Mortgage-Backed Securities and the Financial Crisis of 2008: a Post Mortem*

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Abstract

We examine the payoff performance, up to the end of 2013, of non-agency residential mortgage-backed securities (RMBS), issued up to 2008. For our analysis, we have created a new and detailed data set on the universe of non-agency residential mortgage backed securities, per carefully assembling source data from Bloomberg and other sources. We compare these payoffs to their ex-ante ratings as well as other characteristics. We establish five facts. First, the bulk of these securities was rated AAA. Second, AAA securities did ok: on average, their total cumulated losses up to 2013 are under six percent. Third, the subprime AAA-rated RMBS did particularly well. Fourth, the bulk of the losses were concentrated on a small share of all securities. Fifth, later vintages did worse than earlier vintages. Together, these facts call into question the conventional narrative, that improper ratings of RMBS were a major factor in the financial crisis of 2008.

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1 Introduction

post mortem: an examination of a dead body to determine the cause of death.

Gradually, the deep financial crisis of 2008 is in the rearview mirror. With that, standard narratives have emerged, which will inform and influence policy choices and public perception in the future for a long time to come. For that reason, it is all the more important to examine these narratives with the distance of time and available data, as many of these narratives were created in the heat of the moment.

One such standard narrative has it that the financial meltdown of 2008 was caused by an overextension of mortgages to weak borrowers, repackaged and then sold to willing lenders drawn in by faulty risk ratings for these mortgage back securities. To many, mortgage backed securities and rating agencies became the key villains of that financial crisis. In particular, rating agencies were blamed for assigning the coveted AAA rating to many securities, which did not deserve it, particularly in the subprime segment of the market, and that these ratings then lead to substantial losses at institutional investors, who needed to invest in safe assets and who mistakenly put their trust in these misguided ratings.

In this paper, we re-examine this narrative. We seek to address two questions in particular. First, were these mortgage backed securities bad investments? Second, were the ratings wrong? We answer these questions, using a new and detailed data set on the universe of non-agency residential mortgage backed securities (RMBS), obtained by devoting considerable work to carefully assembling source data from Bloomberg and other sources. This data set allows us to examine the actual repayment stream and losses on principal on these securities up to 2014, and thus with a considerable distance since the crisis events. We find that the standard narrative needs substantial rewriting: the ratings and the losses were not nearly as bad as one is often led to believe.

Specifically, we calculate the ex-post realized losses as well as ex-post realized return on investing on par in these mortgage backed securities, under various assumptions of the losses for the remaining life time of the securities. We will also calculate these returns, when purchasing these securities at market prices in 2008 and 2009. We compare these realized returns to their ratings in 2008 and their promised loss distributions, according to tables available from the rating agencies. We shall investigate, whether ratings were a sufficient statistic (to the degree that a discretized rating can be) or whether they were, essentially, just “noise”, given information already available to market participants at the time of investing such as ratings of borrowers. We also compare the realized returns to the returns on government bonds, in order to judge whether investors shunning these securities in favor of the latter would have fared better, and how much, if so.

It is obvious, that such an ex post evaluation is different from the perhaps more appropriate evaluation ex ante. Ideally, one would take investments in these securities in 2008, evaluate their payoffs in all possible future states of the world, appropriately discounted and compare that to the original investment or their later market prices. Likewise, ideally we would compare those future random streams of payoffs to that of other securities with a similar rating. Crafting these counterfactuals and finding those comparison securities appears to require considerable structure and assumptions. Whether convincingly feasible or not, any such analysis would still need to be benchmarked to the actual and observed realization. That is why we view our contribution as the key step even for such an ex-ante analysis.

We establish five facts. First, the bulk of these securities was rated AAA. Second, AAA securities did ok: on average, their total cumulated losses up to 2013 are under six percent. Table 12 presents more detailed results for these returns, depending on the market segment and assumptions regarding terminal value: these results are presented in greater detail in subsection 4.4. The most important result here may be that AAA securities provided an internal rate of return of about 2.44% to 3.31%, depending on the scenario. The yield on 10-year treasuries in 2008 was between 3 and 4 percent: the difference is surely smaller than what the standard crisis narrative seems to suggest. It mattered quite a bit, whether the mortgages were fixed rate or floating rate. Overall, though, these returns on AAA RMBS strike us as rather reasonable, and unlikely to have thrown the financial system into the abyss.

While we judge the losses on AAA securities to be modest, losses were considerably larger on securities with ratings other than AAA. We examine them in considerable detail. We find that ratings by and large did a good job in sorting securities into categories of risk, as measured by their losses ex-post, starting at a substantial increase in losses, when moving from AAA to AA securities. We find some rating reversals. For example, the accumulated value-weighted loss as a fraction of principal was higher for AA-rated securities than for securities rated C or below even as late as 2012.

Overall, however, these non-AAA-reated securities were of minor importance. The bulk received the AAA rating, so that the substantial losses on most of the non-AAA securities end up to be of comparable total magnitude to the modest losses on AAA-rated securities. Figure 4 shows the cumulative total losses across the universe of non-agency residential mortage backed securities, up to 2013. The total losses amounted to no more than 350 billion dollars, with about 100 billion dollar of these losses attributed to the AAA-rated securities. To put this in perspective, the total losses are less than 2.5 percent of US GDP or less than half a percent annualized over that period, and quite a bit less than the amount devoted to the 2009 American

Recovery and Reinvestment Act or "stimulus" package. From a macro-economic perspective, it is hard to get very excited about losses of that magnitude.

It may be good to emphasize that we only examine non-agency residential mortgage backed securities. Agency-backed securities were backed implicitly by the tax payer and explictly by programs of the Federal Reserve Bank, and therefore their role in the crisis was largely a matter of policy. We also do not investigate higher layers of leveraging and repackaging, such as, say, AAA-rated collateralized debt securities, backed by a basket of lower-rated mortgage-backed securities. Note that losses here are just redistributing the losses of the original rMBS. There are a variety of other securities that got their share of blame. None have received quite the attention of non-agency residential mortgage backed securities, though, which are the focus here.

The paper proceeds as follows. Section 2 provides a discussion of the related literature. Section 3 discusses our unique and novel data set, and how we assembled it. Subsection 4 contains our analysis. Subsection 4.1 examines the ratings, in particular their relationship and their predictive value for future losses. Subsection 4.2 examines the depth, probability and distribution of losses. In subsection 4.3 we explore errors in rating from an ex post perspective, and the degree of rating reversals, where securities with higher ratings experienced larger losses than those with lower ones. Subsection 4.4 examines the resulting annualized returns on an investment at par value, under a range of assumptions on the terminal value. We revisit these return calculations, when examining investment at 2008 market value, in section 4.5, shedding light on the question of underpricing and fire sales during that time. Section 5 concludes.

2 Related Literature

To be completed.

3 The data

We seek to investigate the market for residential non-agency mortgage-backed securities. These securities are excluded from guarantees or insurance by the government agencies "Fannie Mae" (FNMA), "Freddie Mac" (FHLMC) or "Ginnie Mae" (GNMA) due to certain characteristics, such as "jumbo loans" exceeding the limit of, say, 333700 $ in 2004, loans on second properties such as vacation homes, insufficient documentation or borrowers with credit history problems. At the end of 2003, non-agency MBS/ABS had an outstanding amount of 842 billion $, constituting 20% of the entire market for MBS, with agency-backed securities constituting the other

80%.

For our investigation, a major challenge was to obtain a suitable data set for these securities. The market is characterized by considerable decentralization. While the appointed trustees of a deal are responsible for providing investors with detailed information about the performance of the loans underlying the securities every month, there is no centralized repository that collects and organizes the data[1]. In terms of prices, many of these securities do not trade very often, and when they do so the transactions are over-the-counter. This makes it impossible to obtain a suitable time series of transaction prices for individual deals[2].

As there was no readily available, organized data source, we constructed the main data ourselves. We start from the Mortgage Market Statistical Annual 2013 Edition by Inside Mortgage Finance[3]. This publication in Volume II, Table A, Non-Agency MBS Activity, contains a complete list of the RMBS deals, completed over the years 2006-2012. For each deal, the name, the original issuer, the original amount and a few other characteristics are listed. There are a total of 2824 such deals. However, information such as cash flow or losses is not provided here. For our further data base construction, we obtain data from Bloomberg.

For each deal listed by the Mortgage Market Statistical Annual 2013 edition, we search for that deal on Bloomberg. The matching sometimes required a bit of a search, and we managed to find nearly 96 percent of the original list, by principal amount. Once we found the appropriate deal entry, we look for all deals that have similar names going forward and going back in time. Bloomberg lists the deal manager for the original deal. We then also search for all mortgage backed securities from this deal manager from 1987 onwards. Proceeding in that manner, we find a total of 8615 deals, going back to 1987 rather than just 2006, as in the Statistical Annual. In this way we hope to have minimized the number of deals that we may be leaving out. The technical appendix contains a detailed step by step description of how we built our data. Each deal generates approximately 17 separate securities or bonds on average, usually with different ratings, for a total of 143232 securities, each of which we seek to track. Their total prinicipal amount is 5842 billion $. Further details are in table 1. Table 2 provides an overview of the data we obtained for each security..

[Insert Table 1 about here]

[Insert Table 2 about here]

In this manner, we obtain as complete a universe of RMBS securities emerging from these deals, as seems possible, as well as information about their ratings and monthly cash flow and

[1] Some companies including Corelogic and Blackbox Logic collect and sell information and analytic tools to market participants

[2] Now the Financial Regulatory Authority (FINRA) provides some summary statistics on prices and volume of daily transactions.

[3] Information about this source can be found here `http://www.insidemortgagefinance.com/books/`

losses, We downloaded the various pieces of information, security by security, and assembled it into a spread sheet, readable by MATLAB for further analysis. The process took several month to complete, largely due to the download restrictions of Bloomberg. In order to understand our data base construction further, appendix A provides a sample of the information available from the Statistical Annual as well as from Bloomberg, how to read the available information and details on how we constructed our data base. A replication kit, including a more detailed description describing the construction, is available from the authors for those that seek to replicate our analysis.

Table 3 compares the deals in our final database with those in the Statistical Annual. Panel A provides evidence that our database contains about 94% of the deals and about 96% of the issued amount across different types of securities over the 2006-2012 period, which is the available period in the 2013 edition of the Statistical Annual. The fraction covered by our data is about the same across different market segments. Panel B shows the coverage by market segment over time to show that not only the coverage is high overall, but also that it is high consistently over time. The high matching rate for this time period, and the procedure that we followed to search for securities, give us confidence that our conclusions will not follow from having a selected sample.

[Insert Table 3 about here]

We complemented this main data set with data on RMBS price indices as well as house prices. For RMBS prices we obtain the ABX.HE indexes from Markit[4] , which are built to represent CDS transactions on Subprime RMBS issued in 2006 and 2007 for different credit rating levels. Finally, we use publicly available house price data at the state level from Zillow to build some of our control variables.[5]

3.1 Database description

Our constructed database contains information for more than 143 thousand RMBS, which were issued between 1987 and 2013 and are part of about 8,500 securitization deals. Table 1 shows the issuance activity over time. The table shows the boom in activity in terms of deals, bonds, market participants (issuers), and deal size from the early 2000s through 2007, and the corresponding collapse after 2008. Most of the deals after 2008 correspond to resecuritizations.

About 99% of the securities in our data, which represent 97% of the dollar principal amount,

[4]Information about these indexes and how to purchase the data is available here `https://www.markit.com/Product/ABX`

[5]This data can be downloaded at `http://www.zillow.com/research/data/`

are private-label (non-agency), non-government backed,[6] non-CDO securities. We will limit our analysis to these securities throughout the paper.

The collected information can be grouped into groups The first group is the cash flow time series information. This constitutes the bulk of our data. Given downloading limits imposed by Bloomberg, we had to spend several months downloading this information chunk by chunk. For each security we observe the interest payments, principal payments, outstanding balance, the coupon rate and the losses each month after issuance. The second group of variables allows to identify the security and describe some of its characteristics. These include the Cusip ID, deal names, deal managers names, dates of issuance, coupon type and frequency, maturity date, type of tranche, notional amounts, as well as the credit rating assigned by up to 5 different credit rating agencies upon issuance. A third group of variables is related to the collateral of the securities, i.e. the underlying mortgages. These include information on the composition of the mortgages by type of rates (adjustable rates vs fixed rate mortgages), by type of occupancy (vacation home, family home, etc), by purpose of the mortgage (equity take out, refinance, purchase), or by geography (at the state level). This group of variables also includes information commonly used to assess the risk of pools of mortgages. We observe moments of the distribution of the credit scores, loan size, and loan to value ratios across the mortgage loans underlying a deal. A final group of variables include variables that can help us classify securities (for example agency vs non-agency, residential vs non-residential MBS) and commonly used metrics in mortgages backed security analysis such as weighted average maturity (WAM), weighted average coupon (WAC), and weighted average life (WAL). In the on-line appendix we list and describe all the variables in the raw data.

[Insert Table 1 about here]

3.2 Classifying Securities into Market Segments

The most common classification used in the market and one that has determined the narratives of the crisis yields three main categories of MBS: Sub-prime, Alt-A, and Prime (or jumbo)[7]. This classification is available from the Mortgage Market Statistical Annual and it is based on the classification of the bulk of the underlying loans into the same three categories.

Prime non-agency mortgages are jumbo loans that are not qualified for agency guarantees because of their size. Alt-A or Alternative A are loans in the middle of the credit spectrum,

[6] The government backed securities include agency securities and also non-agency securities whose underlying mortgages are backed by the Federal Housing Administration (FHA) and the U.S department of Veterans Affairs (VA)

[7] There are other classifications that we largely ignore. As one example, there is the Scratch & Dent category. These are loans of borrowers with the lowest FICO scores, which sometimes could have been originated outside the underwriting guidelines. These will generally fall under the sub-prime category

missing documentation and other characteristics. Subprime loans are loans further down the credit spectrum. The main characteristic that determines the classification of a loan is the FICO score, but a full description involves the loan-to-value ratio(LTV), loan size, and the documentation supporting the loan. An RMBS predominantly backed by subprime loans will be a Subprime RMBS.

Figure 1 compares that classification for deals issued after 2005 to the mean FICO scores, loan sizes and LTVs available from Bloomberg. Clearly the FICO score is key distinguishing characteristic, but it is not the only one. Figure A1 in the appendix further supports this claim.[8]

[Insert Figure 1 about here]

4 Analysis

We group our analysis and results into several segments. Subsection 4.1 examines the ratings, in particular their relationship and their predictive value for future losses. Subsection 4.2 examines the depth, probability and distribution of losses. In subsection 4.3 we explore errors in rating from an ex post perspective, and the degree of rating reversals, where securities with higher ratings experienced larger losses than those with lower ones. Subsection **??** examines whether later RMBS have become more risky. Subsection 4.4 examines the resulting annualized returns on an investment at par value, under a range of assumptions on the terminal value. We revisit these return calculations, when examining investment at 2008 market value, in section 4.5, shedding light on the question of underpricing and fire sales during that time.

4.1 Ratings

Credit ratings are meant to provide guidance about the credit risk of a security. One of our goals is to assess the degree to which credit ratings were appropriate. It is useful then to take a look at what credit ratings agencies say about their ratings of RMBS. Even though different credit rating agencies present their criteria and definitions in different ways, the following four elements that come directly from agencies' documents are useful to guide and understand our analysis in section 4.2. First, the ratings in structured finance vehicles are long-term ratings: "Long-term ratings are assigned to issuers or obligations with an original maturity of one year or more and reflect both on the likelihood of a default on contractually promised

[8] Similar pictures for loan size and LTV can be found in the technical appendix. They show that LTV and size do not provide a clear cut classification

payments and the expected financial loss suffered in the event of default" (Moody's, *Rating Symbols and Definitions*[9]). Second, comparability of ratings across asset classes or issuers is not straightforward. Credit rating agencies (at least after the crisis) strive for but do not guarantee comparability.[10,11] Credit rating agencies have introduced additional tools such as stress scenarios to promote comparability of ratings across sectors, geographies, and over time. However, some of these tools were not in place before the 2008 crisis.

