year $t+1$. The main coefficients of interest, however, are the predicted effects of jumbo status on the probability of obtaining a (long term, freely prepayable) FRM, shown in columns 2 and 3. Consistent with the previous section, we find small and tightly estimated effects of jumbo status, this time slightly negative: -3 percentage points and insignificantly different from zero for FRM30noPPP, and -4 percentage points and significant at $p < 0.05$ for FRM. Panel B shows that if we only look at the years 2002–ronger over time.[26] For the predicted effects of jumbo status on the probability of obtaining an FRM, we see that there is some variation over time, though the effects are often somewhat imprecisely estimated. For the two years — 2004 and 2005 — for which there is an overlap between the sample used for the DiD analysis and our previous RDD results, the results of the analysis are very similar: the effect of jumbo status on the probability of selecting an FRM is very close to zero, tightly estimated, and not statistically significant. The effect of jumbo status on Pr(FRM30noPPP) is estimated to be very significantly negative (economically and statistically) for one year, the year 2000 (see section 4 for further discussion); it is also negative, although smaller, in 2002. The "Non_sec6" column shows that the predicted effect of jumbo status on the likelihood of a loan being non-securitized six months after origination is also large in 2000 and 2002. This is consistent with the idea that when private securitization is more difficult, lenders become more reluctant to offer FRMs to jumbo borrowers.[27]

[26] The F-statistics from the first-stage regression are above 50 for all years except 1996, where it equals approximately 7, potentially explaining why the estimated treatment effect for that year is so imprecisely estimated.

[27] The estimated coefficient for Non_sec6 is even larger for 2001. However, for that year, unlike for the other years, the coefficient would be much smaller (around 0.1) if we used securitization status 12 months

To sum up, results of this difference-in-differences analysis imply that, during times when the private market is effective at securitizing jumbo mortgages, plausibly exogenous variation in jumbo status has little effect on a borrower's likelihood of matching with a (long-term prepayable) FRM. These results match closely with our earlier RDD findings. On the other hand, particularly the finding of a relatively large effect of jumbo status on contract structure around the year 2000 is suggestive that if securitization markets are disrupted, lenders become much more reluctant to originate FRMs.

We now turn to a particularly stark natural experiment as a further test of this conclusion: the freeze in the nonagency MBS market in the third quarter of 2007.

4 The 2007 MBS Liquidity Freeze and Policy Response

As described in section 2, the U.S. experienced an abrupt collapse in liquidity in the nonagency MBS market around the onset of the financial crisis in August 2007. Here, we study how this episode affects mortgage contract structure. We use two approaches: 1) an extension of the DiD strategy used above, and 2) a linear regression approach where we drop loans close to the CLL, to limit selection issues. Unfortunately, the RDD strategy used earlier is not useful during this crisis period, because the instrument is not statistically powerful, as discussed in section 3.1.

4.1 Difference-in-Differences Analysis

First we apply the same DiD approach used above to estimate how the increase of the CLL in high-cost housing areas (announced in February 2008, and implemented by May) influences mortgage contract structure for affected borrowers. We take May 1, 2008 as the effective starting date of the new limits, rather than the passage of the act itself, because of implementation lags and the issues around TBA deliverability discussed in section 2.

after origination.

We start by identifying the county of each loan in our sample based on zip codes, and then merge with the set of county-level CLLs. For the subset of counties for which the CLL was raised above 417,000, we then take bands of maximum width \$75,000 around 417,000/0.8 (=\$521,250) and compare the prevalence of FRM30noPPP loans in these bands before and after the loan limit is raised. In the "before" period, loans above \$417,000 effectively cannot be securitized, since they are ineligible for purchase by F&F, and the nonagency securitization market is frozen. In the "after" period, though, these loans are eligible for agency securitization. Loans in these areas below \$417,000 in size act as a control group, since they are eligible for securitization in both the "before" and "after" period.[28]

As can be seen in Table 5, the estimated causal effect of securitization-ineligibility on the probability of obtaining a FRM30noPPP is minus 33 percentage points during this period, an effect which is economically very large, and highly statistically significant. The estimated effect of ineligibility on the probability of a loan being non-securitized is also very large, which is of course expected, given the nonagency market freeze.

This finding stands in stark contrast to our pre-crisis results based on the same DiD methodology—recall that when private MBS markets are liquid, eligibility for agency securitization has essentially no effect on the FRM share. The key difference is that after the nonagency MBS market freezes, lenders originating jumbo FRMs have little choice but to retain such mortgages as whole loans. As we will discuss further below, this is an unattractive option given the prepayment risk and interest rate risk associated with such mortgages. The lenders respond by disproportionately contracting the supply of FRMs, leading to substitution towards ARMs by jumbo borrowers.

[28]We chose a three times larger cap on the bandwidth compared to the previous subsection, so as to obtain a sufficient number of observations to precisely estimate the treatment effects. Using narrower bandwidths does not qualitatively affect the results, however; neither does dropping February to April 2008 from the crisis period (as the increase in the CLLs had already been announced), or using 2009, rather than May to December 2008, as the comparison period.

4.2 Fractional Polynomial Regressions

We now consider an alternative estimation approach as a robustness check on the above findings. As discussed at the beginning of section 3.1, directly linking mortgage contract structure to whether the borrower selects a jumbo mortgage would likely lead to significantly biased estimates of the effects of agency securitization, due to sorting of borrowers into the conforming market. However, Figure 3 suggests that these selection effects are concentrated relatively close to the CLL (within about 20 percent of the limit). Consequently, in this section we consider a third estimation approach, amenable to estimation both before and after the onset of the financial crisis, in which we control for endogenous selection into jumbo or conforming mortgages simply by excluding loans with principal amounts close to the CLL.

We estimate linear probability models, where the dependent variable is equal to one if the borrower selects a 30-year prepayable FRM and zero otherwise. This choice is modeled as a fractional polynomial function of the loan amount, which provides a flexible way to account for the possibly non-linear relationship between loan size and demand for an FRM.[29]) We add a dummy variable for whether the loan amount exceeds the CLL, with the goal of picking up discrete jumps in Pr(FRM30noPPP) as a result of being in the jumbo segment. The coefficient on this jumbo dummy is the main variable of interest. We also control for the same borrower covariates as in section 3.2.

Our analysis includes only purchase mortgages originated between January and September of each calendar year. Under the presumption that selection effects are most severe close to the CLL, we exclude mortgages with loan amounts between 95% and 120% of the CLL.[30] We estimate separate regressions by origination year between 1996 and 2007, as well as a

[29] See Royston and Altman (1994) for an introduction to fractional polynomial (FP) models. In our analysis, we consider FP functions up to degree 2, meaning that we find the powers (p_1, p_2) from the predefined set $S = \{-2, -1, -0.5, 0, 0.5, 1, 2, 3\}$ (where 0 means $log(x)$, with x denoting the loan amount) in order to obtain the best fit of our dependent variable on $\beta_1 x^{p_1} + \beta_2 x^{p_2}$ and the other covariates. Going beyond degree 2 is too costly computationally in our application.

[30] In other unreported specifications we have experimented with dropping a larger band around the limit, up to 140% or 160% of the CLL; this generally produces similar results, with the coefficient on the jumbo dummy moving somewhat closer to zero.

separate regression for the "crisis" period (August 2007 to April 2008).

Results of this analysis are presented in Table 6. The results show that, controlling for other observable borrower characteristics and dropping loans near the CLL, the difference in the FRM share between the jumbo and conforming markets in the years preceding the crisis, while not zero, is relatively small, consistently of the order of around 10 percentage points. However, in the crisis period, this difference sharply increases, to 34 percentage points.

Note that the estimated coefficient on the jumbo dummy may be an upper bound of the effects of F&F intervention and higher MBS liquidity on contract structure, since borrowers in the conforming and jumbo segment may still differ in terms of unobservables that influence mortgage choice, such as expected mortgage tenure, expected income, risk aversion, etc. Given this potential omitted variable bias, we rely on the estimated coefficients mainly to study variation over time, rather than interpret the magnitude of the coefficient directly.

Our key result here is also illustrated graphically in Figure 6. This figure shows that the FRM share is high in the conforming market during this financial crisis period. However, the share drops very sharply and discontinuously, and from visual inspection, permanently, at the CLL during the crisis. Compared to Figure 3, the drop-off in FRM share around the CLL is much larger.