Third, the ratings are given to reflect expected losses. According to Moody's their structured finance ratings"reflect both the likelihood of a default and the expected loss suffered in the event of default. Ratings are assigned based on a rating committees assessment of a security's expected loss rate (default probability multiplied by expected loss severity)."[12]. Fourth, the ratings are meant to provide a relative measure of the credit risk and not an absolute one: "Standard & Poor's credit ratings are designed primarily to provide relative rankings among issuers and obligations of overall creditworthiness; the ratings are not measures of absolute default probability".[13]

Table 4 describes the credit rating activity in our database based on the assignment of a rating upon issuance. Besides the fact that a large fraction of our securities are rated, two other elements are worth noting. First, Moody's and Standard &Poor's have bigger market shares than Moody's. Apparently, investors in CDOs had a preference for CDOs rated by the first two firms. At the time of rating a CDO transaction, these two firms would take a conservative approach (assign a lower rating to those bonds rated by a third-party) if the CDO had purchased or used as reference RMBS bonds not rated by them. This opens the possibility that there are differences in the performance of bonds rated by different agencies via some investor-driven selection process. In our econometric analysis we will include controls for which credit rating agency rated the security whenever is required. Second, more than 62% of the securities (which represent 85% by value of principal) had at least 2 ratings.

In our analysis below we will present results by one summary credit rating, as follows. We abstract from the rating qualifiers "-" and "+". So for example a BBB+ for us is a BBB and

[9]The document can be downloaded at `https://www.moodys.com/sites/products/)AboutMoodysRatingsAttachments/MoodysRatingSymbolsandDefinitions.pdf`

[10]The following quote from Moody's in *Rating Symbols and Definitions* illustrates the point "Moodys differentiates structured finance ratings from fundamental ratings (i.e., ratings on nonfinancial corporate, financial institution, and public sector entities) on the global long-term scale by adding (sf) to all structured finance ratings. The addition of (sf) to structured finance ratings should eliminate any presumption that such ratings and fundamental ratings at the same letter grade level will behave the same. The (sf) indicator for structured finance security ratings indicates that otherwise similarly rated structured finance and fundamental securities may have different risk characteristics. Through its current methodologies, however, Moody's aspires to achieve broad expected equivalence in structured finance and fundamental rating performance when measured over a long period of time".

[11]From Standard & Poor's article *General Criteria: Understanding Standard & Poor's Rating Definitions*, "Our rating symbols are intended to connote the same general level of creditworthiness for issuers and bonds in different sectors and at different times". This is available at `https://www.standardandpoors.com/en_US/web/guest/article/-/view/sourceId/5435305`

[12]From Moody's document *Rating Symbols and Definitions*

[13]From Standard & Poor's article *General Criteria: Understanding Standard & Poor's Rating Definitions*

an A- is an A. This should not be too problematic since an A- should be closer to an A than to a BBB. Whenever a security has 2 or more ratings from different agencies we average the rating. For instance, if agency 1 rates it as AAA, and rating agency 2 as AA, and rating agency 3 as AAA, the bond will be AAA.[14] For the case of two agencies, one rating a bond as AAA and one as AA, we solved the tie upwards, so the bond would be AAA. These discrepancies are not common in the data.

[Insert Table 4 about here]

We can now document our ***first fact***: **The great majority of non-agency RMBS securities were assigned a AAA rating upon issuance**. Almost 87% of the principal amounts and 57% of the bonds had the highest rating. Most of the other rated securities were investment grade securities (BBB or higher); only about 9% of the bonds, which represent a little bit more than 1% by principal value had non-investment grade ratings upon issuance. Table 5 presents the numbers in detail. Moreover, the breakdown by credit rating agency is essentially the same (see the last three columns of Table 5).

[Insert Table 5 about here]

4.2 Losses

In this section we analyze the losses incurred by non-agency RMBS. A loss occurs, when a scheduled payment is not made or when there is a complete default on the remaining principal and stream of payments. We observe the time series of the losses suffered month by month by each of the securities in our data. This allows us to calculate the cumulative losses at different points in time and study the differences across ratings, vintages, and market segments. In the main text, we present our results, where we weight our computations by the original principal amount of the RMBS. The technical appendix complements this with unweighted results.

Panel A of Figure 2 plots the cumulative losses as a fraction of original principal (weighted by this value) as of December 2013 for all RMBS in our database. Figure 3 provides the same plot for AAA securities alone, broken down by their three categories, prime, Alt-A and subprime. These figures together with table 6 document our ***second fact***: **AAA securities did ok: on average, their total cumulated losses up to 2013 are under six percent.** They furthermore document our ***third fact***: **the subprime AAA-rated RMBS did particularly well.**.

[14]This clearly requires a mapping of the different ratings across agencies. We used the mapping provided by the Bank of International Settlements, which is available here `http://www.bis.org/bcbs/qis/qisrating.htm`

[Insert Table 6 about here]

[Insert Figure 2 about here]

[Insert Figure 3 about here]

This fact requires some discussion. The fact that AAA securities had lower losses than the other securities does not make them a AAA security. It is possible that the loss rate does not correspond to what a AAA security should exhibit. Here we find difficulties with some of what rating agencies say about their ratings. First, they are meant to provide a relative ranking, they are not to be associated with specific probability of default levels, and the ratings for structured finance securities may capture different credit risk than ratings for other securities. Moreover, almost mechanically, an average AAA security will exhibit lower losses than a lower-rated security since the AAA tranches are the last to face losses in the capital structure. Therefore, a pure relative comparison through a ranking will not be enough to say that a AAA security actually behaved as such. We therefore, think that the second fact must involve a comparison with other AAA securities, and a relative comparison across RMBS with different ratings that should be not only in terms of ranking, but also in terms of level differences in their loss rates. In terms of the relative comparison, the figure shows that the long-run loss rates of AAA-rated RMBS as of December 2013 were several orders of magnitude lower than those of other investment-grade RMBS.

These cumulative losses of 2.3% of principal may considered large for securities with a AAA rating. Indeed, judging by a table[15] provided by Moody in 2001 of ideal expected losses by credit rating over time, losses of this size should be expected for BBB securities and not for securities rates AAA. Put differently, losses of this size should be unlikely for AAA rated securities. Then again, the financial crisis of 2008 should be considered an unlikely disaster. Compared to the magnitude of this crisis, we consider the cumulated losses of 2.3% over the six years 2008 to 2013 (both included) as quite modest indeed. Figure 4 shows the distribution of the corresponding total cumulated losses on all non-agency RMBS securities. The total for AAA-rated securities is around 100 billion US $ over the course of six years, due to the large underlying principal. While not negligible, it would be a challenge to blame the magnitude of the financial crisis on these losses, as often seems to be done in the standard narratives. Even taking into account the total losses of 323 billion US $ over the course of six years seem to us a magnitude that would need to take considerable amplification and addition by other factors to bring down the entire financial system.

[15] The table can be found in a document available at `http://siteresources.worldbank.org/EXTECAREGTOPPRVSECDEV/Resources/570954-1211578683837/Bielecki_Moodys_Rating_SME_transactions.pdf`

We can break down the analysis by market segment defined by loan type (Prime, Alt-A, and Subprime). Panel A of Figure 2, figure 3, table 6 or the additional vintage-level detail provided by table 7 document the ***third fact***: **the subprime AAA-rated RMBS did particularly well.** AAA-rated Subprime Mortgage Backed Securities were the safest securities among the non-agency RMBS market. As of December 2013 the principal-weighted loss rates AAA-rated subprime securities were on average 0.42% We consider this to be a surprising fact given the usual narrative for the causes of the financial crisis and its assignment of the considerable blame to the subprime market and its mortgage-backed securities. An example of this narrative is provided by Gelman and Loken (2014)[16]: "We have in mind an analogy with the notorious AAA-class bonds created during the mid-2000s that led to the subprime mortgage crisis. Lower-quality mortgages —that is, mortgages with high probability of default and, thus, high uncertainty—were packaged and transformed into financial instruments that were (in retrospect, falsely) characterized as low risk".

[Insert Table 7 about here]

Table 7 shows that the bad performance of AAA securities is primarily due to the Alt-A segment of the market, which in principle was backed by mortgage loans of borrowers with better credit risk prospects. The fact that Prime and Alt-A RMBS exhibit loss rates comparable to those of Subprime securities for ratings below AAA, and worse for the highest rated securities is evidence of the lower screening effort exerted by financial institutions that found easier to securitized and sell loans of higher-quality borrowers, as documented by Keys et al. (2009, 2010, 2012). For completeness, appendix figure A4 presents the incidence of losses by market segment, again with a relatively strong performance of AAA-rated subprime bonds in comparison with similar rated Prime and Alt-A bonds, and with a comparable (poor) performance for the other ratings.

Figure 2 and 3 reveal that losses in AAA securities picked up in 2011. This may seem late, but it is the result of the credit support protection enjoyed by AAA securities. These losses, however, are to a large degree predictable once delinquencies in the underlying loans pick up. If delinquencies are large enough to predict that lower tranches will be wiped out, then one can predict AAA securities facing losses. Since many lower-rated tranches have faced big losses, we should expect AAA securities to keep accumulating some losses beyond the final period in our plot. However, as of December 2013, AAA securities taken together still had $341 billion of cushion coming from lower-rated bonds. Given that all the losses over the last 6 years do not

[16]We have chosen this quote because it is quite representative of the common narrative during the crisis and useful for our purposes. We have not chosen it as a critique of the article by Gelman and Loken (2014), whose subject of interest is not the RMBS market per se

reach this amount and given the recovery of the US economy, we do not believe our conclusions are going to change dramatically.

Panel B of figure 2 plots the fraction of securities facing losses. By this measure, we do see a relatively large incidence of losses, even in AAA securities, even though the size of the losses is small relative to the principal amount. We can then ask, what does the distribution of losses look like across securities? Figure 5 shows that losses tend to be concentrated in a few securities; the outcome is almost binary, either the losses as a fraction of principal are low, or the security gets wiped out. With this, we have documented our ***fourth fact***: **the bulk of the losses were concentrated on a small share of all securities.**

[Insert Figure 5 about here]

Table 8 shows the losses as a fraction of principal as of 2013 for the different credit ratings and for different groups of vintages. Table table 7 contains additional detail, broken down by type. While the average losses on AAA rated securities were fairly modest, regardless of the type and the vintage, later vintages did worse. Table 8 shows that principal-weighted losses on AAA rated securities issued before 2003 were less than 0.03% and even were below 0.4% for those issued from 2003 to 2005, but that this went up to a considerable 4.8% on securities issued from 2006 to 2008. Considerably larger rises in loss rates by vintages occur for lower-rated securities. For example, while A-rated securities issued before 2003 lost less than 0.6%, dramatic losses of nearly 66% occured for the 2006-2008 vintage. With that we obtain our ***fifth fact***: **later vintages did worse than earlier vintages.**

[Insert Table 8 about here]

Can we therefore conclude that ratings deteriorated over time and that rating agencies became more generous? This certainly has been a theme in much of the narrative of the crisis. The deterioration in performance could also have been due to bad luck, though. Consider a security issued long before the peak of the house price boom, and compare it to an otherwise identical security issued just at the peak. The former security is less likely to be subject to losses, since the 2013 value of the underlying home relative to the original purchase price is higher for the former compared to the latter. If one views the arrival of the house price decline as a random event, unrelated to current level of house prices, one could argue that the resulting higher losses for the later vintages were just a stroke of bad luck, and not the result of a more liberal rating. While obviously a very benign interpretation, it is useful to check, how far the house price movements at the time of issuance can explain the subsequent loss performance.

Similar remarks may apply to other covariates. We therefore run the cross-sectional regressions

$$l_i = \alpha + y + \beta X_i + \epsilon_i \tag{1}$$

$$\tag{2}$$

where l_i is the loss as a fraction of principal as of December 2013 for RMBS i, y is a set of vintage or issue-year fixed effects, and X_i are our covariates. We also run these cross-sectional regressions with dl_i as the dependent variable, where dl_i is a dummy that takes the value 1 if the the cumulative losses of RMBS i are strictly greater than zero as of December 2013. The covariates are the amount of credit support, credit ratings, moments of the distribution of the characteristics of the underlying mortgages (LTV, size, and FICO scores), the purpose of the mortgages (purchase, refinancing, equity takeout), the type of mortgage as it relates to the interest rate (Fixed-rate vs Adjustable Mortgage Rates), geography fixed effects[17], and house price appreciation.

Figure 6 presents the results for losses across all securities and by credit rating, where the regressions are weighted by the original principal amount. The coefficient corresponding to the 2001 vintage fixed effect is normalized to zero. Figure 7 plots the vintage fixed effects for Prime, Alt-A, and Subprime RMBS overall and by the credit rating assigned upon issuance. Comparing these results to table 8 shows that the inclusion of the covariates does little to explain the performance deterioration of the later vintages. Judging by these results, we therefore cautiously endorse the view that rating standards have deteriorated in the run-up to the crisis. Moreover, these results are consistent with the findings of Adelino et al. (2015), who argue that middle income borrowers had an increasing relative role in mortgage delinquencies and defaults in the run-up to the crisis. These results are also consistent with the idea that securitization contributed to bad lending by reducing incentives of lenders to carefully screen borrowers, and that lower screening standards happened for relatively high FICO scores as those loans were easier to securitize as argued by Keys et al. (2010).

[Insert Figure 6 about here]

[Insert Figure 7 about here]

It is instructive to investigate the relationship of the house price boom and busts, shown state-by-state in figure 8, and its relationship to the losses of the RMBS. For each security in our data set, we know the top five states in terms of the locations of the underlying mortgages, and the fraction of the total principal invested there. We thus run a regression of losses on

[17] We use information on the concentration of mortgages backing the pool by state to include geography controls

these fractions multiplied with a state dummy, as well as possibly a set of covariates. For the covariates, we chose dummy variables for the credit rates as well as mortgage type (Prime, Alt-A and Subprime). More precisely, we use that classification of the Statistical Annual and match it to cut-offs in terms of FICO scores, as indicated in figure'**??**. We then use the FICO scores available from Bloomberg, to classify the securities into Prime, Alt-A and Subprime for all other deals, since Bloomberg does not list that categorization.

The regression coefficient on each fraction times state dummy then provides an estimate of the losses that would have occured, if an RMBS had invested in that state only. This exercise results in the maps shown in figure 9, sorting the loss state dummies again into quintiles, with and without controls. These figures may best be compared to the bottom map of figure 8. There are similarities, such as a fairly benign region from North Dokata to Texas, or the darker regions around Nevada.

Table 9 estimates that relationship more formally. There, we have calculated a linear regression of the cumulative loss as a fraction of initial principal on the change in house prices, both during the run-up phase from 2000-2006 as well as the crash-phase from 2006-2009. To find the house price change relevant for each RMBS, we have averaged the house price changes over the five top states in which that security was invested, using the relative investment shares to calculate these averages. Our preferred specifications are in columns (3) and (5). There, we find that the increase in house prices decreased losses, but that the subsequent decrease in house prices increased losses for the security. According to column (5), say, an additional increase of house prices from 2000 to 2006 decreased losses by 0.18 percent of principal, while an additional decline of house prices from 2006 to 2009 by one percent increased losses by 0.53 percent. Column (3) provides a rather similar answer. If only the price increase is included or if state dummies are included, with the weights given by the investment shares, these effects (rather naturally) disappear.

[Insert Figure 8 about here]

[Insert Figure 9 about here]

[Insert Table 9 about here]

While we argue that the losses at least on the AAA securities have been modest, they certainly are larger than what should be expected for a typical AAA-rated security. According to a 2001 table by Moody's concerning the idealized expected losses over a period of 10 years by credit rating, AAA securities should be expected to have losses of 0.0055%, AA in a range from 0.055% to 0.22%, A is a range from 0.385% to 1%, and BBB in a range from 1.43% to

3.36%. Comparing these numbers to the implied levels from Table 8, we see that only securities issued before 2003 and perhaps also AAA-rated securities issued in 2003-2005 had losses roughly commensurate with these table values.

To summarize, even though AAA-rated RMBS bonds suffered some losses, the losses were relatively small. To a large degree, RMBS securities rated AAA and issued until 2005 behaved like within expectations for AAA securities, even in an environment of extreme stress. In particular, the much-maligned subprime segment did particularly well. The securitization and rating process did fail perhaps for non-AAA investment grade bonds: these ratings were, in retrospect, too high, and in particular so for the 2006-2008 vintage. However, it is the AAA securities and their role as safe assets for pension funds and other institutions that have received the bulk of the attention: they also constituted the bulk of the market.

4.3 Credit Rating Rankings and Reversals

In this section we explore the credit rating and their rankings, using their ex-post performance in relationship to ex-ante ratings, covariates available at the time of rating and corresponding expectations. With this, we seek to address two questions. How close to appropriate were the ratings, in hindsight? And: even if losses turned out to be higher than expected, did the rating agencies do a good job in ranking securities appropriately?