These striking trends in mortgage origination occur exactly at the same time as the collapse in nonagency securitization activity, as shown in Figure 2. The figure shows that in the jumbo market, the fraction of mortgages that are not securitized shoots up markedly during the crisis. In contrast, securitization volumes remain robust in the non-jumbo segment, thanks to the continued availability of agency securitization.

Tables 4 and 6 and the second panel of Figure 6 also show that a similarly sharp drop in FRM share around the CLL was present during 1999 and 2000. This period corresponds to the aftermath of the LTCM collapse, as well as a sharp decline in MBS issuance due to rising interest rates.[31] Our interpretation, supported by the patterns in Figure 2, is that

[31]Mortgage interest rates, as measured by the Freddie Mac conventional interest rate series on 30-year FRMs, rose from 6.79% in January 1999 to 8.52% by May 2000, reflecting rising Treasury yields. This led

MBS liquidity of jumbo loans declined during this period, reflecting the smaller pipeline of new securities, although not as dramatically as during the financial crisis. We posit that the agency MBS market was less affected by these events, because of its greater overall size, and the much greater liquidity of the TBA market.

4.3 Robustness Checks

A possible alternative explanation for the above findings is a borrower selection effect in the jumbo market during the financial crisis. After the nonagency MBS market becomes illiquid, the overall supply of credit in the jumbo market contracts relative to the conforming market (as illustrated by the sharp increase in the spread between jumbo and conforming mortgage interest rates, for example). If this contraction leads to rationing of borrowers with a preference for FRMs, it could explain the low FRM share above the conforming loan limit during this period.

To test for this possibility, we reestimate our analysis using a subsample of the most creditworthy borrowers, those with FICO scores above 760. Under the selection effects hypothesis, our key coefficient estimate will be attenuated amongst this subsample, because they are less likely to be credit rationed in the jumbo market during the financial crisis than the average borrower. However, under our "risk management" interpretation, the estimated effect of agency MBS access on the FRM share will be similar to our baseline estimates, or may even become larger, because prepayment risk is generally considered to be larger amongst more creditworthy borrowers.

Our results are consistent with this second explanation, not the first. Our coefficient estimates are slightly larger for the high FICO subsample. For example, for the DiD estimation,

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to a sharp decline in mortgage origination volumes, particularly for refinancings. The trade publication "Mortgage Banking" writes in December 1999 that "The refi market has dried up—so far there hasn't been carnage in the overall origination marketplace, [but] there's no doubt that the impact of interest rates has been great, with every company affected by excess capacity." Pointing to volatility in MBS markets during this period, the "American Banker" writes in September 1999 that "The market is 'getting crushed,' he [a market participant] said. Mortgage spreads are 'at or near the spreads of fall 1998, and still there's not that much buying,' he said, referring to the liquidity crisis that hit the capital markets last fall."

our baseline estimate for the share of FRM30noPPP increases in magnitude from -0.33 to -0.45. This suggests the low FRM share in the jumbo market is indeed driven by concerns about hedging interest rate risk and prepayment risk, rather than selection effects driven by credit risk.

[To add: insert table of results for high FICO borrowers]

4.4 Discussion

The evidence from the 2007 nonagency MBS freeze, as well an earlier period of apparent instability in 1999–2000, suggests that mortgage lenders are sensitive to changes in the ease with which jumbo mortgages can be securitized. Lack of access to securitization translates directly into a decline in lenders' willingness to originate FRMs (not just in absolute terms, but also compared to ARMs), and a significant shift in equilibrium household mortgage choice towards adjustable-rate contracts.

These findings imply that lenders are unwilling to retain FRMs on-balance sheet as whole loans. Our interpretation of this behavior is that it reflects two risks specifically associated with FRMs, *prepayment risk* and *interest rate risk*. Prepayment risk is the risk that the value of the mortgage will change due to fluctuations in borrower prepayment behavior. This risk is important for FRMs because the mortgage is prepaid at par, which may differ substantially from its market value given the long duration of FRMs. Borrowers are more likely to prepay when market interest rates fall and the prepayment option is most valuable. The relation between interest rates and prepayment is sharply nonlinear and unstable over time, however; furthermore, a variety of nontraded risks also influence prepayment rates, such as housing market liquidity and price growth, credit conditions, labor market turnover and so on. This combination of factors make it difficult for lenders to hedge prepayment risk effectively. Gabaix, Krishnamurthy, and Vigneron (2007) provide evidence of the costs associated with bearing nondiversifiable prepayment risk; these authors show that the marginal MBS investor requires a return premium to hold securities backed by FRMs which appears to reflect nonsystematic rather than systematic risk from the perspective of the economy as a whole.

Interest rate risk is the risk that the mortgage value will change due to shifts in the term structure of interest rates. This risk affects a lender's value and cash flows if the mortgage asset is not matched by liabilities of similar duration, which generally is not the case for banks funded primarily by deposits. In principle, lenders can hedge this risk using interest rate swaps, although in practice this strategy may be costly because of counterparty credit risk and liquidity risk (Liu, Longstaff, and Mandell 2006). Maturity mismatch due to a high portfolio concentration of FRMs was a primary cause of the wave of failures of U.S. savings and loan institutions in the early 1980s (White 1991).

In a frictionless setting, mortgage lenders would incur no particular costs in bearing interest rate and prepayment risk privately, consistent with Modigliani and Miller (1958). However, more recent research has shown that bearing undiversified risks is costly in the presence of financial imperfections, with significant effects on real firm outcomes (e.g. Froot, Scharfstein, and Stein 1993; Froot and Stein 1998). Our results are consistent with the key idea of this research, as in our setting financial firms seem to make product market decisions (which loans to supply) at least in part based on risk management concerns.

Securitization is a tool for diversifying and repackaging the prepayment and interest rate risk associated with FRMs. In addition to simple pass-through securities, which account for much of the MBS market, more sophisticated structures such as collateralized mortgage obligations can be used to further concentrate duration and/or prepayment risk into particular classes of securities, such as z-bonds and PAC support bonds (see e.g. Fabozzi, Bhattacharya, and Berliner 2009 for more details). Beyond transferring risks from the balance sheet of the originator, these securities allow these risks to be held by investors best able to manage and bear them. Our empirical results suggest that the willingness of originators to supply FRMs depends importantly on the availability of these liquid securitization markets.

5 Policy Implications and Caveats

Taken at face value, our findings have a number of specific policy implications for ongoing reform of the U.S. mortgage finance system. First, our results suggest that regulatory or legislative actions that make securitization more difficult, such as more stringent risk retention requirements, may lead to a lower share of FRMs amongst affected mortgages. Incentives to increase the use of covered bonds, as sometimes proposed, could also potentially reduce the FRM share.[32]

Second, our results imply that maintaining the current GSE-centered mortgage finance system is *not* necessary for FRMs to remain widely available at competitive rates, as long as private securitization markets are liquid.[33]

Third, recent experience suggests that private MBS markets are likely to be subject to more volatility in liquidity than government-backed markets, leading to relatively lower FRM supply in periods when MBS liquidity freezes, as we document in the jumbo market during the recent financial crisis. Scharfstein and Sunderam (2011), for example, argue in favor of government intervention in mortgage funding markets only during crisis periods, which could mitigate these effects.

We emphasize a number of important caveats associated with these policy conclusions. Perhaps the most important is that we conduct a partial equilibrium analysis based on local variation in access to securitization markets. It is possible that our results would not

[32] In a standard covered bond structure, a noncallable bond is issued backed by a pool of loans known as the "cover pool" that remains on the balance sheet of the originator. Prepayment risk is borne by the originator, just as if the mortgages were funded by deposits. Covered bonds can reduce interest rate risk however, since the bond is generally of long duration, like the mortgages in the cover pool. Covered bonds are popular in some continental European countries, such as Germany. In contrast to a standard noncallable covered bond, in Denmark, mortgage banks issue bonds that mimic the cashflows on each mortgage origination, transferring prepayment risk to bondholders. For this reason, lenders in Denmark are willing to originate a high share of long-term prepayable FRMs, like the U.S., but unlike other countries in Europe (see Green and Wachter 2005 for a further discussion.) Our empirical results suggest that shifting to a Danish-style system would not significantly affect the FRM share, but shifting to a system based on standard covered bonds would be likely to reduce the relative supply of FRMs. This is because the latter approach would require lenders to retain prepayment risk, which, as we have shown, lenders are reluctant to do.