We present two exercises. In the **first exercise**, we compare the average realized losses of securities to Moody's expected losses by rating. Moody's has published a table of "Idealized Cumulative Expected Loss Rate" which we present as reference in the appendix in Figure A5.[18] For example, in 10 years a BBB- security would be expected to have a loss rate of approximately 3.35%. Each of our securities had an initial (ex-ante) credit rating and therefore an expected loss rate based on Moody's Table. For each security, we assign an ex-post rating based on its actual realized loss rate. So, if a given security had a realized loss rate between the AAA and the AA expected loss rate on Moody's table (between 0.0055% and 0.22% in 10 years), the security receives an ex-post rating of AA. Then we compare the ex-ante rating with the ex-post rating. Figure 10 presents the results. The solid line is the fraction of securities by original rating (ex-ante). The dotted line is the fraction of securities that would have received a given rating based on their realized loss rates. According to the figure, on average, AAA ratings were not given in excess, but too many securities were given investment grade ratings. This figure, however, hides the fact that having on average the right number of AAA securities does not mean that AAA securities were given the right rating as many ex-ante AAA could be ex-post AA while

[18] The table is originally available here https://www.moodys.com/sites/products/productattachments/marvel_user_guide1.pdf or herehttp://siteresources.worldbank.org/EXTECAREGTOPPRVSECDEV/Resources/570954-1211578683837/Bielecki_Moodys_Rating_SME_transactions.pdf

many ex-ante AA can be ex-post AAA. Figure 11 addresses the issue by showing the fraction of securities for which ex-ante and ex-post ratings coincide (labeled as Correct Rating), those for which the ex-post rating is higher than the ex-ante rating (labeled as Deflated Rating), and those for which the ex-post rating is lower than the ex-ante rating (labeled as Inflated Rating). While about 75% of AAA securities received a rating that was in line with the expected losses, AA securities were almost entirely wrongly rated, and securities with ratings A and below had a large fraction of inflated ratings. Figure 12 provides a three-dimensional overview of the given ex-ante rating and the ex-post rating, based on our exercise. Ideally, all the mass would accumulate along the diagonal. The off-diagonal mass gives a visual impression of "rating gone wrong". The story of this picture is fairly clear. Many of the AAA-rated securities deserved their ratings, though a good portion should have been rated lower, in hindsight. For all the other securities, we find a bimodal result. The smaller share had no losses at all, justifying a AAA rating ex post. The larger share had substantial losses, that would have required a rating below CCC. There hardly is any mass on the diagonal, except for AAA ratings.

[Insert Figure A5 about here]

[Insert Figure 10 about here]

[Insert Figure 11 about here]

[Insert Figure 12 about here]

In the **second exercise**, we wish to understand, whether the ratings could have been improved upon at the time, aside from the overall extent of the losses examined above. We seek to calculate the extent to which the inclusion of additional covariates X, available at the time of rating, for a higher-ranked security predicts larger loss probabilities than observed on average for lower-ranked securities. We call this a ratings reversal.

More precisely, for $\alpha \in [0, 1]$ as well as for each rating, say AAA, we first seek to estimate $P(Loss > \alpha \mid AAA)$ and $P(Loss > \alpha \mid AAA, X)$, given the crisis of 2008. For the former, we estimate this probability with the fraction of AAA-securities, whose losses exceeded α at the end of 2013. For the latter and for each security i rated AAA and with covariates X_i, construct the observation

$$Y_i = 1_{Loss_i > \alpha}$$

indicating, whether the losses for security i exceeded α or not. We then estimate a linear probability model[19], per linear regressing these observations Y_i on the covariates X_i. Note that

[19]A linear probability model was computationally easier than a probit model, while yielding essentially the same results, when we cross-checked.

we estimate this probability model separately for each α. One could, instead, formulate a model for losses and infer the probability of losses exceeding any given treshold α from that model and the observed covariates.

We then seek to estimate the gain from including covariates as well as the probability of ratings reversals. For each α, we define the gain from including covariates X compared to the raw difference between securities rated AAA and AA as

$$Gain_{AAA,AA}(\alpha) = \frac{E\left[|P(Loss > \alpha|AAA, X) - P(Loss > \alpha \mid AAA)|\right]}{P(Loss > \alpha \mid AAA) - P(Loss > \alpha \mid AA)} \tag{3}$$

where the outer expectation is taking an expectation over the random covariates X. We estimate the numerator by the sample average of $\hat{P}(Loss > \alpha|AAA, X_i) - \hat{P}(Loss > \alpha \mid AAA)$ for all AAA-rated securities i and the probability estimators explained above. We likewise define $Gain_{AAA,A}(\alpha)$, $Gain_{AA,A}(\alpha)$, etc.. We define the probability of rating reversals for AAA-rated securities to AA securities as

$$Reversal_{AAA,AA}(\alpha) = P\left(P(Loss > \alpha \mid AAA, X) > P(Loss > \alpha \mid AA)\right)$$

where the outer probability is likewise taken as an expectation over the random covariates X. We estimate $Reversal(\alpha)$ by calculating the fraction of all AAA-rated securities i, for which $\hat{P}(Loss > \alpha \mid AAA, X_i)$ exceeds $\hat{P}(Loss > \alpha \mid AA)$, with $\hat{P}(\cdot)$ denoting the estimator of $P(\cdot)$ explained above. We likewise construct estimators for $Reversal_{AAA,A}(\alpha)$, $Reversal_{AA,A}(\alpha)$, etc..

As covariates, we made use of (essentially) all the additional information on these securities provided by Bloomberg. . They are the dollar value of the principal of the security, the average FICO score, the mean Loan-To-Value ratio, the mean loan size, the original credit support, the weighted average coupon, the weighted average life, the fraction of loans with adjustable mortgage rates, the fraction of loans for single family homes, the fraction of loans for condos, the fraction of loans for first purchases, the fraction of loans for refinancing, a dummy for floating coupon securities, a dummy for floating rate securities, a set of dummy variables for the top 5 states represented in the underlying mortgage loans, a set of dummy variables for the credit rating agencies involved in rating each security.

Panel A of Table 10 reports estimates of the gains given by equation 3, for all the pairwise comparisons between a given rating and ratings below it for investment grade RMBS. We see that covariates did carry information that would have been useful to predict losses, and to assign ratings, particularly for the AA, A, and BBB ratings. For AAA ratings, only for low values of alpha we see some gains from the covariates. The estimates of rating reversals is reported in panel B of Table 10. It turns out that the value of α matters considerably. If $\alpha = 0$, then we find a 40 percent probability of rating reversal. To understand, consider the probability of the occurrence of any loss, as shown in table A2. It turns out that AAA securities were actually somewhat more likely to incur losses than AA securities: the overall fractions are 28 percent versus 16 percent. We know already, however, that losses on AAA securities are typically small, if they occur at all. Figure 5 shows that the distribution for AAA securities puts more weight on small losses compared to the distribution for other investment grade securities. Thus, as α is increased to, say, 10%, we find a rating reversal probability of only 3%.

[Insert Table 10 about here]

[Insert Table A2 about here]

Given the financial crisis, a treshold of $\alpha = 0$ may then be too stringent to judge the appropriateness of the rankings. Overall we judge that the rating agencies got the rankings about right. This conclusion comes with a number of caveats, of course. First, the construction of the securities often implies mechanically, that lower-ranked securities will be hit with losses before that happens to higher-ranked securities. The ranking of securities for any given deal is therefore very unlikely to be incorrect (assuming that rating agencies did indeed check the loss sequencing): the comparison here is more interesting regarding the consistency of rankings for securities across deals. Second, all our inference is conditional on the crisis of 2008: this is the only set of observations we got. We obviously cannot infer anything here about the appropriateness of the ratings or their rankings across all potential futures from 2007 on forward. Finally, we have used the realized losses to estimate the weight on information available a priori, in order to check for rating reversals. Obviously, the rating agencies did not have that information at hand at the time when they had to give their assessments.

4.4 Returns

One of our goals in this paper is to assess the performance of RMBS as investments. In this section, we investigate the performance for a buy-and-hold investor, who purchased the RMBS at par at issuance, and plans to hold them until all payments have matured. Only investment-grade securities were sold at par: so we focus on these.

We have calculated these returns in two ways. One is to calculate the internal rate of return. This is the rate r that solves net present value equation

$$P_0 = \sum_{t=1}^{T} \frac{i_t + p_t}{(1+r)^t} + \frac{TV_T}{(1+r)^T} \tag{4}$$

where P_0 is the initial value of the security, i_t is the monthly cash flow corresponding to interest payments, p_t is the monthly cash flow corresponding to principal paydown, and TV_T is the terminal value at some date T. The other approach and our preferred approach is to calculate the discount margin θ over a benchmark interest rate r_t. The discount margin can be interpreted as the average return above the benchmark. For the benchmark, we are using the 3-month Treasury Bill. The discount margin is the value for θ that solves

$$P_0 = \sum_{t=1}^{T} \frac{i_t + p_t}{\left(1 + r_t^{t\_bill} + \theta\right)^t} + \frac{TV_T}{\left(1 + r_t^{t\_bill} + \theta\right)^T} \tag{5}$$

We will present results mainly for the latter: results for the internal rate of return provide rather similar insights. Note that we do not take into account risk prices or term premia in either calculation.

We set T to be December 2013, given our data set. We observe the payments i_t as well as p_t, but we do need to make assumptions regarding the terminal value TV_T. The natural candidate for the terminal value is the outstanding principal balance at time T, which is part of the monthly information that we have for each security. To that end, it is important to understand how past losses affect the outstanding principal value in the data. In a typical prospectus for an RMBS one can find the explanation: realized losses are applied to reduce the principal amount and "if a loss has been allocated to reduce the principal amount of your class of certificates, you will receive no payment in respect of that reduction." From this we conclude that the principal balance recorded in the data at date T already incorporates losses on principal that have occured previously rather than leaving them on the book. However it is possible that there needs to be some additional discounting of the outstanding principal value, because additional losses may be expected in the future. We therefore examine six different scenarios regarding the terminal value. The first three assume that all securities are valued at 80%, 90% and 100% of the principal outstanding as of December 2013.

For the Fourth scenario, we assume that each security trades at a loss equal to the loss rate it has suffered up to that point. For the fifth, we assume that each security trades at a loss equal to the mean loss rate of the securities with the same original credit rating and same vintage. The sixth is similar to the fifth, except for using the median loss rate rather than the mean.

To provide a perspective for the first three scenarios, we consulted information provided by FINRA for the month of December 2013, see figure 14. In 2009, the Financial Industry Regulatory Authority (FINRA) made a proposal to collect data for ABS, CDO, and MBS securities.[20] Now daily reports going back to May 2011 with the number of transactions, trade volume, and statistics on transaction prices are publicly available.[21]. From these reports one can see that, as of December 2013, investment-grade securities were mostly trading with prices above 90, and non-investment grade with prices above 75 and generally above 80. We therefore consider our range from 80 to 100 percent to be reasonable.

Table 12 presents results for the realized internal rate of return calculations, for the first three scenarios regarding the terminal value. The most important result here may be that AAA securities provided an internal rate of return of about 2.44% to 3.31%, depending on the scenario. It mattered quite a bit, whether the mortgages were fixed rate or floating rate. For fixed rate mortgages, AAA securities returned between 3.6 and 4.8 percent, depending on the market segment and assumptions regarding the terminal value. For floating rate mortgages, AAA securities returned between 0.4 and 3.8 percent. Overall, though, these returns on AAA RMBS strike us as rather reasonable, and unlikely to have thrown the financial system into the abyss.

Tables 13, 14, 15, and 16 present the results of our discount margin computations. In general we see that under the different assumptions the computed rates of return are very stable, and change in the expected direction when changing the terminal value assumption from 80%, to 90% and to 100%, and change in a way that is consistent with the results and analysis of the losses that we have already presented in section 4.2 for the other assumptions. For AAA securities which on average presented small loss rates the returns are quite stable across assumptions and also for securities older vintages as they have more time to produce cash flows and pay down the principal.

[Insert Figure 14 about here]

[Insert Table 12 about here]

[Insert Table 13 about here]

[Insert Table 14

[Insert Tables 15 and 16 about here]

The distribution of returns is left skewed, with a very long left tail, as evidenced by the mean quite far to the left of the median and large standard deviation. This is another version of our Fourth fact, that losses were concentrated on a small share of all securities.

[20] https://www.finra.org/newsroom/2009/finra-proposes-expanding-trace-reporting-asset-backed-securities

[21] Reports are available and can be downloaded at http://tps.finra.org/idc-index.html

We find that 65% of the AAA securities, under the assumption of a terminal value equal to 80% of the outstanding balance would yield a return equal or higher than the average Libor rates over this time period.

In Table 15 we break down the return by market segment as defined the mortgage loan type. These results show about a 2 percentage point realized premium of Prime over Subprime securities. This may be surprising at first given that we showed that losses in subprime securities were not particularly worse than in other segments and for AAA were actually lower. One reason behind this is the fact that the fraction of floating rate bonds (almost 90%) in the subprime segment was higher than the fraction of floating rate bonds in the Alt-A (about 62%) and Prime (about 46%) segments. In a period of low interest rates like the one we consider, floating rate bonds did worse than fixed rate bonds. To show this and obtain more comparable measures, we break down the computations for AAA bonds by vintage, by mortgage loan type and also by the type of bond according to the type of rate it would pay (fix or floating). We present weighted median rates in Table 16 along with the US 3-month Libor rate as benchmark. We see that across vintages and loan types, fixed rate AAA securities provided returns between 2 and 5 percentage points higher than the Libor. Floating rate bonds yielded lower returns, always higher than the Libor for Prime securities, and generally larger than the Libor but smaller than Prime returns for Alt-A and Subprime (except for vintages 2006 and 2007).

4.5 Prices

While we examined the returns to purchasing RMBS at issuance and holding them to maturity in the previous section, one may also wish to examine the returns when purchasing them at market prices, in particular at the height of the financial crisis of 2008. While individual price series for the RMBS do not seem to exist, time series for indices are available. On January 16th 2006, Markit launched a series of asset-backed credit default swap indexes on US home equity Asset Backed Securities. The indexes are tradable synthetic derivatives, which reference 20 subprime RMBS deals/bonds. There are four series of indexes, each of which corresponds to a different vintage of securities: series 06-01 references deals issued between June 2005 and January 2006, series 06-02 references deals issued between January 2006 and June 2006, series 07-01 references deals issued between June 2006 and January 2007, and series 07-02 references deals issued between January 2007 and June 2007. The 20 deals used in each series are determined at the inception of the index and they never change. These deals are selected among a list of fifty deals of the 25 largest issuers (2 deals per issuer) and they must meet the following main criteria: the deal size must be at least $500 million, it must have tranches with all of 5 ratings (AAA, AA, A, BBB, and BBB-), it must have been rated by both S&P

and Moody's, each tranche must have a weighted average life of at least 4 years with the AAA having a minimum of 5 years, the weighted average FICO credit score of the obligors on the assets backing the securities issued in the RMBS transaction must not exceed 660 as of its issuance date, and each Required Tranche must bear interest at a floating rate, with the base rate being one month LIBOR.

Each series corresponds to a set of 6 indexes by credit rating, from AAA to BBB-. In any transaction involving the index there is a protection buyer and a protection seller. The protection buyer makes two types of payments to the protection seller. One is a one-time payment upfront computed as the difference between par value and the index value multiplied by the notional amount[22] The second type of payment is a coupon or spread, payable monthly. This coupon is fixed for a given index. For example, for the AAA.06-1 index, the coupon is fixed at 18 basis points per annum, while for the BBB.07-01 is 224 basis points. The protection buyer receives payments from the protection seller in the event of interest shortfalls, principal shortfalls, and writedowns. Based on the value (or "price") of the index, one can compute excess returns between t and $t+1$ as

$$r^e = \frac{price_{t+1} - price_t}{price_t} + spread \times \frac{day\_count}{360}$$

One can think of this as an excess return over some risk-free benchmark (for example Libor) by thinking about the funded transaction: the protection seller faces the risk up to 100% of the notional, if after entering the transaction he sets aside this amount at risk, he will earn some benchmark rate like the libor. The running coupon and the index appreciation will make up the rest of the return.

Figure 13 plots the prices of indexes of the different series (vintages) by credit rating. Only the AAA tranches and the AA tranche of the 2006-01 vintage recover strongly after the crisis. The corresponding monthly returns computed with the formula above are shown in Table 17. What these numbers as well as figure 13 reveal is that substantial returns were earned by investors purchasing these securities in May 2009 and holding them to December 2013. On the other hand, excess returns were near zero or negative, when the purchase was made in June 2007. The excess returns on AAA rated securities was substantially negative for anyone purchasing them in, say, June 2007 and selling them in May 2009, implying losses of up to 6 percent per month, while for any long term investor, who held out until December 13, we obtain the still modest losses of 0.41 percent on a monthly basis as the worst of the AAA securities, i.e. the vintage 2007-2. Securities further down in the rating scale performed considerably worse.