[33] At the time of this writing, liquidity in the nonagency MBS market is low but slowly improving, reflected in a small number of recent jumbo MBS deals sponsored by the issuer Redwood Trust Inc.

translate directly to a large change in the mortgage finance system, such as winding down F&F and replacing them with a purely private funding market.

There are different reasons why private markets might be unable to provide 30-year FRMs at competitive rates for the whole market, rather than just the jumbo market. One possibility is that without a government guarantee against default risk, many institutional investors and foreign entities may no longer be able or willing to invest in MBS. As a higher fraction of FRMs is securitized relative to adjustable-rate mortgages, this might cause a larger increase in FRM rates.

Other general equilibrium effects could either reduce or increase the private market's effectiveness at supplying FRMs. For example, if the agency MBS market were smaller (or disappeared completely), this would likely reduce market liquidity of the TBA ("to-be-announced") MBS market, which accounts for the bulk of agency MBS trading activity. Since investors in nonagency mortgages often use TBA forward contracts to hedge short-term risks associated with non-conforming mortgages, this could have spillovers on the private nonagency MBS market, which are not captured in our partial equilibrium analysis. On the other hand, it seems possible that some kind of TBA-like market structure could emerge organically from a private market in response to a winding-down of F&F.[34] Indeed, a shift towards a larger private, nonagency MBS market could further increase the liquidity of MBS backed by non-conforming FRMs and thus have a positive effect on their supply.

We note that, while we find no causal effect of F&F on mortgage structure in recent history prior to the financial crisis, these agencies almost certainly played a causal role in establishing the long-term FRM historically. In fact, it is possible that there is path-dependence in the type of mortgages that are offered and popular: if a country begins from an equilibrium in which FRMs are rare, then the secondary market for such mortgages is likely to be small and illiquid, and there will also be less product market competition for

[34] Amongst other issues, there are some legal hurdles that would need to be overcome for TBA trading to be possible in the nonagency MBS market; in particular, the market would need to be exempt from the registration requirements of the Securities Act of 1933 (see Vickery and Wright 2011 and Dechario et al. 2011 for a more detailed discussion).

these instruments. These factors in turn make FRMs more expensive, keeping their market share low, and reinforce the illiquidity of the MBS market. On the other hand, government intervention that leads to coordination on FRMs as the dominant product may create a "virtuous cycle," enabling FRMs to remain the dominant contract type even if government support is subsequently removed.[35]

Finally, we emphasize that our analysis is entirely positive rather than normative in nature. This paper does *not* take a stand on whether or not maintaining the primacy of the 30-year FRM is a desirable policy goal from a social welfare perspective, a question on which experts and policymakers sharply disagree (see e.g. Lea and Sanders 2011). We do emphasize, however, that changes in the FRM share are likely to have important consequences for household risk management, monetary policy transmission, and systemic risk, given the importance of residential mortgages and MBS in household and investor portfolios.

6 Conclusions

We find that liquid securitization markets are a key driver of the supply of fixed-rate mortgages, and thus have important effects on U.S. household portfolios. Quantitatively, our estimates based on recent experience indicate that the share of FRMs is 25–30 percentage points higher when lenders are able to easily securitize newly-originated mortgages. Our evidence suggests that government backing is not necessary for maintaining FRM supply, but only as long as private securitization markets are liquid and well functioning. As we have emphasized, these findings have a number of implications for the ongoing debate around U.S. mortgage finance reform, which is among the most pressing economic policy issues facing the U.S. today. From a broader perspective, our results provide a striking illustratation of how the institutional features of the financial system can shape financial contracting and the allocation of risk amongst households and investors.

[35] One implication of this path-dependency argument: one should not infer that prepayable FRMs would disappear in the U.S. in the absence of government sponsorship just because FRMs are generally rare in other countries which do not feature this support.

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Table 1: Conforming loan limits over sample period

CLL is the maximum loan size that Fannie Mae and Freddie Mac are legally able to purchase. CLL/0.8 gives the threshold for a property's appraisal value such that properties below this threshold can be financed with a conforming loan at 80% loan-to-value ratio. Since February 2008, CLLs have been varying at the county level, as explained in the main text.

Year	CLL (1 unit), in $	CLL/0.8
1996	207,000	258,750
1997	214,600	268,250
1998	227,150	283,938
1999	240,000	300,000
2000	252,700	315,875
2001	275,000	343,750
2002	300,700	375,875
2003	322,700	403,375
2004	333,700	417,125
2005	359,650	449,563
2006	417,000	521,250
2007	417,000	521,250
2008	417,000 – 729,750	521,250 – 911,563
2009	417,000 – 729,750	521,250 – 911,563

Table 2: Fuzzy regression discontinuity design: Results

Table shows estimated treatment effect ("Wald estimate") of being in the jumbo segment of the mortgage market on: the probability of obtaining a freely prepayable fixed-rate mortgage with term of 30 years or higher (FRM30noPPP); the probability of obtaining any type of fixed-rate mortgage (FRM); and the probability of a loan being held in portfolio six months after origination (Non_sec6). The treatment effect is given by the ratio of the change in Pr(dependent variable) to the change in Pr(jumbo) around the appraisal threshold CLL/0.8 (see equation (1)). Estimation uses local linear regressions with bandwidth 0.08 and a triangle kernel that gives more weight to observations near the boundary. All regressions include year-month dummies. We use the "rd" Stata command by Nichols (2011) to perform the estimation.

A. Pooled, January 2004 – July 2007

	FRM30noPPP	FRM	Non_sec6
Change in Pr(dep. var.)	0.00552	0.00973***	0.00346
	(0.00340)	(0.00341)	(0.00257)
Change in Pr(jumbo)	0.145***	0.145***	0.152***
	(0.00227)	(0.00227)	(0.00261)
Treatment effect	0.0381	0.0672***	0.0227
(Wald estimate)	(0.0236)	(0.0238)	(0.0168)
N	407443	407443	310280

B. Year-by-year, 2004 – 2007, for FRM30noPPP only

	2004	2005	2006	2007
Change in Pr(dep. var.)	-0.000306	0.00962	0.00950	0.00228
	(0.00664)	(0.00597)	(0.00691)	(0.00848)
Change in Pr(jumbo)	0.127***	0.165***	0.176***	0.0899***
	(0.00456)	(0.00379)	(0.00476)	(0.00571)
Treatment effect	-0.00241	0.0583	0.0538	0.0253
(Wald estimate)	(0.0523)	(0.0365)	(0.0395)	(0.0947)
N	111348	132695	100526	62874

Robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Difference-in-differences estimates: Results (pooled data)

Sample includes purchase-money mortgages with appraisal amounts in $[\mathrm{CLL}_t/0.8 - \min(\mathrm{CLL}_{t+1}/0.8 - \mathrm{CLL}_t/0.8,\ 25000),\ \mathrm{CLL}_t/0.8 + \min(\mathrm{CLL}_{t+1}/0.8 - \mathrm{CLL}_t/0.8,\ 25000)]$ originated between April and September of each calendar year. Controls in each specification include month dummies, state dummies, a cubic function of FICO score at origination (with a dummy for missing FICO), an investor dummy (including second homes), a condo dummy, and a subprime dummy. Standard errors are clustered at the individual loan level, as the same loan can be part of the "high appraisal" band in year t and the "low appraisal" band in year $t+1$.