[22]the notional amount is adjusted by the so-called factor, which refers to the outstanding principal amount of the underlying bonds.

These results are generally in line with our findings of the payoff streams in the other sections.

[Insert Figure 13 and Table 17]

5 Discussion and Conclusion

We have examined the payoff performance, up to the end of 2013, of non-agency residential mortgage-backed securities (RMBS), issued up to 2008. For our analysis, we have created a new and detailed data set on the universe of non-agency residential mortgage backed securities, per carefully assembling source data from Bloomberg and other sources. We have compared these payoffs to their ex-ante ratings as well as other characteristics. We have established five facts. First, the bulk of these securities was rated AAA. Second, AAA securities did ok: on average, their total cumulated losses up to 2013 are under six percent. Table 12 presents more detailed results regarding their returns, depending on the market segment and assumptions regarding terminal value. The most important result here may be that AAA securities provided an internal rate of return of about 2.44% to 3.31%, depending on the scenario. The yield on 10-year treasuries in 2008 was between 3 and 4 percent: the difference is surely smaller than what the standard crisis narrative seems to suggest. It mattered quite a bit, whether the mortgages were fixed rate or floating rate. Overall, though, these returns on AAA RMBS strike us as rather reasonable, and unlikely to have thrown the financial system into the abyss. Third, the subprime AAA-rated RMBS did particularly well. Fourth, the bulk of the losses were concentrated on a small share of all securities. Fifth, later vintages did worse than earlier vintages. Together, these facts call into question the conventional narrative, that improper ratings of RMBS were a major factor in the financial crisis of 2008.

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6 Figures and Tables

Table 1: **RMBS Database: Deals, Securities, Nominal Amounts by Year of Issuance**

This table reports some figures that describe the size of our database of Residential Mortgage Backed Securities by year of issuance. All the information comes from Bloomberg.

Year	No. Deal Managers	No. Deals	No. MBS	Notional ($ Billion)	Average Deal Size ($ Million)
1987 - 1999	35	858	9,462	244.2	284.6
2000	20	227	2,724	93.8	413.2
2001	23	397	5,815	179.9	453.1
2002	30	574	8,255	314.0	547.1
2003	30	788	12,420	475.1	603.0
2004	30	1,106	15,787	723.4	654.1
2005	29	1,361	22,017	1,005.2	738.5
2006	39	1,563	27,184	1,237.4	791.7
2007	35	1,027	19,143	936.1	911.5
2008	20	108	1,541	103.3	956.4
2009	17	151	5,660	170.6	1,129.9
2010	17	135	6,089	155.9	1,154.5
2011	13	101	3,182	68.3	676.5
2012	11	92	1,789	36.5	396.9
2013	13	127	2,164	98.7	776.9
All Years	83	8,615	143,232	5,842.3	678.2

Table 2: **Database Variables**

Security Identification	***Credit Rating***
Cusip ID	Current and Original Ratings (5 agencies)
Deal Name	***Other Security Characteristics***
Deal Manager	Credit Support at Issuance
Issuer Company	Original Principal Amount
Security Classification	***Collateral Description***
Deal Type (eg. CMBS, RMBS)	Mortgage Purpose (% Equity Takeout, Refinance)
Collateral Type (eg. Home, Auto, Student)	LTV Distribitution (min, max, mean, 25th, 50th,75th)
Collateral Type (eg. ARM vs FRM)	Credit Score Distribution (min, max, mean, 25th, 50th,75th)
Agency Backed (yes, no)	Mortgage Size Distribution (min, max, mean, 25th, 50th,75th)
Agency (eg. Fannie Mae, Freddie Mac)	MBS metrics 1: Weighted Average Coupon
Dates	MBS metrics 2: Weighted Average Life
Issue Date	MBS metrics 3: Weighted Average Maturity
Pricing Date	Fraction of ARM and FRM
Maturity Date	Occupancy (% of Owner, Investment, Vacation)
Security Description	***Geographic Information***
Bond type (e.g. Floater, Pass-through, Interrest Only)	Fraction of mortgages in top 5 states
Tranche Subordination Description	***Cash Flow and Losses***
Coupon Type (e.g. Fixed, Floating)	Monthly Interest and Prinicipal Payment
Coupon Frequency (e.g. Monthly)	Monthly Outstanding balance
Coupon Index Rate (e.g. 3M-libor)	Monthly Losses

Table 3: **Database Coverage of the universe of Non-Agency RMBS**

This table compares our database to the universe of mortgage-backed securities for 2006 to 2012, as listed in the Mortgage Market Statistical Annual 2013 Edition.

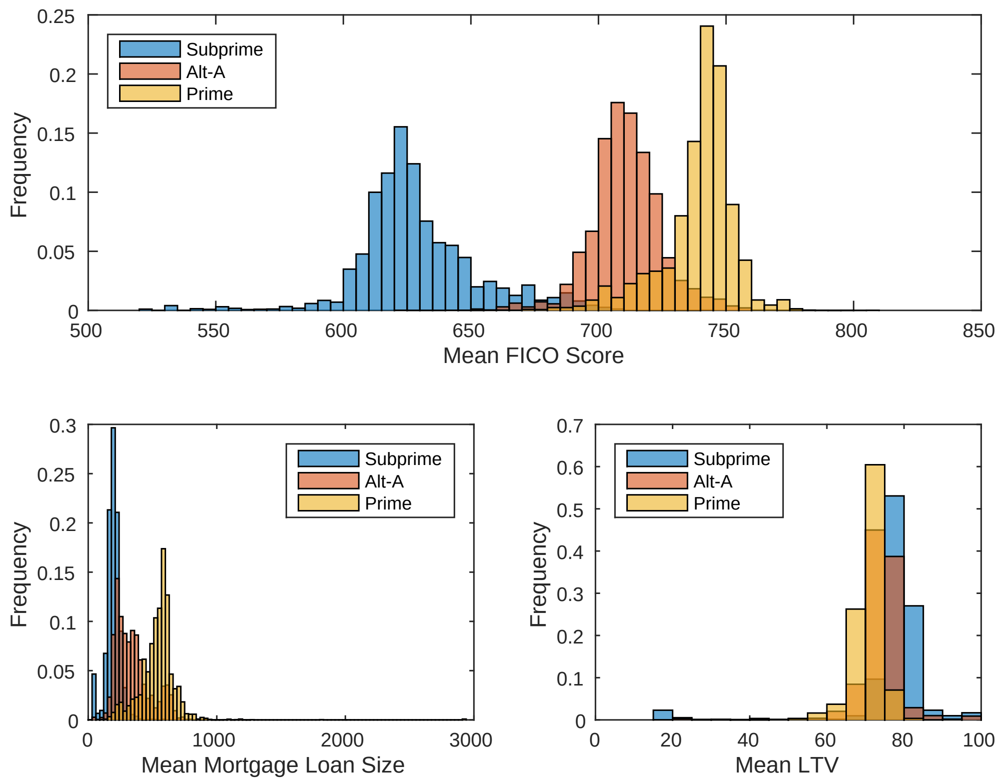
Panel A: Principal Amount and Deals Coverage by Type of Mortgage-backed Security

	Prime		**Alt-A**		**Subprime**		**Other**		**Total**	
	Amount	Deals	Amount	Deals	Amount	Deals	Amount	Deals	Amount	Deals
Unmatched	9.8	15	16.2	30	33.6	52	26.3	90	85.9	187
Matched	406.5	484	596.5	739	656.4	771	304.4	643	1,963.8	2,637
Total	416.3	499	612.7	769	690.0	823	330.7	733	2,049.8	2,824
Pct. Matched	97.7	97.0	97.4	96.1	95.1	93.7	92.0	87.7	95.8	93.4

Panel B: Principal Amount Coverage by Year and Type of Mortgage-backed Security

Type of MBS	**Year**							
	2006	2007	2008	2009	2010	2011	2012	All Years
All								
Principal Amount	1,129.3	697.0	58.6	60.4	63.8	27.6	13.2	2,049.8
Pct. Matched	97.3	93.4	95.2	95.0	97.7	97.3	91.6	95.8
Prime								
Principal Amount	218.79	180.4	7.0	5.5	0.5	0.7	3.5	416.3
Pct. Matched	96.9	98.6	94.4	100.0	100.0	100.0	100.0	97.7
Alt-A								
Principal Amount	362.79	247.4	1.9	-	0.7	-	-	612.7
Pct. Matched	99.1	94.9	72.5	100.0	100.0	100.0	100.0	97.4
Subprime								
Value	470.11	213.4	2.4	0.9	-	0.5	2.8	690.0
Principal Amount	96.6	91.8	97.9	100.0	100.0	100.0	100.0	95.1
Other								
Value	77.57	55.8	47.4	54.0	62.6	26.4	6.9	330.7
Principal Amount	93.8	76.0	100.0	100	100	100	100	92.0

Figure 1: **Distribution of Mean FICO Score, Loan Size, and LTV by Type of Loan**



The types of mortgages in the figure are Prime, Alt-A and Subprime. As there is no flag in our data that allows us to classify securities by type of mortgages, we rely on the classification provided in the Mortgage Market Statistical Annual 2013 Edition. Since we only have information in the Statistical Annual for the period 2006-2012, only securities issued in those years are included.

Table 4: **Credit Rating Activity of Non-Agency Residential Mortgage Backed Securities: 1987-2013**

This table presents some figures about the credit rating activity in the RMBS market between 1987 and 2013.

	MBS Bonds		Principal Amount	
Rating Activity	**No.**	**Pct.**	**($ Billion)**	**Pct.**
Rated by at least one agency	115,282	81.4	5,214.1	92.0
Rated by 2 or more agencies	87,937	62.1	4,812.3	84.9
Rated by all 3 big agencies	16,324	11.5	1,085.0	19.1
Rated by all agencies	0	0.0	0	0.0
Rated by Standard & Poors	90,006	63.6	4,518.0	79.7
Rated by Moody's	67,036	47.3	3,931.5	69.4
Rated by Fitch	58,692	41.4	2,530.6	44.6
Rated by Kroll (KBRA)	207	0.1	19.7	0.3
Rated by DBRS	7,179	5.1	366.6	6.5
Not Rated	26,348	18.6	453.8	8.0
All Bonds	141,630	100.0	5,667.9	100.0

Table 5: **Non-Agency Residential Mortgage Backed Securities: Credit Rating Composition 1987-2013**

This table shows the number of bonds and their corresponding principal amounts by credit rating. The credit rating corresponds to the rating assigned to a bond upon issuance. If several ratings were given, we have taken an average.

	MBS Bonds		Principal Amount		Principal Amount By Agency		
Rating	**No.**	**Pct.**	**($ Billion)**	**Pct.**	**S&P**	**Moody's**	**Fitch**
AAA	65,590.0	56.8	4,535.1	86.9	88.9	89.8	89.8
AA	13,298.0	11.5	297.0	5.7	4.8	5.4	4.1
A	13,355.0	11.6	212.3	4.1	2.9	2.5	3.7
BBB	13,062.0	11.3	118.4	2.3	1.9	1.8	1.8
BB	6,096.0	5.3	40.1	0.8	0.6	0.4	0.4
B	3,865.0	3.3	13.6	0.3	0.4	0.0	0.1
CCC	66.0	0.1	0.3	0.0	0.2	0.0	0.0
CC	22.0	0.0	0.6	0.0	0.2	0.0	0.0
C	51.0	0.0	3.3	0.1	0.1	0.0	0.0
Rated	115,405.0	81.2	5,220.5	91.7	4,523.4	3,931.5	2,531.4
Not Rated	26,774.0	18.8	472.1	8.3			

Table 6: **RMBS Losses Six Years After The Beginning of the Financial Crisis**

This table shows the number of securities with losses and the dollar size of the losses in December 2013, about six years after the beginning of the Subprime crisis in mid-2007.

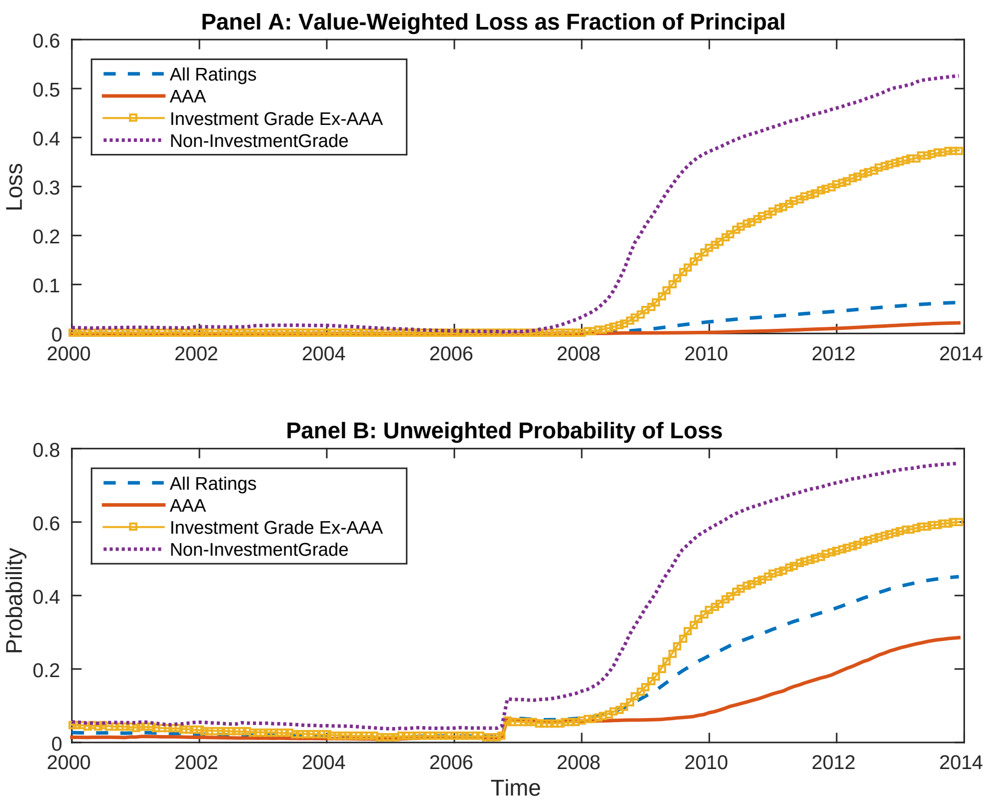
Panel A: Losses by Credit Rating as of December 2013

	Number of Securities			Dollar Amount		
	Total	W/ Losses	Pct. Losses	Total	W/ Losses	Pct. Losses
All RMBS	93,902	43,264	46.1	4,965.6	323.3	6.5
AAA	49,188	14,511	29.5	4,402.4	101.1	2.3
AA	12,087	6,425	53.2	263.6	89.6	34.0
A	11,144	6,752	60.6	144.9	56.3	38.8
BBB	12,015	8,309	69.2	101.6	48.0	47.3
NIG	9,468	7,267	76.8	53.1	28.3	53.2