A. All years (1996-2006)

	(1) Jumbo	(2) FRM30noPPP	(3) FRM	(4) Non_sec6
$(year_i = t)\times$ $appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]$	0.138*** (0.00168)			
Jumbo		-0.0302 (0.0186)	-0.0413** (0.0163)	0.0812*** (0.0131)
N	758776	758776	758776	491639

B. 2002-2006 only

	(1) Jumbo	(2) FRM30noPPP	(3) FRM	(4) Non_sec6
$(year_i = t)\times$ $appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]$	0.182*** (0.00201)			
Jumbo		-0.0113 (0.0186)	-0.0301* (0.0175)	0.0615*** (0.0136)
N	480358	480358	480358	315081

Clustered standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Difference-in-differences estimates: Results (year by year)

Sample includes purchase-money mortgages with appraisal amounts in [$\mathrm{CLL}_t/0.8$ - min($\mathrm{CLL}_{t+1}/0.8$ - $\mathrm{CLL}_t/0.8$, 25000), $\mathrm{CLL}_t/0.8$ + min($\mathrm{CLL}_{t+1}/0.8$ - $\mathrm{CLL}_t/0.8$, 25000)] originated between April and September of each calendar year. Controls in each specification include month dummies, state dummies, a cubic function of FICO score at origination (with a dummy for missing FICO), an investor dummy (including second homes), a condo dummy, and a subprime dummy.

	1996				**1997**			
	Jumbo	FRM30noPPP	FRM	Non_sec6	Jumbo	FRM30noPPP	FRM	Non_sec6
$(year_i = t)\times$ $appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]$	0.0291*** (0.00951)				0.0844*** (0.00710)			
Jumbo		-0.429 (0.347)	-0.236 (0.233)	-0.0194 (0.247)		0.0863 (0.0969)	-0.0424 (0.0740)	-0.0364 (0.0892)
N	23028	23028	23028	13424	51863	51863	51863	29622
Adj. R^2	0.0248	.	0.0895	0.117	0.0706	0.0392	0.0788	0.0211

	1998				**1999**			
	Jumbo	FRM30noPPP	FRM	Non_sec6	Jumbo	FRM30noPPP	FRM	Non_sec6
$(year_i = t)\times$ $appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]$	0.0502*** (0.00516)				0.0690*** (0.00650)			
Jumbo		-0.170 (0.125)	0.0337 (0.0881)	-0.00833 (0.0966)		0.0235 (0.125)	0.0170 (0.105)	0.184** (0.0793)
N	65277	65277	65277	36293	44373	44373	44373	28728
Adj. R^2	0.0526	0.0259	0.0256	0.0222	0.0450	0.0503	0.0737	0.136

	2000				**2001**			
	Jumbo	FRM30noPPP	FRM	Non_sec6	Jumbo	FRM30noPPP	FRM	Non_sec6
$(year_i = t)\times$ $appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]$	0.127*** (0.00527)				0.0474*** (0.00419)			
Jumbo		-0.293*** (0.0547)	-0.197*** (0.0447)	0.208*** (0.0376)		0.201 (0.133)	0.226** (0.115)	0.264*** (0.0721)
N	63329	63329	63329	46554	70186	70186	70186	45099
Adj. R^2	0.0997	0.0808	0.141	0.159	0.0433	0.0215	.	0.0355

	2002				2003			
	Jumbo	FRM30noPPP	FRM	Non_sec6	Jumbo	FRM30noPPP	FRM	Non_sec6
$(year_i = t)\times$ $appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]$	0.121***				0.0849***			
	(0.00420)				(0.00417)			
Jumbo		-0.138**	-0.142***	0.169***		-0.0989	-0.132*	0.0873
		(0.0538)	(0.0469)	(0.0377)		(0.0833)	(0.0775)	(0.0888)
N	98915	98915	98915	47306	69473	69473	69473	39070
Adj. R^2	0.0684	0.0440	0.0933	0.0673	0.0390	0.0915	0.175	0.0439

	2004				2005			
	Jumbo	FRM30noPPP	FRM	Non_sec6	Jumbo	FRM30noPPP	FRM	Non_sec6
$(year_i = t)\times$ $appr_i \in (CLL_t/0.8, CLL_{t+1}/0.8]$	0.223***				0.252***			
	(0.00327)				(0.00297)			
Jumbo		0.00721	-0.0122	0.0574***		0.00989	0.0151	0.0718***
		(0.0223)	(0.0223)	(0.0185)		(0.0203)	(0.0202)	(0.0135)
N	143715	143715	143715	104197	128617	128617	128617	101346
Adj. R^2	0.135	0.116	0.145	0.0357	0.202	0.153	0.173	0.0344

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

Table 5: Difference-in-differences for nonagency MBS freeze vs. period with increased CLLs

"Crisis period" is taken to be August 2007 to April 2008. Comparison period with higher CLLs ("CLL_{2008}") is May 2008 (when issuance of high-balance MBS started) to December 2008. The coefficient on Jumbo should be interpreted as the causal effect of being in the jumbo segment during the crisis period relative to the comparison period (when jumbos became effectively conforming).

	(1) jumboind	(2) FRM30noPPP_u	(3) FRM	(4) Non_sec6
Crisis period × $appr_i \in (417\text{k}/0.8, CLL_{2008}/0.8]$	0.0846***			
	(0.00243)			
Jumbo		-0.331***	-0.233***	0.270***
		(0.0649)	(0.0633)	(0.0471)
N	88685	88685	88685	79138
Adj. R^2	0.118	0.0870	0.0901	0.214

Robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Fractional polynomial regressions, excluding loans near conforming loan limit

Dependent variable = 1 if borrower selects a 30-year FRM without prepayment penalties, = 0 otherwise. Sample includes purchase-money mortgages originated between January and September of each calendar year. Controls in each specification include month dummies, state dummies, a cubic function of FICO score at origination (with a dummy for missing FICO), an investor dummy (including second homes), a condo dummy, and a subprime dummy. Each regression excludes mortgages between 95% and 120% of the conforming loan limit.

	(1) 1996	(2) 1997	(3) 1998	(4) 1999	(5) 2000	(6) 2001	(7) 2002	(8) 2003	(9) 2004	(10) 2005	(11) 2006	(12) 2007 (to July)	(13) Crisis
Jumbo	-0.216***	-0.113***	-0.111***	-0.178***	-0.314***	-0.173***	-0.0965***	-0.0819***	-0.0763***	-0.110***	-0.0975***	-0.116***	-0.341***
	(0.00576)	(0.00523)	(0.00384)	(0.00400)	(0.00518)	(0.00511)	(0.00479)	(0.00362)	(0.00258)	(0.00220)	(0.00245)	(0.00361)	(0.00458)
N	555328	524742	905651	903218	542403	727018	823613	1379699	1382666	1656286	1470872	947540	759295
Adj. R^2	0.0462	0.0406	0.0325	0.0440	0.121	0.0430	0.0431	0.0392	0.0936	0.159	0.201	0.151	0.134
FP Deviance	621277.9	613370.9	878152.7	952085.3	584888.1	746228.2	1034558.8	1831277.7	1870272.5	2116727.9	1786786.6	959344.7	469982.2
FP Powers	-2 1	-1 0	-2 2	-2 2	0 0	.5 .5	0 .5	.5 .5	1 2	-1 -1	-1 -1	-1 0	-.5 0

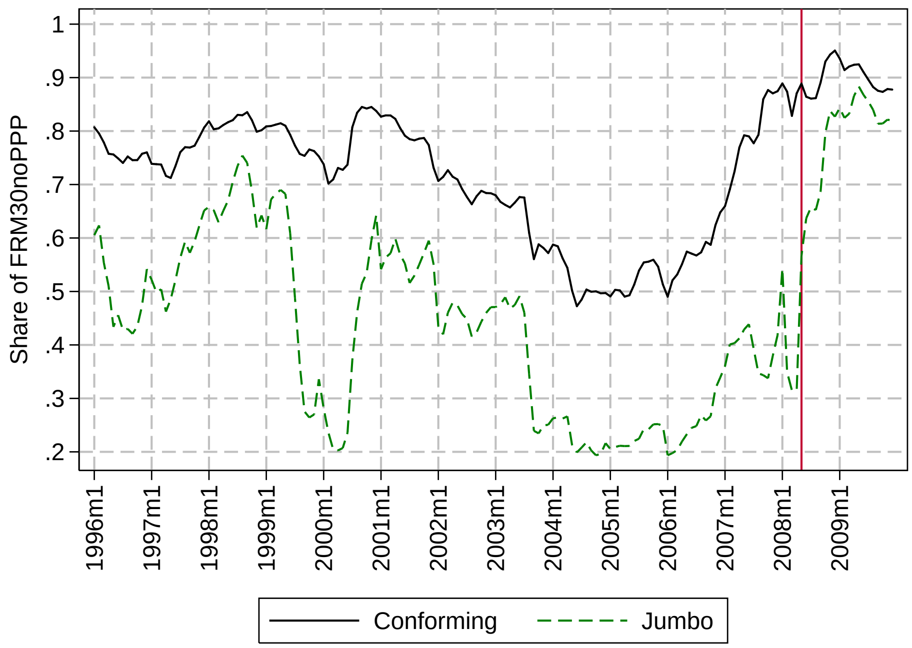
Robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Market share of fixed-rate mortgages in jumbo and non-jumbo segment, 1996–2009

Author calculations based on LPS data. Purchase-money mortgages only; shares are value-weighted. For purposes of the graphs "Conforming" refers to mortgages with an initial principal balance below the national conforming limit. The vertical line in May 2008 marks the effective introduction of "super-conforming" mortgages (jumbo mortgages that F&F were allowed to purchase).