Panel B: Losses by Mortgage Type and Credit Rating as of December 2013

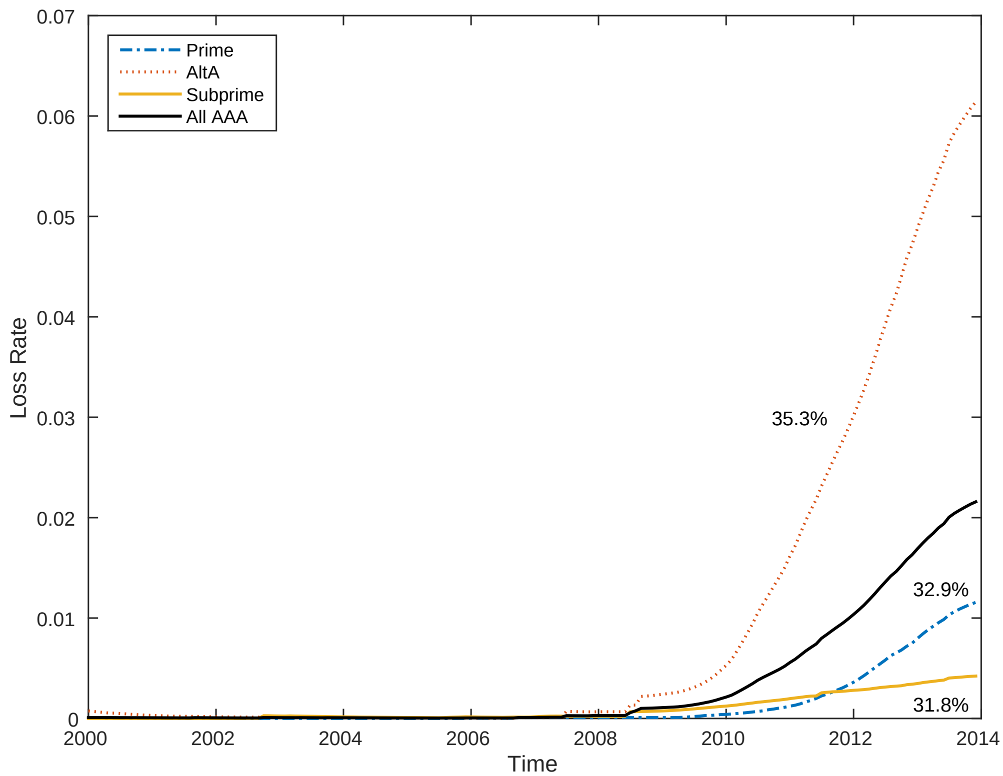
	Number of Securities			Dollar Amount		
	Total	W/ Losses	Pct. Losses	Total	W/ Losses	Pct. Losses
All Securities						
Prime	25,476.	11,987	47.1	1,238.7	37.5	3.0
Alt-A	27,135	17,763	65.5	1,327.3	145.2	10.9
Subprime	18,705	9,172	49.0	1,196.0	119.1	10.0
AAA Rated Securities						
Prime	15,610	5,418	34.7	1,172.7	14.8	1.3
Alt-A	14,851	7,646	51.5	1,210.0	78.9	6.5
Subprime	6,509	560	8.6	979.5	4.3	0.4
Investment Grade Ex-AAA Securities						
Prime	6,436	3,827	115.8	54.0	18.4	34.0
Alt-A	9,610	7,769	80.8	96.5	55.3	57.3
Subprime	10,893	7,456	68.4	203.9	104.8	51.4
Non-Investment Grade Securities						
Prime	3,430	2,742	79.9	12.0	4.3	36.2
Alt-A	2,674	2,348	87.8	20.8	10.9	52.7
Subprime	1,303	1,156	88.7	12.7	10.0	78.7

Figure 2: **Losses and Unweighted Probability of Loss in RMBS Over Time**



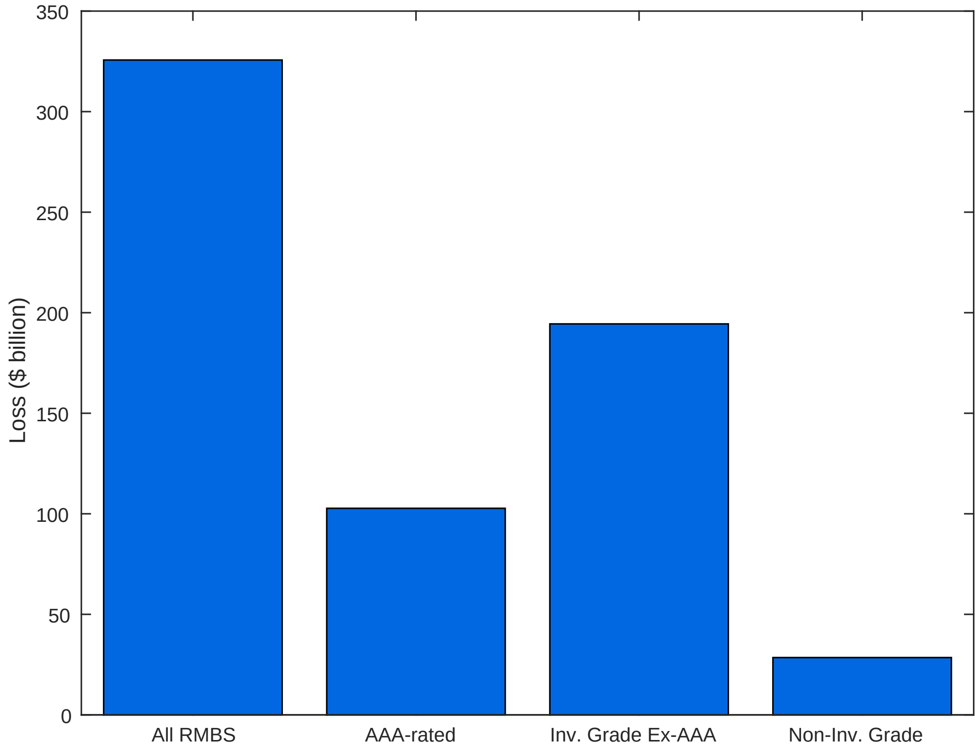
This figure shows the losses as a fraction of principal and the probability of losses incurred by the Residential Mortgage Backed securities in our database during the period 2000-2013.

Figure 3: **Losses Over Time by Type of Mortgage for AAA-Rated RMBS**



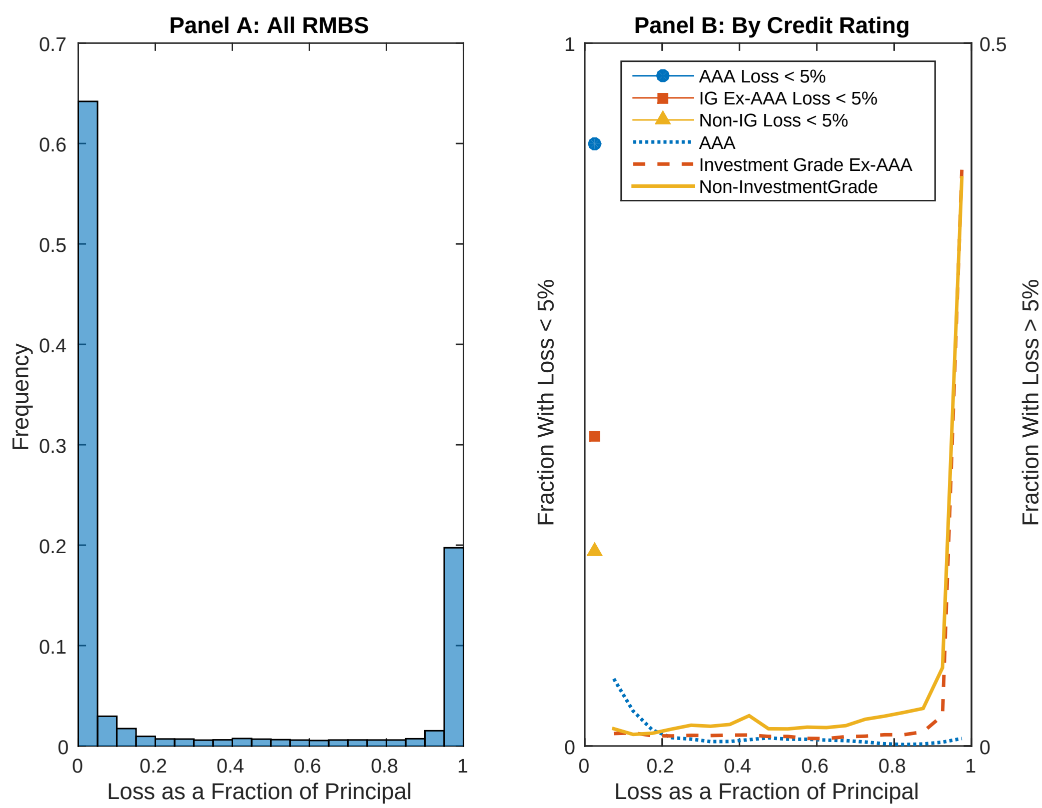
This figure plots the losses as a fraction of principal weighted by principal amount for the AAA-rated Residential Mortgage Backed Securities in our database during the period 2000-2013 by type of mortgage loan.

Figure 4: **Dollar Amount of Losses in Non-Agency RMBS**



This figure shows the cumulative Dollar amount of losses in RMBS up to December 2013 in billions of dollar. The category Investment Grade Ex-AAA includes AA, A, and BBB rated securities. The Non-Investment Grade Category includes all bonds rated BB and below

Figure 5: **Distribution of Loss Size for All RMBS**



Panel A presents the distribution of cumulative losses as of December 2013 as a fraction of the original principal amount for all the RMBS in our database issued from 1987 through 2008. Panel B shows the distribution of cumulative losses as of December 2013 as a fraction of the original principal amount for different groups of RMBS based on the type of the underlying mortgage loans.

Table 7: **Losses and Credit Ratings by Vintage Group and Type of Mortgage Loan**

This table presents principal-weighted regressions of the cumulative loss as fraction of initial principal as of December 2013 on credit rating dummy variables for all the RMBS in our database issued through 2008 classified by the type of mortgage loan underlying the securities.

	Prime			Alt-A			Subprime		
Rating	**Before 2003**	**2003 - 2005**	**2006 - 2008**	**Before 2003**	**2003 - 2005**	**2006 - 2008**	**Before 2003**	**2003 - 2005**	**2006 - 2008**
AAA	0.0000	0.0032***	0.0259***	0.0002	0.0076***	0.0953***	0.0004	0.0013	0.0068***
	(0.0001)	(0.0008)	(0.0015)	(0.0003)	(0.0015)	(0.0015)	(0.0008)	(0.0018)	(0.0020)
AA	0.0001	0.2242***	0.5841***	0.0045**	0.2097***	0.7824***	0.0007	0.0348***	0.6260***
	(0.0007)	(0.0052)	(0.0093)	(0.0019)	(0.0060)	(0.0080)	(0.0040)	(0.0061)	(0.0061)
A	0.0006	0.2837***	0.3071***	0.0080***	0.3620***	0.7260***	0.0151***	0.1566***	0.7600***
	(0.0011)	(0.0075)	(0.0117)	(0.0027)	(0.0094)	(0.0119)	(0.0050)	(0.0077)	(0.0078)
BBB	0.0039***	0.3065***	0.2957***	0.0267***	0.4728***	0.5161***	0.0718***	0.3609***	0.8654***
	(0.0013)	(0.0088)	(0.0146)	(0.0033)	(0.0115)	(0.0117)	(0.0058)	(0.0091)	(0.0094)
BB	0.0163***	0.2850***	0.2303***	0.0499***	0.6415***	0.3546***	0.1113***	0.5755***	0.8861***
	(0.0021)	(0.0095)	(0.0143)	(0.0054)	(0.0173)	(0.0144)	(0.0199)	(0.0191)	(0.0166)
B	0.0336***	0.7159***	0.8828***	0.0863***	0.7765***	0.4816***	0.2448***	0.5133***	0.7463***
	(0.0026)	(0.0165)	(0.0344)	(0.0075)	(0.0254)	(0.0193)	(0.0419)	(0.0580)	(0.0495)
CCC	-	0.2474**	0.9484***	0.9710***	0.6840***	0.8850**	-	0.3836**	0.9931***
	(0.0754)	(0.1091)	(0.2731)	(0.0866)	(0.1954)	(0.3523)	(0.0977)	(0.1949)	(0.1512)
CC	-	0.0109	-	-	-	0.6322***	-	0.1189	-
	(0.1109)	(0.0951)	(0.2628)	(0.1027)	(0.0977)	(0.1078)	(0.1027)	(0.3823)	(0.5566)
C or Below	-	0.7679***	0.9687	0.4963***	-	0.3112***	-	0.3775	0.9932**
	(0.1215)	(0.1359)	(0.5928)	(0.0449)	(0.0219)	(0.0241)	(0.1369)	(0.3712)	(0.5020)
Observations	4,095	13,366	8,015	2,908	8,226	16,001	1,363	6,028	11,314
R-squared	0.0554	0.3468	0.4182	0.1571	0.4329	0.4975	0.1432	0.3217	0.7052
Weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
$*p < 0.10, **p < 0.05, ***p < 0.01$

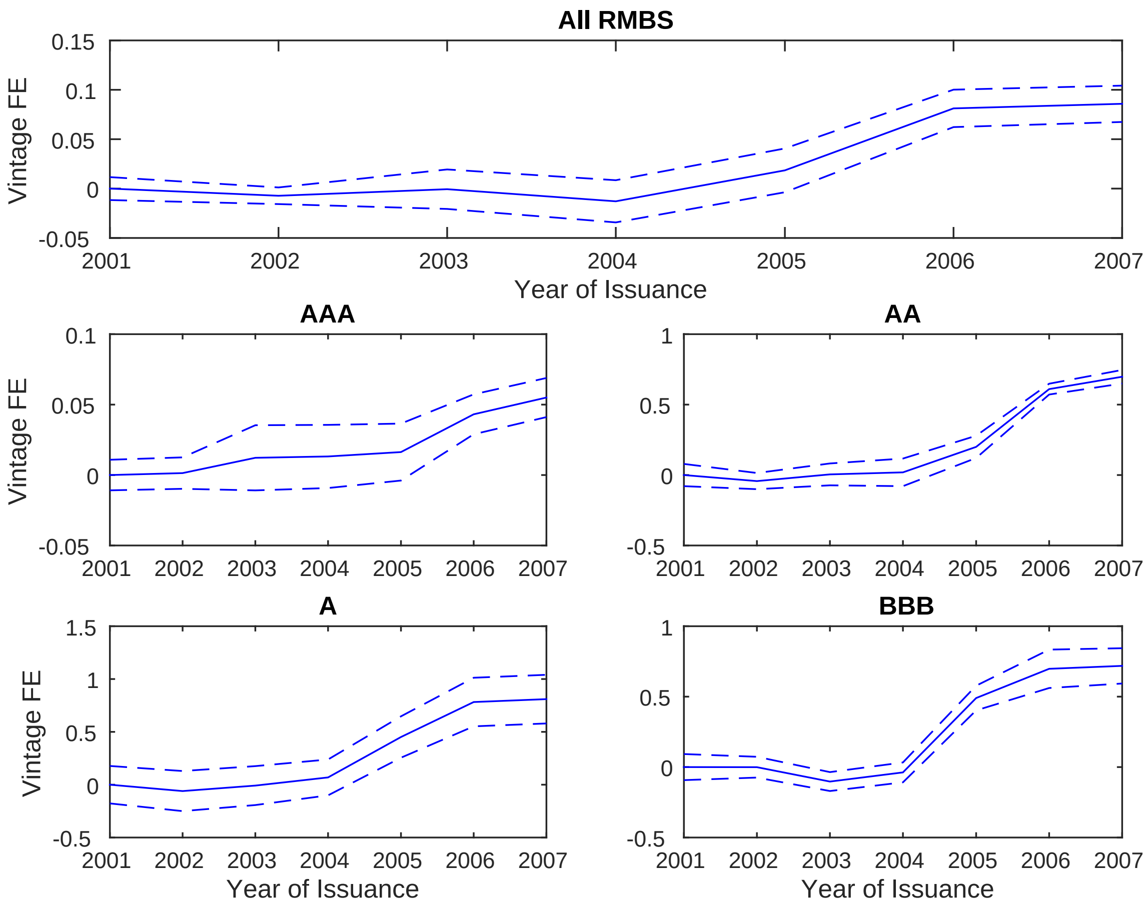
Table 8: **Principal-Weighted Losses in RMBS and Credit Ratings**

This table shows regressions of the cumulative loss as fraction of initial principal as of December 2013 on credit rating dummy variables. The regressions are weighted by the principal dollar amount upon issuance of each RMBS.