A. 30-year FRMs without prepayment penalties



B. All FRMs

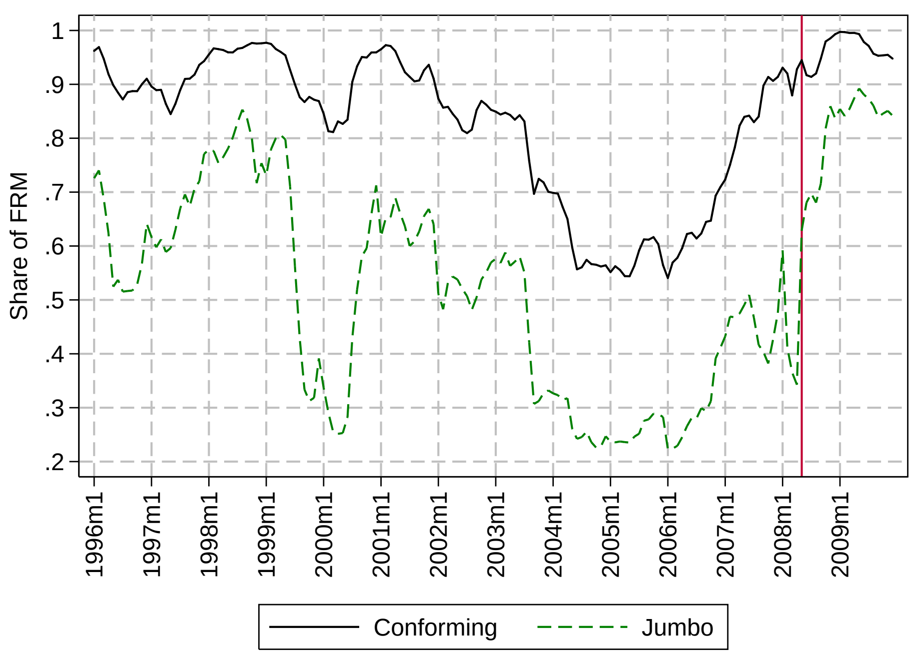
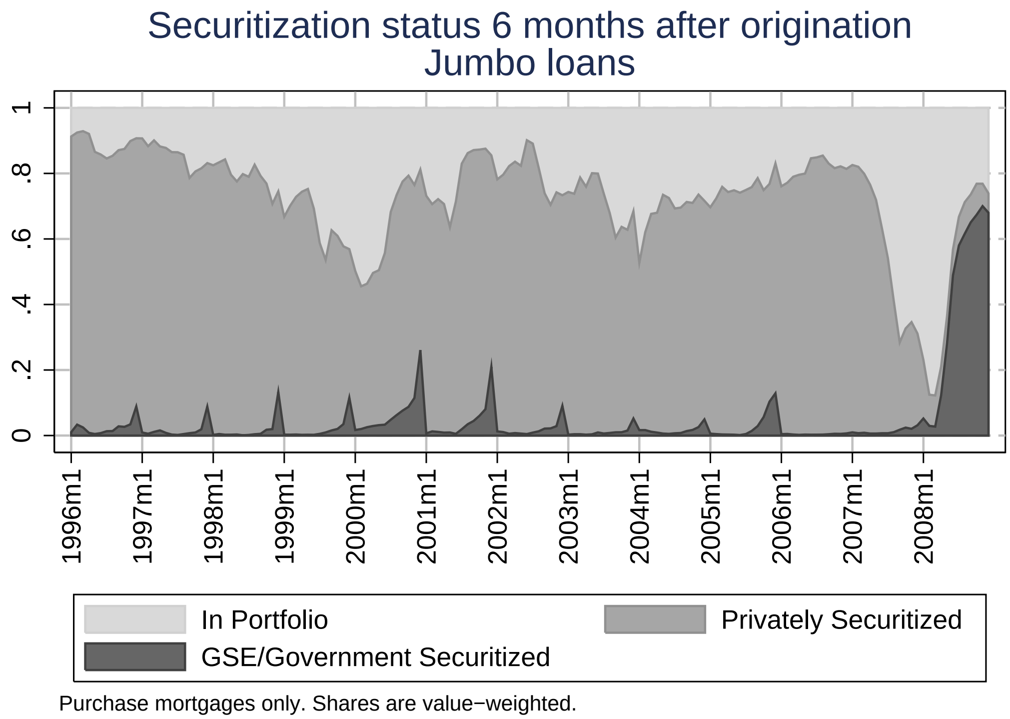


Figure 2: Securitization activity in jumbo and non-jumbo segment

Author calculations based on LPS data. Purchase-money mortgages only; shares are value-weighted. Jumbo status is determined relative to national conforming limit; in particular, for 2008 this includes "super-conforming" mortgages in high-cost areas. Securitization status is measured six months after origination of a loan, so that only mortgages that are in the dataset by that point (and have not yet prepaid) are included in this calculation. X-axis indicates mortgage origination date, not securitization date.



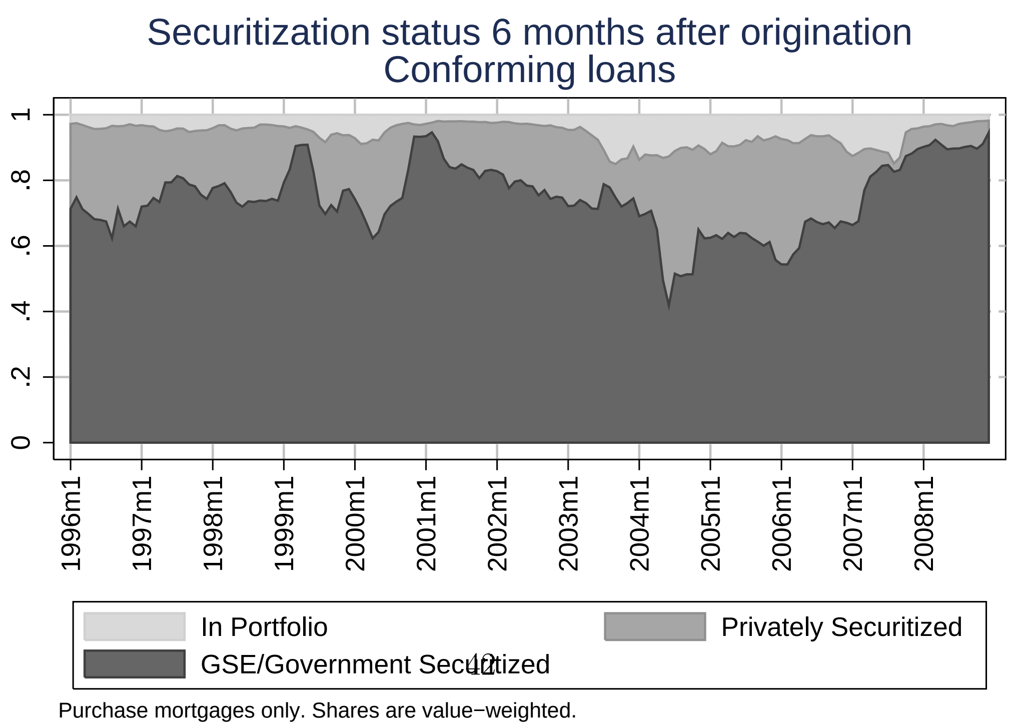
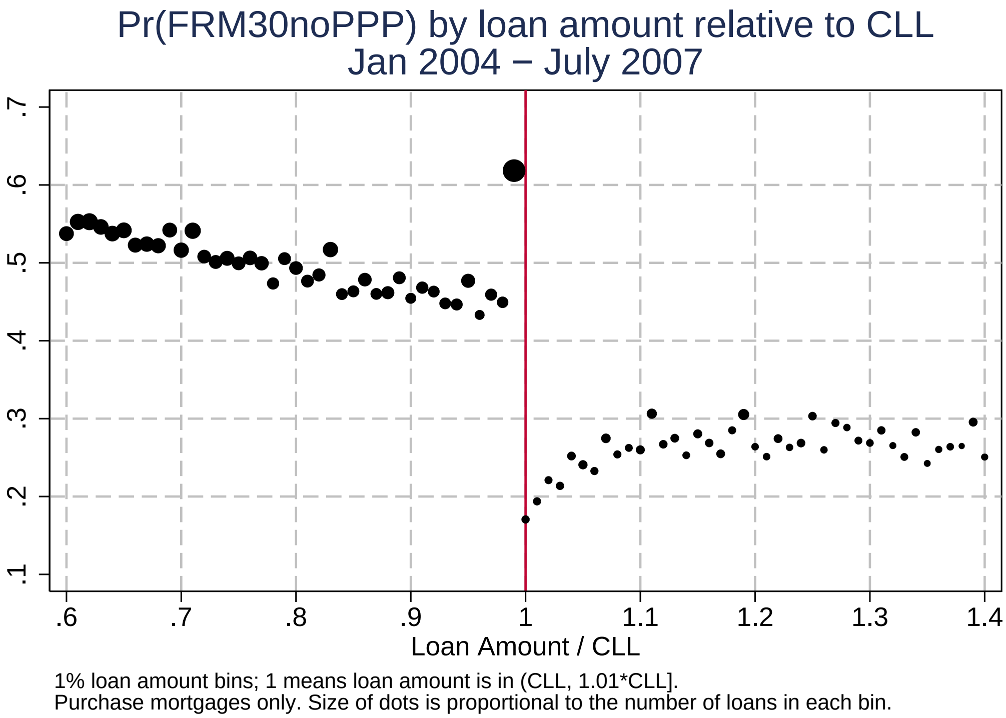


Figure 3: Selection around the conforming loan limit

A. Contract structure



B. FICO score distribution

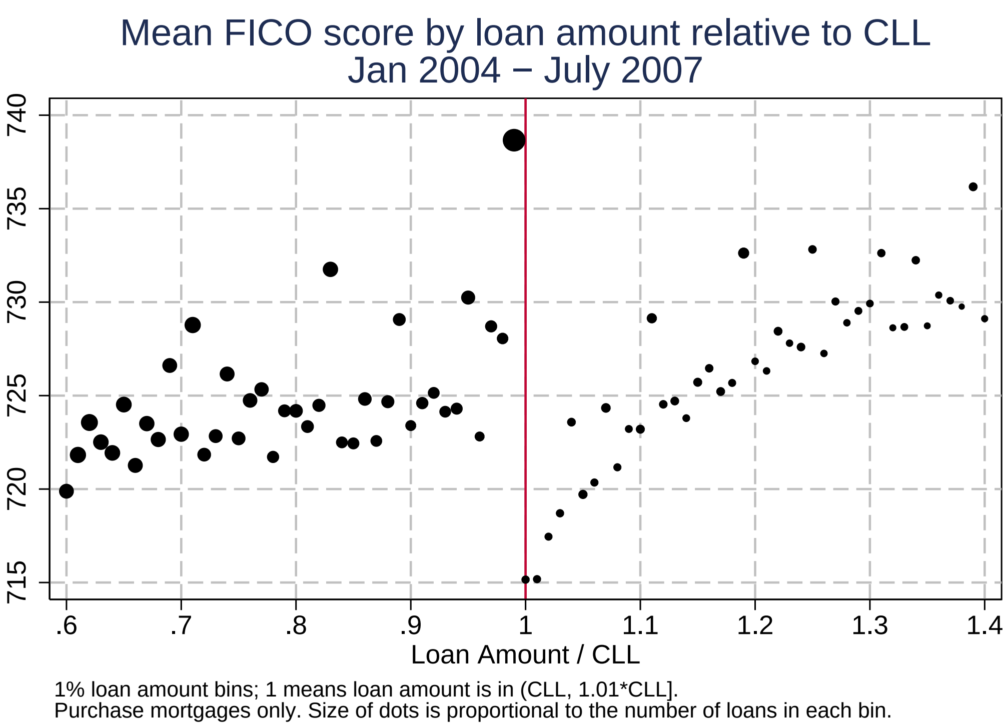
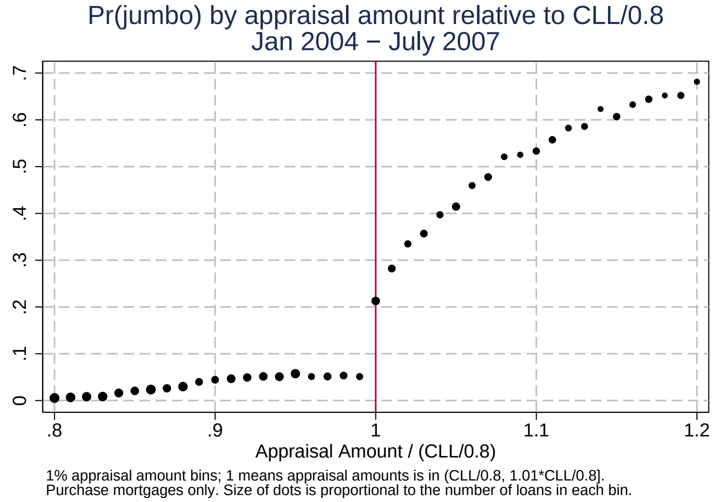
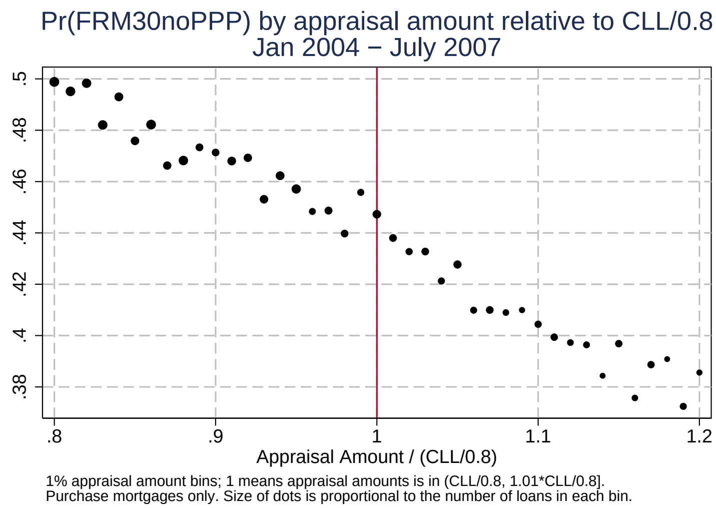