Credit Rating	**Full Sample**	**Before 2003**	**2003 - 2005**	**2006-2008**
AAA	0.0218***	0.0002	0.0034***	0.0483***
	(0.0006)	(0.0001)	(0.0007)	(0.0011)
AA	0.3096***	0.001	0.1180***	0.5091***
	(0.0025)	(0.0008)	(0.0028)	(0.0043)
A	0.3620***	0.0055***	0.2000***	0.6572***
	(0.0033)	(0.0008)	(0.0036)	(0.0062)
BBB	0.4480***	0.0334***	0.3152***	0.6655***
	(0.0040)	(0.0013)	(0.0041)	(0.0072)
BB	0.4923***	0.0653***	0.4886***	0.5136***
	(0.0064)	(0.0029)	(0.0075)	(0.0102)
B	0.5812***	0.0938***	0.6989***	0.5619***
	(0.0117)	(0.0042)	(0.0147)	(0.0182)
CCC	0.7360***	0.4125***	0.4102***	0.9465***
	(0.0867)	(0.0558)	(0.0987)	(0.1361)
CC	0.2036***	0.1364	0.0251	0.2005***
	(0.0562)	(0.0964)	(0.1228)	(0.0719)
C or Below	0.3863***	0.0661***	0.6607***	0.3604***
	(0.0225)	(0.0227)	(0.1665)	(0.0274)
Observations	93,902	19,230	38,381	36,291
R-squared	0.3217	0.0852	0.2972	0.485

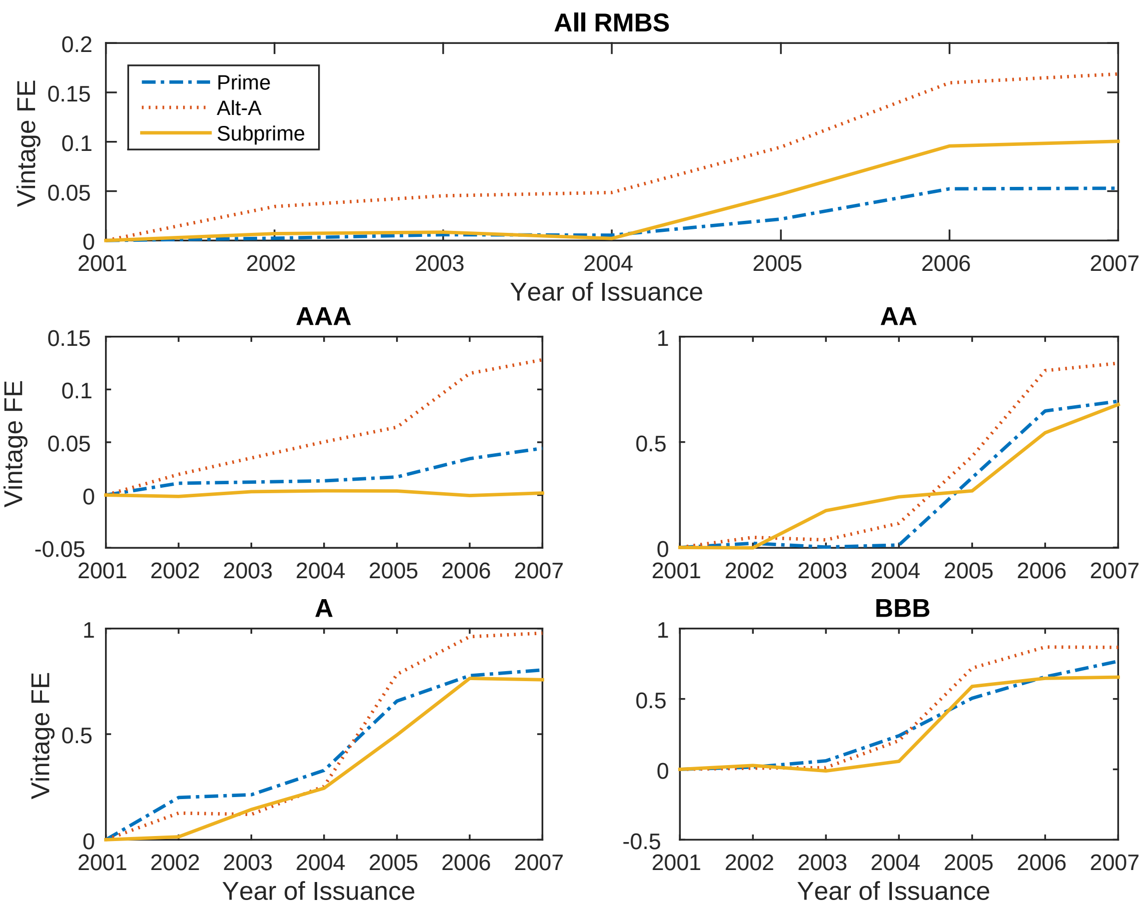
Standard errors in parentheses
$*p < 0.10, **p < 0.05, ***p < 0.01$

Figure 6: **Vintage Fixed Effects on Weighted Losses**



This figure plots the coefficient estimates corresponding to issue year (vintage) dummy variables in linear regressions that have as left hand side variable the cumulative losses as of December 2013 as a fraction of principal and on the right hand side have all the covariates available in our database as controls. The lines are the mean plus/minus one standard error.

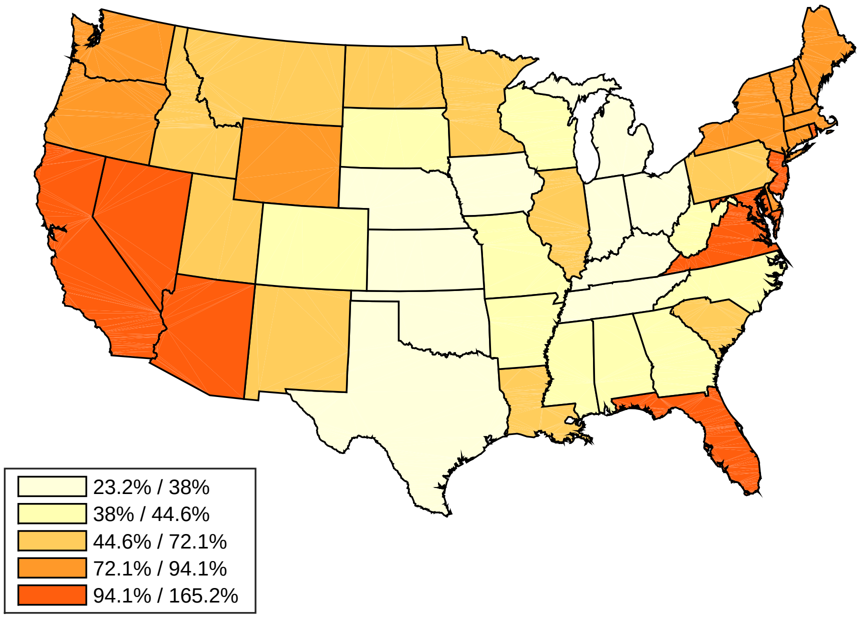
Figure 7: **Vintage Fixed Effects on Weighted Losses by Type of Mortgage Loan**



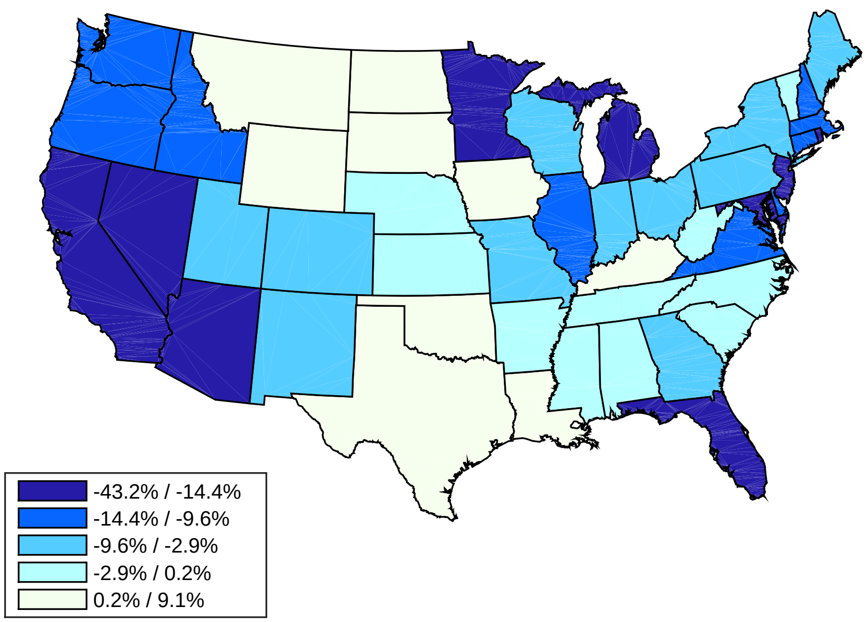
This figure plots the coefficient estimates corresponding to issue year (vintage) dummy variables in linear regressions that have as left hand side variable the cumulative losses as of December 2013 as a fraction of principal and on the right hand side have all the covariates available in our database as controls.

Figure 8: **State-Level House Price Boom and Bust From 2000-Q1 to 2009-Q2**

Panel A. Boom: 2000-Q1 to 2006-Q4



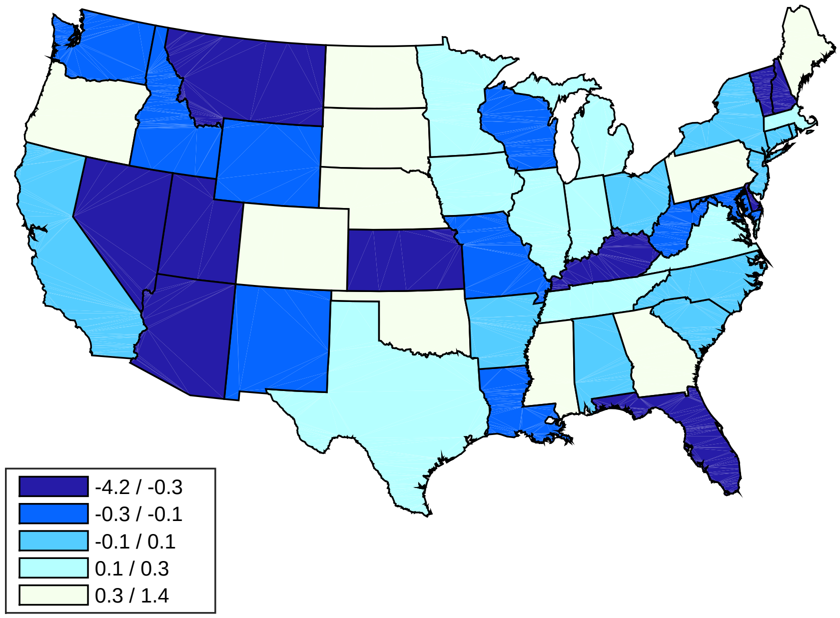
Panel B. Bust: 2006-Q4 to 2009-Q4



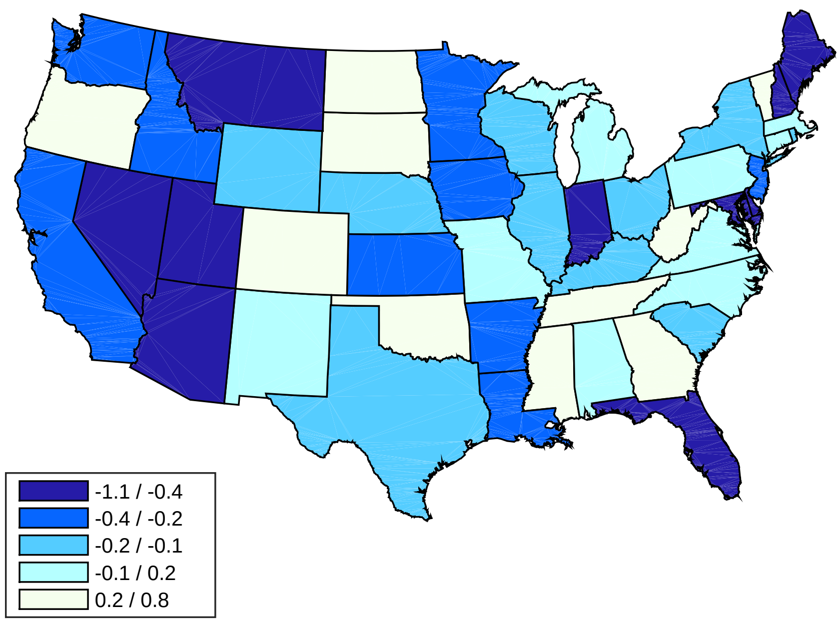
This map highlights the differences in house price increases between the first quarter of 2000 and the fourth quarter of 2006 and house price decreases between the fourth quarter of 2006 and the fourth quarter of 2009 across states. The house price data comes from the Federal Housing Agency and corresponds to the State-Level All-transaction indexes available here `http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index-Datasets.aspx#qexe`. States are grouped in quintiles according to the house price change the experienced in each period. Each color on the map represents a quintile, with darkest colors representing bigger absolute changes (red for the period of price increases and blue for the period of price decreases).