Figure 4: Regression discontinuity analysis

A. Probability of selecting a jumbo mortgage



B. Probability of selecting a 30-year prepayable FRM



C. Probability of selecting any FRM

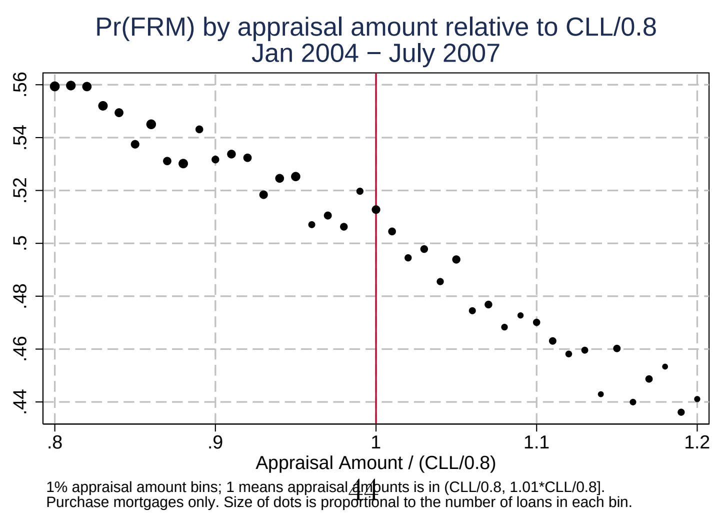
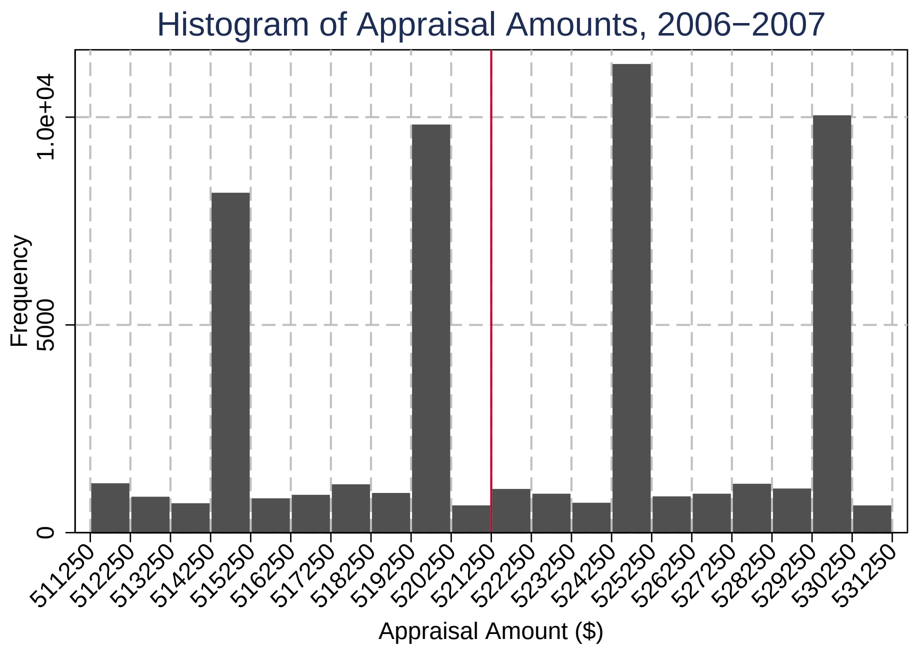


Figure 5: No evidence for selection around appraisal amount CLL/0.8

A. Histogram of appraisal amount: Figure shows the distribution of loan volumes for different property appraisal values around the "conforming property price" threshold. There is no evidence of a distortion in the distribution, suggesting borrowers do not materially adjust their home buying patterns in order to qualify for a conforming mortgage with LTV of 80%.



B. FICO score distribution

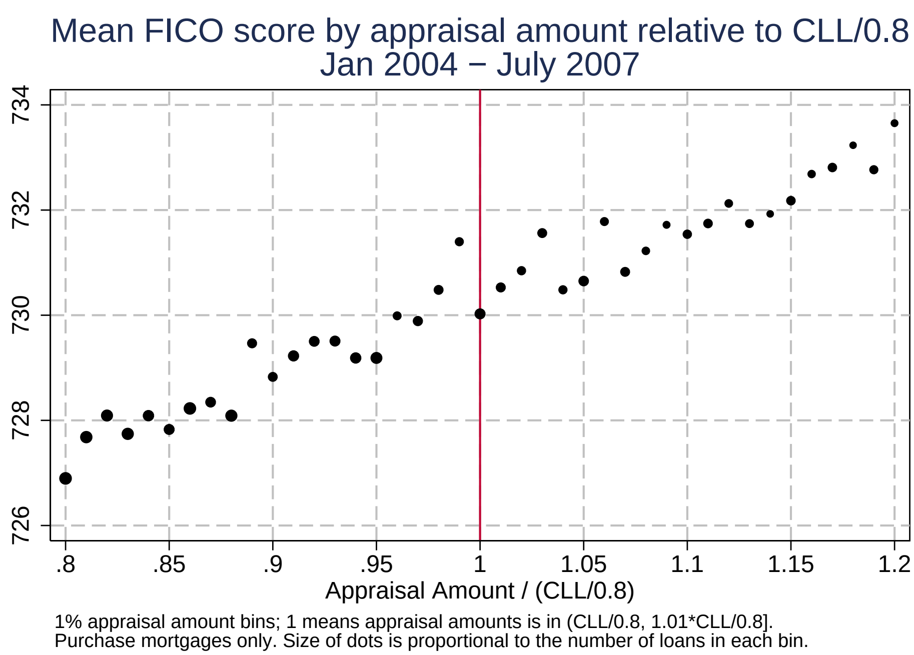
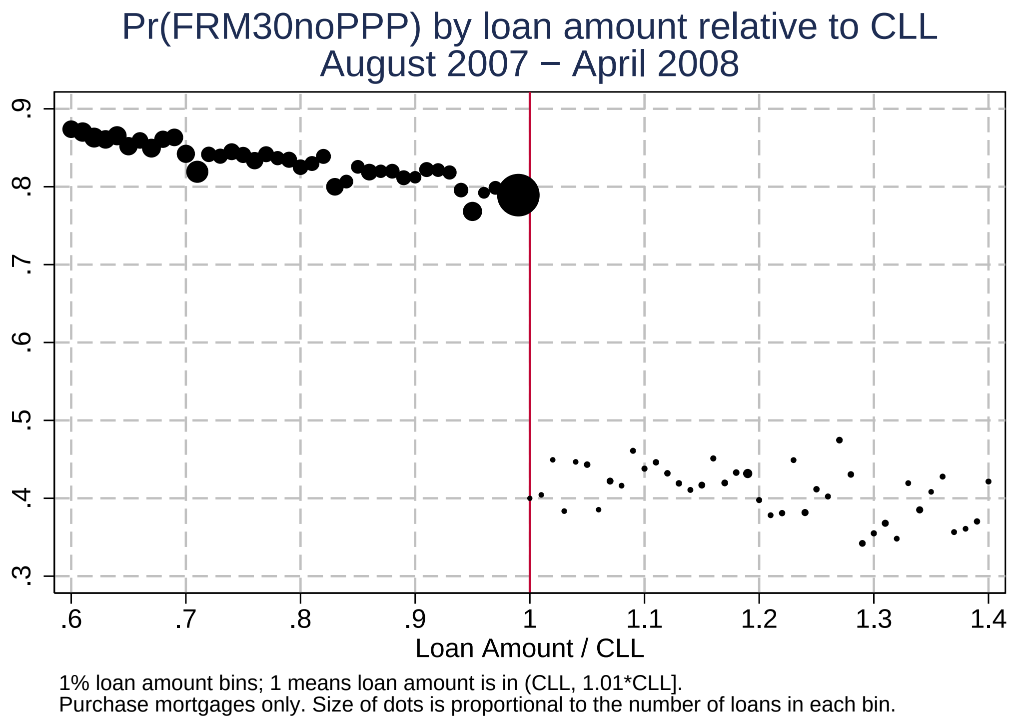
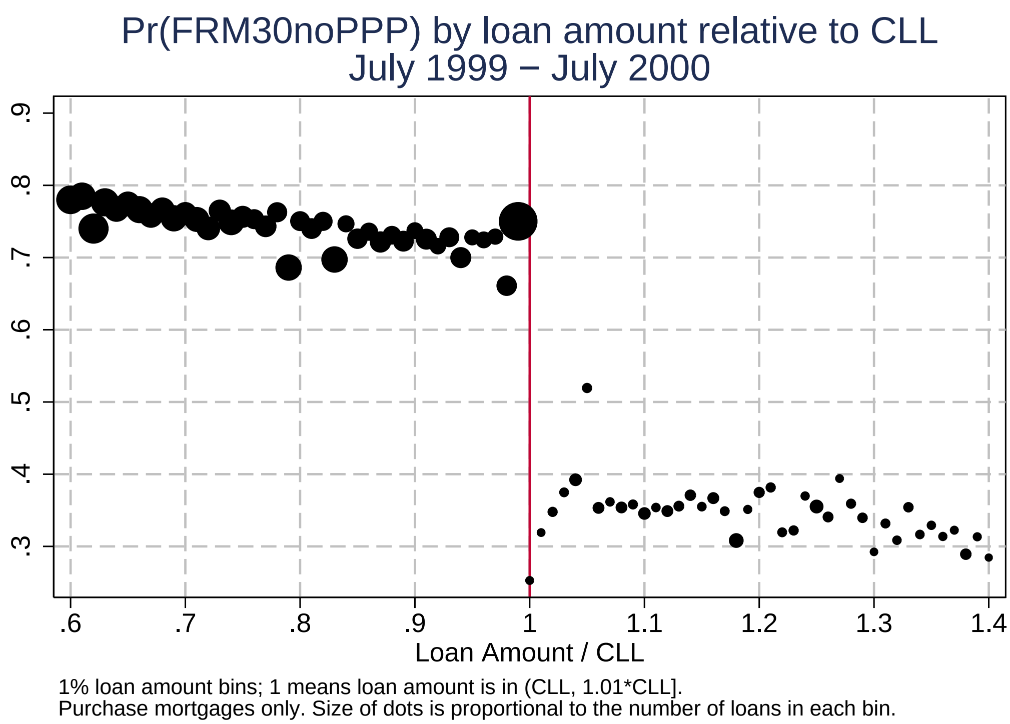