Figure 9: **State-Level Dummies on Loss Rates: with and without controls**

Panel B. Dummy Coefficients Regression with Controls

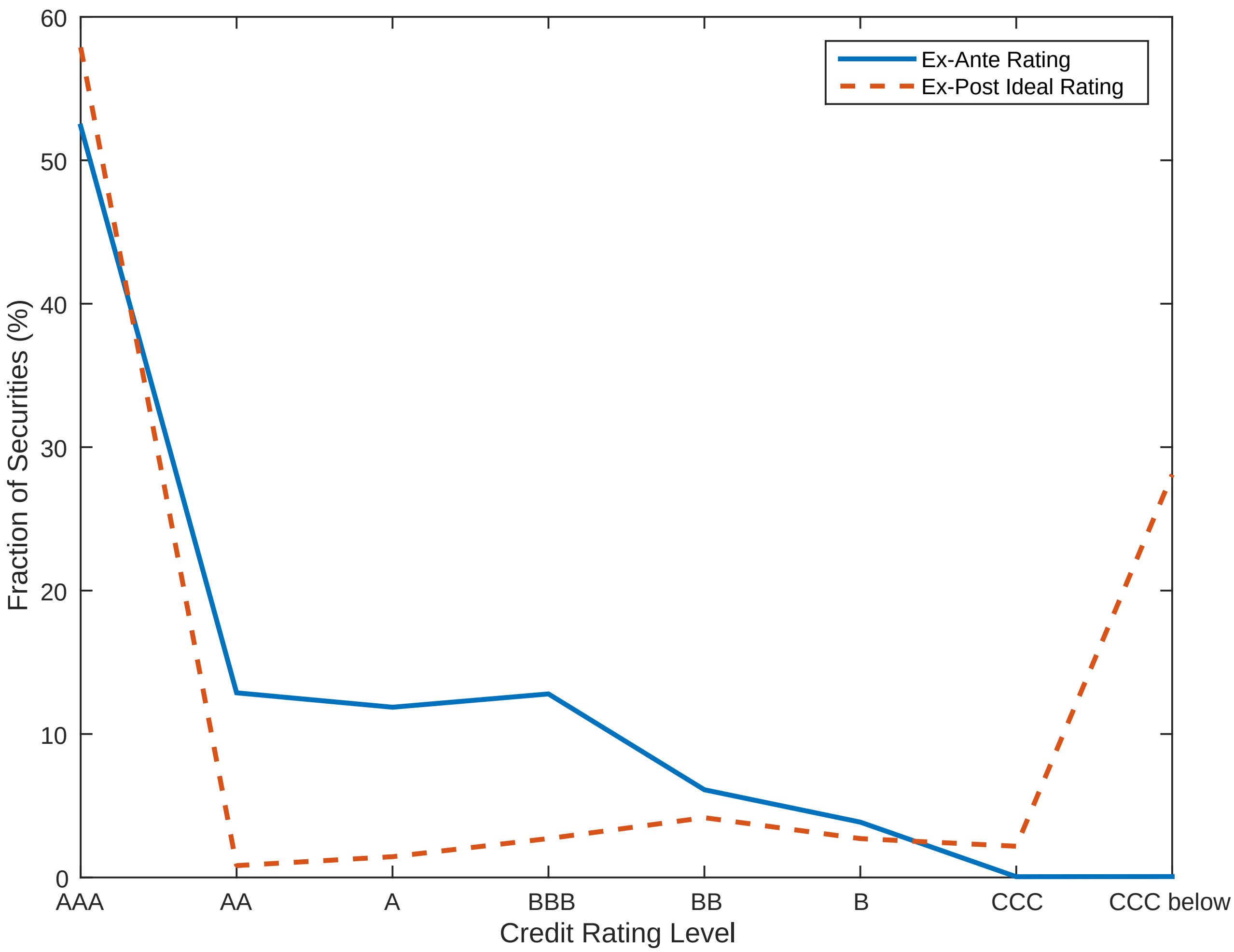


Panel B. Dummy Coefficients Regression without Controls



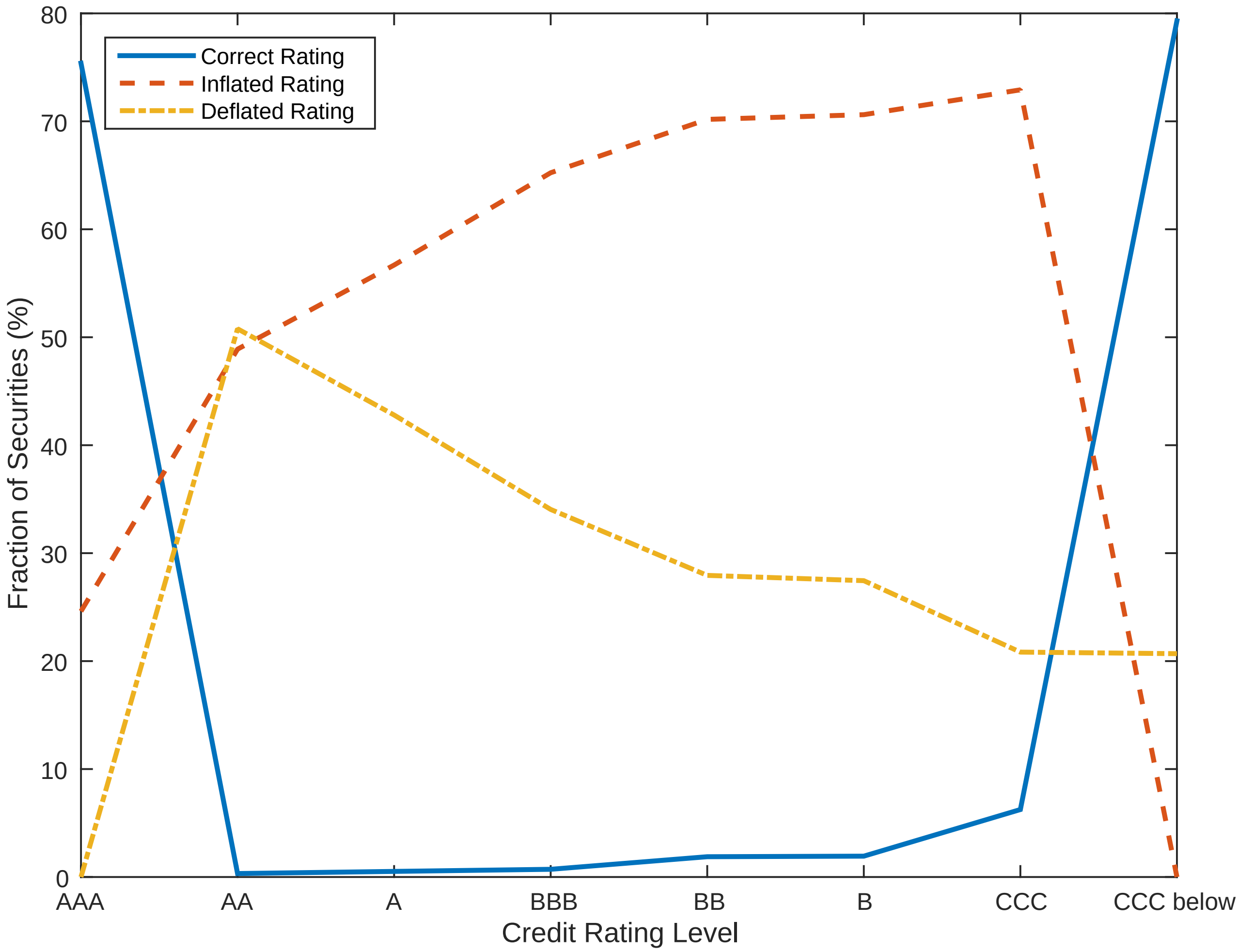
The map is colored according to the regression of loss rates on the state dummy variables, with or without the inclusion of additional controls. The regression coefficients are sorted into quintiles to deliver the coloring scheme, with darker colors representing larger losses.

Figure 10: **Ex-Ante vs Ex-Post Ideal Ratings**



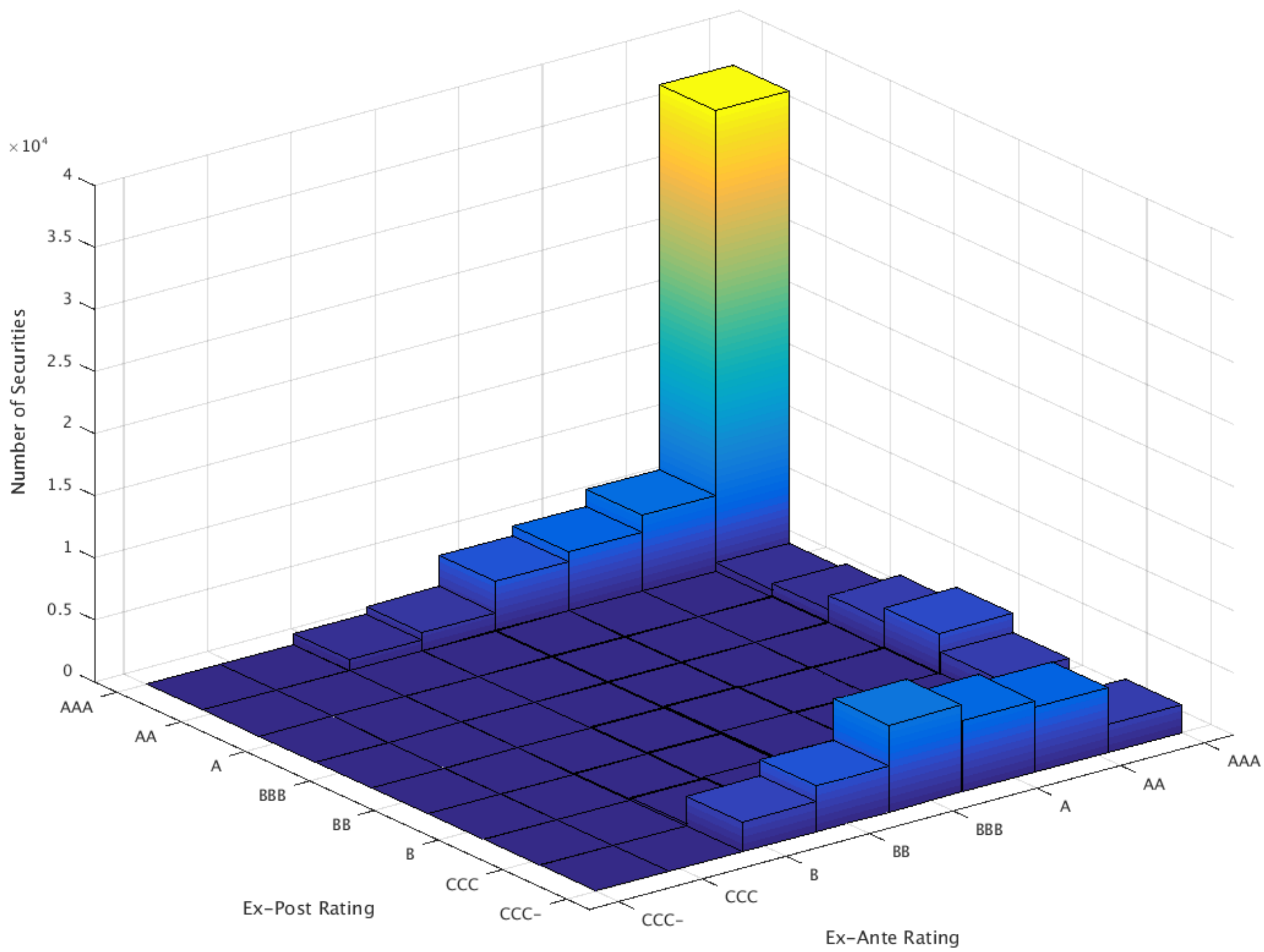
In this figure, for each security, we compare the original credit rating (which we call here Ex-Ante Rating) to the rating that ex-post we would have assigned given the security's realized loss using Moody's idealized Expected Loss Table by Rating. This table is available here `http://siteresources.worldbank.org/EXTECAREGTOPPRVSECDEV/Resources/570954-1211578683837/Bielecki_Moodys_Rating_SME_transactions.pdf`*. The solid line shows the fraction of securities that was assigned each rating level. The dotted line shows the fraction of securities that should have gotten each rating level based on their loss as a fraction of original principal. We do this for all securities issued up to 2008.*

Figure 11: **"Right" and "Wrong" Ratings Based on Moody's Ideal Ratings**



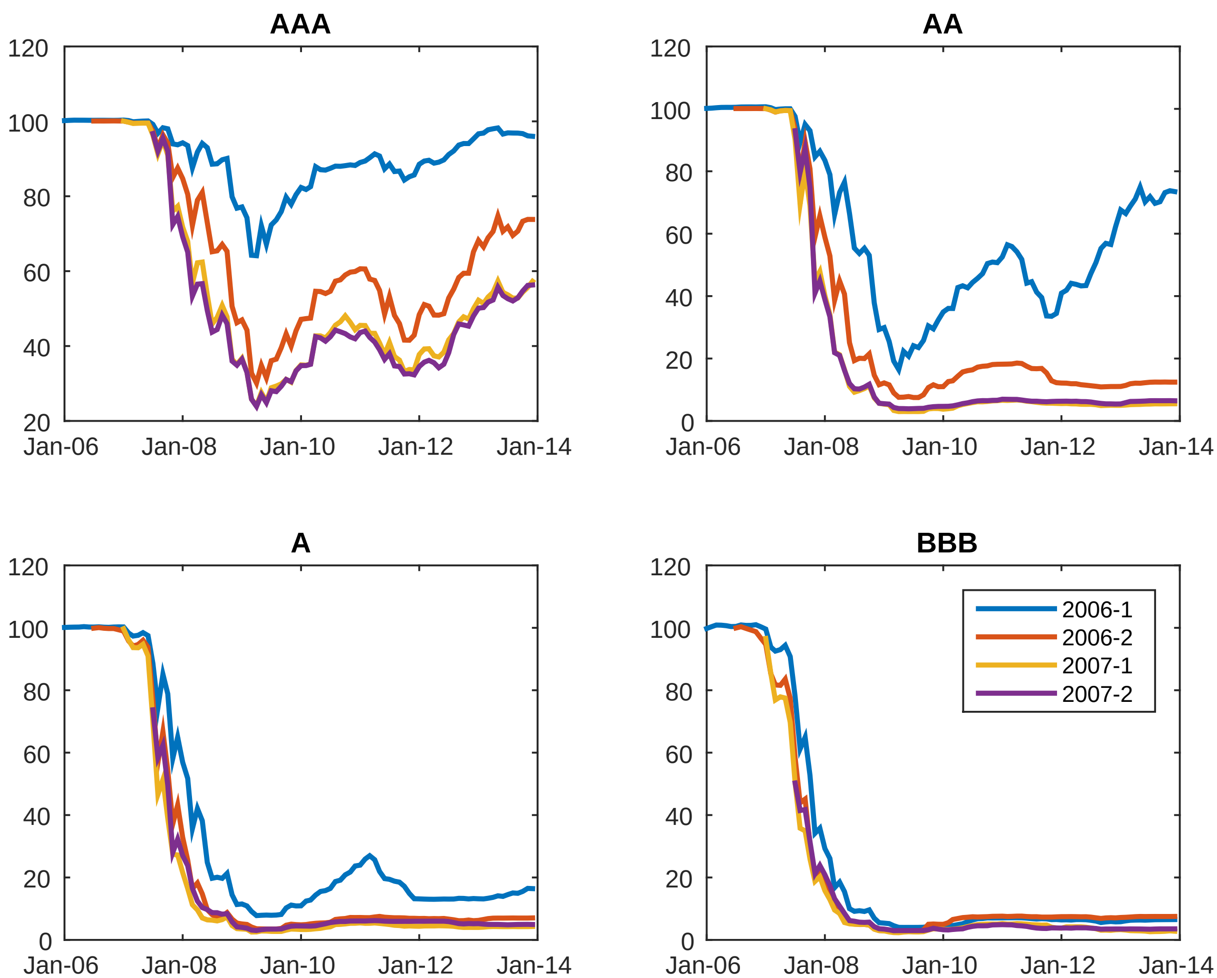
This figure compares the original rating of each security to the rating we would have assigned ex-post based on Moody's idealized Expected Loss Table by Rating.

Figure 12: **"Misratings" Ratings Based on Moody's Ideal Ratings**



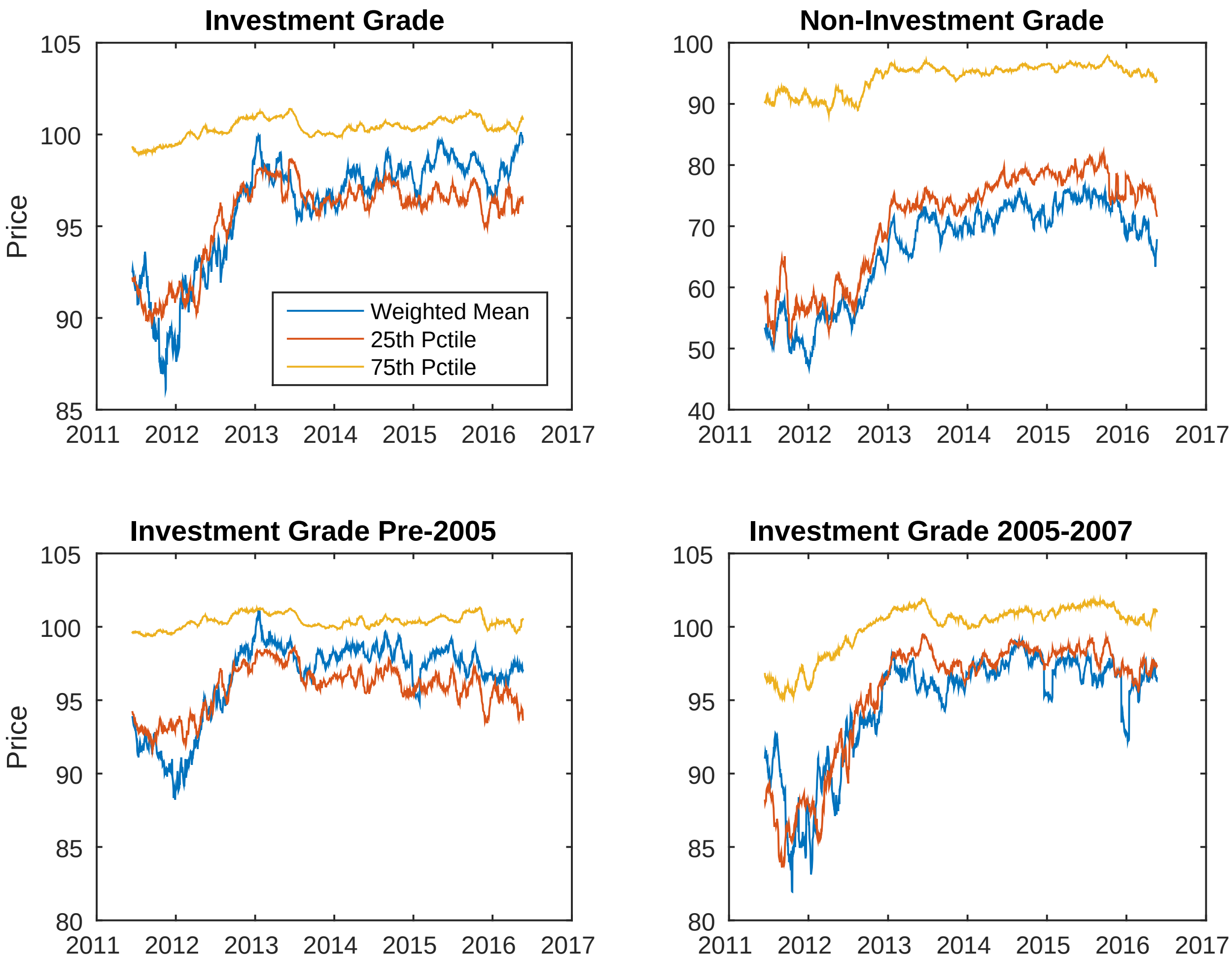
This figure classifies each security in a bin defined in two dimensions. One dimension is the ex-ante credit rating as determined by the original credit rating. The second dimension is the ex-post rating determined by Moody's table for idealized expected losses. If all securities had behaved as expected, all the mass would be represented in bars on the diagonal running southwest-northeast in the plot. The height of the bar represents the number of securities.

Figure 13: **Subprime RMBS Price Indexes**



This figure plots the prices of ABX.HE indexes by Markit. Each line represents a vintage of subprime RMBS and the Index. Each panel shows the evolution of prices over time by credit rating. These indexes are constructed based on 20 deals.