Figure 6: FRM share by origination bin during 2007–08 and 1999–2000





A Appendix

In this appendix, we present robustness checks of our regression discontinuity design. In particular, we check the sensitivity of the results presented in Table 2 to different choices of the estimation bandwidth, both for the pooled data (Table A.1) and year-by-year (Table A.2).

Additionally, Figure A.1 presents some additional descriptive graphs about the freeze of the nonagency MBS market in the third quarter of 2007.

Table A.1: Fuzzy regression discontinuity design: Robustness checks for pooled data, January 2004–July 2007

A. FRM30noPPP

	bandwidth=0.04	0.06	0.10	0.12
Change in Pr(dep. var.)	0.00737	0.00567	0.00636**	0.00599**
	(0.00483)	(0.00389)	(0.00305)	(0.00277)
Change in Pr(jumbo)	0.127***	0.138***	0.150***	0.156***
	(0.00307)	(0.00255)	(0.00207)	(0.00192)
Treatment effect	0.0583	0.0411	0.0424**	0.0385**
	(0.0384)	(0.0284)	(0.0204)	(0.0179)
N	186368	305142	493886	600056

B. FRM

	bandwidth=0.04	0.06	0.10	0.12
Change in Pr(dep. var.)	0.0137***	0.0114***	0.0100***	0.00908***
	(0.00484)	(0.00390)	(0.00305)	(0.00278)
Change in Pr(jumbo)	0.127***	0.138***	0.150***	0.156***
	(0.00307)	(0.00255)	(0.00207)	(0.00192)
Treatment effect	0.108***	0.0825***	0.0667***	0.0583***
	(0.0389)	(0.0287)	(0.0206)	(0.0181)
N	186368	305142	493886	600056

C. Non_sec6

	bandwidth=0.04	0.06	0.10	0.12
Change in Pr(dep. var.)	0.00290	0.00358	0.00361	0.00397*
	(0.00362)	(0.00293)	(0.00231)	(0.00211)
Change in Pr(jumbo)	0.133***	0.145***	0.158***	0.164***
	(0.00353)	(0.00293)	(0.00238)	(0.00220)
Treatment effect	0.0219	0.0247	0.0228	0.0242*
	(0.0272)	(0.0201)	(0.0145)	(0.0128)
N	142084	232977	376842	457661

Robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.2: Fuzzy regression discontinuity design: Robustness checks for pooled data, year-by-year 2004–2007

Reporting estimated treatment effect only, for bandwidths 0.05, 0.08, 0.11

A. FRM30noPPP

	2004	2005	2006	2007
Bandwidth = 0.05	-0.0320	0.116**	0.0247	0.000123
	(0.0680)	(0.0520)	(0.0567)	(0.126)
N	66047	80301	59675	37512
Bandwidth = 0.08	-0.00241	0.0583	0.0538	0.0253
	(0.0523)	(0.0365)	(0.0395)	(0.0947)
N	111348	132695	100526	62874
Bandwidth = 0.11	0.0257	0.0388	0.0579*	0.0305
	(0.0427)	(0.0296)	(0.0321)	(0.0780)
N	146563	170658	136625	85174

B. FRM

	2004	2005	2006	2007
Bandwidth = 0.05	0.0559	0.150***	0.0991*	-0.0699
	(0.0698)	(0.0530)	(0.0580)	(0.119)
N	66047	80301	59675	37512
Bandwidth = 0.08	0.0458	0.0799**	0.103**	-0.0186
	(0.0535)	(0.0371)	(0.0403)	(0.0895)
N	111348	132695	100526	62874
Bandwidth = 0.11	0.0559	0.0531*	0.0951***	0.0195
	(0.0436)	(0.0301)	(0.0327)	(0.0741)
N	146563	170658	136625	85174

C. Non_sec6

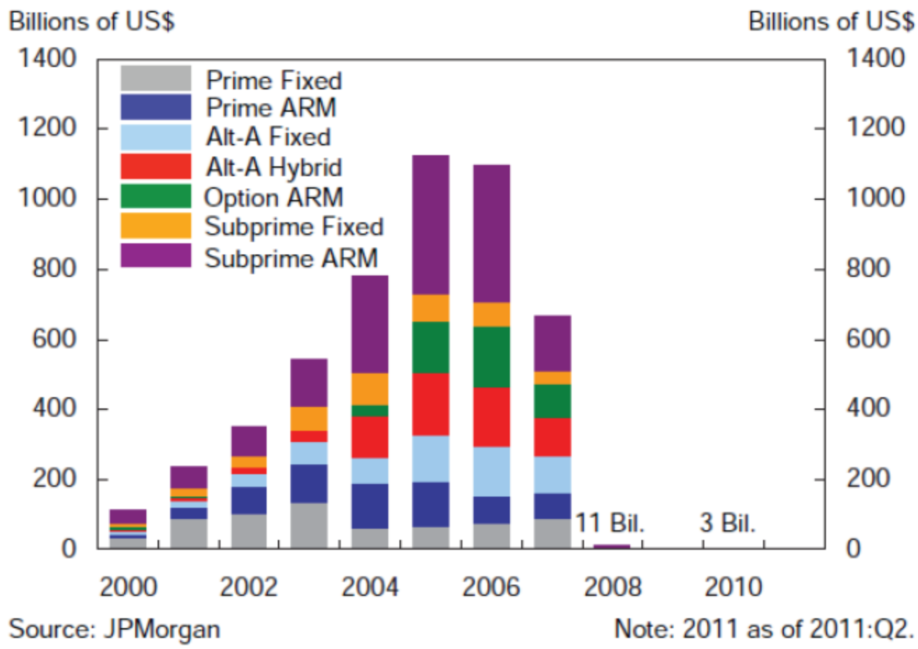
	2004	2005	2006	2007
Bandwidth = 0.05	0.0262	0.0296	0.0217	0.0617
	(0.0627)	(0.0356)	(0.0338)	(0.0841)
N	42876	61270	48519	32769
Bandwidth = 0.08	0.0238	0.0377	0.0191	-0.0135
	(0.0476)	(0.0252)	(0.0239)	(0.0644)
N	72370	101161	81755	54994
Bandwidth = 0.08	0.0277	0.0388*	0.0233	-0.0285
	(0.0383)	(0.0205)	(0.0195)	(0.0535)
N	95268	130196	111213	74463

Robust standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure A.1: The freeze in the jumbo MBS market

A. Nonagency MBS securitization. Graph plots issuance volume over time for nonagency MBS of different types. “Prime” refers to prime jumbo mortgages. Alt-A, subprime and option ARM MBS also include mortgages above the conforming loan limit. Source: Financial System Oversight Committee Annual Report, 2011.



B. Jumbo and conforming mortgage rates. Figure presents interest rates on 30-year fixed-rate jumbo and conforming mortgages, based on survey data collected by HSH Associates. Mortgage rates are expressed as a spread to the average of the 5-year and 10-year Treasury yield. Crisis onset is marked at August 2007, the month that BNP Paribas suspends convertibility for two hedge funds, reflecting problems in subprime MBS markets.