Figure 14: **Summary Statistics of Prices Collected by FINRA**



This figure shows summary statistics of daily transaction prices collected by the Financial Industry Regulatory Authority from May 2011 through May 2016 on Non-Agency MBS. The plots at the top break up the statistics by Investment Grade and Non-Investment Grade, while the plots at the bottom break up the statistics by groups of vintages only for Investment Grade securities. FINRA produces this information daily since 2011. The lines in the different figures correspond to 22-day moving averages (daily monthly averages) of the daily values reported by FINRA. Here we report the principal weighted average and the 25th and 75th percentiles of the average transaction price. The daily reports are available here `http://tps.finra.org/idc-index.html`

Table 9: **House Prices and Loss Rates**

This table presents linear regressions to study the relation between the the cumulative loss as fraction of initial principal as of December 2013 and changes in house prices.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔHP 2000-2006	0.073***		-0.218***		-0.178***	-0.021		
	0.003		0.010		0.012	0.027		
ΔHP 2006-2009		-0.203***	-0.63***		-0.532***	0.342***		
		0.006	0.021		0.020	0.061		
Price Reversal				-0.238***				
				0.007				
AA					0.426***	0.423***	0.423***	0.427***
					0.003	0.003	0.003	0.003
A					0.493***	0.488***	0.489***	0.492***
					0.004	0.004	0.004	0.004
BBB					0.555***	0.55***	0.55***	0.555***
					0.005	0.005	0.005	0.005
BB					0.5***	0.492***	0.494***	0.502***
					0.007	0.007	0.007	0.007
B					0.599***	0.594***	0.594***	0.606***
					0.013	0.012	0.013	0.013
CCC					0.749***	0.74***	0.739***	0.747***
					0.087	0.086	0.086	0.088
CC					0.496***	0.493***	0.482***	0.512***
					0.089	0.087	0.088	0.089
C or Below					0.324***	0.305***	0.307***	0.348***
					0.023	0.022	0.022	0.023
Subprime					0.009***	-0.003*	-0.004**	0.008***
					0.002	0.002	0.002	0.002
Alt-A					0.049***	0.032***	0.033***	0.06***
					0.002	0.002	0.002	0.002
Contstant	0.011***	-0.001	0.019***	-0.121***	-0.038***	0.059***	-0.026***	0.004***
	0.002	0.002	0.002	0.006	0.005	0.007	0.004	0.001
State Dummies	No	No	No	No	No	Yes	Yes	No
Weighted Dummies	No	No	No	No	No	Yes	Yes	No
Observations	93,902	93,902	93,902	93,902	71,316	71,316	71,316	71,316
R-squared	0.0059	0.0107	0.0156	0.0128	0.4345	0.4513	0.4492	0.4272
Weighted Regression	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 10: **Credit Rating Reversals**

Panel A presents the calculation of equation (3).

Panel A: Gains from Including Other Covariates

	$\alpha = 0$	$\alpha = 0.05$	$\alpha = 0.1$	$\alpha = 0.25$	$\alpha = 0.5$	$\alpha = 0.75$	$\alpha = 0.9$
Principal Value Weighted							
AAA vs AA	1.65	0.47	0.24	0.12	0.08	0.04	0.03
AAA vs A	2.26	0.58	0.28	0.14	0.08	0.04	0.03
AAA vs BBB	0.82	0.32	0.17	0.09	0.06	0.03	0.02
AA vs A	-8.52	-6.76	-6.69	-11.29	-20.50	-59.50	- -699.95
AA vs BBB	2.27	2.54	2.77	2.59	2.79	2.62	2.54
A vs BBB	1.90	1.94	2.07	2.32	2.82	3.02	3.11

Panel B: Credit Rating Reversals

	$\alpha = 0$	$\alpha = 0.05$	$\alpha = 0.1$	$\alpha = 0.25$	$\alpha = 0.5$	$\alpha = 0.75$	$\alpha = 0.9$
Principal Value Weighted							
AAA switched to AA	49.9	13.9	1.0	0.3	0.3	0.0	0.0
AAA switched to A	54.5	21.4	2.3	0.3	0.3	0.0	0.0
AAA switched to BBB	31.2	2.8	0.4	0.3	0.2	0.0	0.0
AA switched to A	75.4	73.2	72.8	71.7	69.0	67.4	66.1
AA switched to BBB	63.8	63.1	63.1	62.8	60.9	59.2	57.8
A switched to BBB	67.4	67.7	67.9	68.1	68.5	67.3	65.4

Table 11: **Principal-Weighted Probability of Loss in RMBS and Credit Ratings**

This table presents linear regressions to study the relation between the probability of incurring losses and credit ratings.

Credit Rating	**Full Sample**	**Before 2003**	**2003 - 2005**	**2006-2008**
AAA	0.2747***	0.0639***	0.1667***	0.4636***
	(0.0016)	(0.0019)	(0.0021)	(0.0028)
AA	0.1603***	0.0207*	0.1010***	0.1667***
	(0.0066)	(0.0107)	(0.0088)	(0.0106)
A	0.2073***	0.0178	0.1472***	0.3351***
	(0.0087)	(0.0111)	(0.0114)	(0.0155)
BBB	0.3177***	0.1690***	0.3168***	0.3136***
	(0.0104)	(0.0170)	(0.0131)	(0.0179)
BB	0.5943***	0.2203***	0.6514***	0.4819***
	(0.0169)	(0.0389)	(0.0238)	(0.0253)
B	0.5885***	0.2264***	0.7656***	0.4303***
	(0.0308)	(0.0560)	(0.0466)	(0.0452)
CCC	0.5822**	0.9361	0.4627	0.5364
	(0.2272)	(0.7475)	(0.3134)	(0.3381)
CC	0.6340***	0.4459	-0.0239	0.5364***
	(0.1472)	(1.2919)	(0.3900)	(0.1785)
C or Below	0.7176***	0.0696	0.8333	0.5364***
	(0.0589)	(0.3045)	(0.5286)	(0.0681)
Observations	93,902	19,230	38,381	36,291
R-squared	0.0370	0.0079	0.0451	0.0376

Standard errors in parentheses
$*p < 0.10, **p < 0.05, ***p < 0.01$

Table 12: **Internal Rate of Return Calculations From Issuance to 2013 by Credit Rating. For AAA: also Type of Mortgage.**

Return Statistic	80% TV	90% TV	100% TV
By Credit Rating			
AAA	2.44	2.89	3.31
AA	-7.90	-7.01	-6.21
A	-10.92	-10.10	-9.35
BBB	-13.56	-12.80	-12.11
Inv. Grade Ex AAA	-9.01	-8.15	-7.38
By Type of Mortgage			
AAA Prime	3.61	3.98	4.33
AAA SubPrime	1.61	2.14	2.62
AAA AltA	1.37	2.01	2.61
Fixed Rate MBS			
AAA Prime Fixed	4.25	4.56	4.84
AAA SubPrime Fixed	4.86	4.96	5.04
AAA AltA Fixed	3.64	4.13	4.58
Floating Rate MBS			
AAA Prime Floating	3.03	3.45	3.83
AAA SubPrime Floating	1.45	1.97	2.44
AAA AltA Floating	0.42	1.12	1.76

Table 13: **Discount Margin (Return Over 3-month Tbill) Calculations From Issuance to 2013 by Credit Rating**

This table presents discount margin calculations for the RMBS in our database by credit rating using the 3-month Tbill rate as benchmark. The discount margin IRR solves equation 5.

	Terminal Value Assumption					
Return Statistic	**80% TV**	**90% TV**	**100% TV**	**Same Loss**	**Mean Loss**	**Median Loss**
			Panel A: Principal Value - Weighted			
AAA-Rated						
Mean	0.0	0.3	0.7	0.6	0.7	0.6
Median	1.3	1.6	2.1	2.1	2.1	1.9
Std. Dev.	20.1	20.2	20.2	20.2	20.2	20.2
AA-Rated						
Mean	-1.6	-1.6	-1.6	-1.7	-1.8	-1.7
Median	-0.4	0.7	1.8	1.7	-1.1	-1.0
Std. Dev.	52.5	52.4	52.6	52.6	51.9	51.8
A-Rated						
Mean	-1.2	-1.2	-1.2	-1.2	-1.3	-1.2
Median	-0.1	0.4	1.0	1.0	-4.4	-3.6
Std. Dev.	52.5	52.4	52.6	52.6	51.9	51.8
BBB-Rated						
Mean	-1.0	-1.0	-1.0	-1.0	-1.1	-1.1
Median	-5.3	-7.5	-7.4	-8.2	-18.1	-11.3
Std. Dev.	67.6	66.9	67.1	67.0	65.5	66.1
			Panel B: Unweighted			
AAA-Rated						
Mean	-1.3	-1.2	-1.0	-1.0	-1.0	-1.0
Median	2.2	2.6	2.8	2.7	2.8	2.7
Std. Dev.	34.3	34.8	34.8	34.8	34.8	34.8
AA-Rated						
Mean	-5.3	-5.5	-5.5	-5.5	-5.8	-5.6
Median	-1.2	-0.8	-0.4	-1.1	-7.8	-8.1
Std. Dev.	58.7	58.2	58.5	58.3	57.6	57.7
A-Rated						
Mean	-6.9	-7.2	-7.2	-7.2	-7.4	-7.3
Median	-18.0	-25.3	-25.3	-26.2	-32.8	-26.2
Std. Dev.	58.7	58.2	58.5	58.3	57.6	57.7
BBB-Rated						
Mean	-8.3	-8.6	-8.6	-8.6	-8.9	-8.7
Median	-34.3	-41.0	-41.0	-41.2	-44.1	-41.1
Std. Dev.	70.8	69.7	69.8	69.7	69.1	69.2

Table 14: **Principal Value Weighted Discount Margin (Return Over 3-month Tbill) Calculations by Vintage**

This table presents discount margin calculations for the RMBS in our database by vintage (year of issuance) using the 3-month Tbill rate as benchmark. The discount margin IRR solves equation 5.

	Terminal Value Assumption					
Return Statistic	**80% TV**	**90% TV**	**100% TV**	**Same Loss**	**Mean Loss**	**Median Loss**
Vintage 2000						
Mean	0.0	0.0	0.0	0.0	0.0	0.0
Median	5.1	5.1	5.1	5.1	5.1	5.1
Std. Dev.	22.1	22.1	22.1	22.1	22.1	22.1
Vintage 2001						
Mean	0.1	0.1	0.1	0.1	0.1	0.1
Median	5.4	5.4	5.4	5.4	5.4	5.4
Std. Dev.	19.8	19.8	19.7	19.7	19.7	19.7
Vintage 2002						
Mean	0.1	0.1	0.1	0.1	0.1	0.1
Median	3.9	3.9	3.9	3.9	3.9	3.9
Std. Dev.	21.5	21.5	21.5	21.5	21.5	21.5
Vintage 2003						
Mean	0.2	0.2	0.2	0.2	0.2	0.2
Median	3.4	3.6	3.7	3.7	3.7	3.7
Std. Dev.	10.6	10.7	10.7	10.7	10.7	10.7
Vintage 2004						
Mean	0.3	0.3	0.3	0.3	0.3	0.3
Median	3.2	3.3	3.5	3.5	3.5	3.5
Std. Dev.	17.1	17.1	17.2	17.2	17.2	17.2
Vintage 2005						
Mean	0.1	0.2	0.2	0.2	0.2	0.2
Median	3.4	3.8	4.0	4.0	4.0	4.0
Std. Dev.	16.7	16.6	16.5	16.6	16.5	16.5
Vintage 2006						
Mean	-1.9	-1.8	-1.7	-1.8	-1.9	-1.8
Median	1.6	2.2	2.8	2.7	2.8	2.5
Std. Dev.	33.8	33.9	34.0	34.0	34.6	34.0
Vintage 2007						
Mean	-1.3	-1.2	-1.1	-1.1	-1.2	-1.2
Median	1.3	1.9	2.5	2.4	2.3	2.0
Std. Dev.	39.9	40.0	40.2	40.2	40.2	40.1

Table 15: **Discount Margin (Return Over 3-month Tbill) Calculations From Issuance to 2013 by Type of Mortgage Loan**

This table presents discount margin calculations for the RMBS in our database by type of mortgage loan using the 3-month Tbill rate as benchmark. The discount margin IRR solves equation 5.

	Terminal Value Assumption					
Return Statistic	**80% TV**	**90% TV**	**100% TV**	**Same Loss**	**Mean Loss**	**Median Loss**
Panel A: Principal Value - Weighted						
Subprime						
Mean	-2.2	-2.2	-2.1	-2.1	-2.4	-2.3
Median	0.0	0.6	1.5	1.5	1.4	0.9
Std. Dev.	35.0	35.2	35.3	35.4	35.8	35.3
Alt-A						
Mean	-1.5	-1.4	-1.3	-1.4	-1.3	-1.3
Median	0.8	1.3	2.0	1.9	1.9	1.7
Std. Dev.	35.4	35.6	35.7	35.7	35.7	35.6
Prime						
Mean	0.4	0.4	0.5	0.5	0.5	0.5
Median	3.2	3.5	3.8	3.8	3.8	3.7
Std. Dev.	15.2	15.4	15.2	15.3	15.3	15.3
Panel B: Unweighted						
Subprime						
Mean	-8.5	-8.7	-8.6	-8.7	-9.2	-8.9
Median	-1.2	-0.3	0.0	-0.1	-1.8	-2.4
Std. Dev.	64.4	64.2	64.4	64.3	63.8	63.7
Alt-A						
Mean	-9.7	-9.9	-9.8	-9.9	-9.9	-9.9
Median	-0.4	0.2	0.8	0.4	0.6	0.2
Std. Dev.	64.1	63.7	63.9	63.8	63.8	63.8
Prime						
Mean	-2.0	-2.2	-2.1	-2.1	-2.1	-2.2
Median	2.9	3.3	3.6	3.6	3.6	3.4
Std. Dev.	37.2	38.0	38.1	38.1	38.1	38.1

Table 16: **Median Discount Margin (Return Over 3-month Tbill) for AAA-rated RMBS by Vintage, Loan Type and Bond Type**

This table presents discount margin calculations for the AAA RMBS in our database by type of mortgage loan, vintage, and by type of bond (floating rate or fixed rate) using the 3-month Tbill rate as benchmark. The discount margin IRR solves equation 5.

	Fixed Rate			**Floating Rate**			**3-Month**
Loan Type	**80% TV**	**90% TV**	**100% TV**	**80% TV**	**90% TV**	**100% TV**	**Libor**
Vintage 2000							
Subprime	4.5	4.5	4.5	1.6	1.6	1.6	
Alt-A	4.0	4.0	4.0	2.6	2.6	2.6	2.4
Prime	3.7	3.7	3.7	3.2	3.3	3.3	
Vintage 2001							
Subprime	2.9	2.9	2.9	0.3	0.4	0.4	
Alt-A	4.9	4.9	4.9	3.8	3.8	3.9	2.1
Prime	4.7	4.7	4.7	4.4	4.4	4.4	
Vintage 2002							
Subprime	2.8	2.8	2.8	-0.1	-0.1	-0.1	
Alt-A	4.6	4.7	4.7	1.1	1.2	1.2	2.0
Prime	4.4	4.4	4.4	3.0	3.0	3.0	
Vintage 2003							
Subprime	4.9	5.1	5.4	-0.7	-0.6	-0.6	
Alt-A	3.6	3.7	3.7	1.2	1.3	1.5	2.4
Prime	3.5	3.5	3.6	1.6	1.6	1.7	
Vintage 2004							
Subprime	4.4	4.6	4.7	-0.9	-0.8	-0.8	
Alt-A	4.0	4.1	4.2	0.6	0.9	1.2	2.0
Prime	3.9	4.0	4.1	2.1	2.4	2.7	
Vintage 2005							
Subprime	5.0	5.3	5.8	0.6	0.8	0.8	
Alt-A	3.9	4.4	4.8	0.9	1.5	2.0	2.1
Prime	4.2	4.5	4.8	2.5	3.0	3.5	
Vintage 2006							
Subprime	4.3	5.0	5.7	0.7	1.3	2.0	
Alt-A	3.1	3.9	4.6	-0.1	0.9	1.8	2.1
Prime	4.5	4.9	5.4	2.8	3.4	4.1	
Vintage 2007							
Subprime	4.3	5.0	5.8	-0.6	0.6	1.6	
Alt-A	2.9	3.8	4.6	-1.0	0.2	1.3	1.9
Prime	4.5	5.1	5.6	2.4	3.1	3.8	

Table 17: **Subprime RMBS Returns for Deals Underlying ABX.HE Indexes**

This table reports monthly returns computed from the evolution of prices of the ABX.HE indexes. The calculations shows three time periods. The first period is the entire period of analysis, 2006-2013. The second period runs from January 2006 through May 2009, when the prices of AAA bonds bottomed out. The third period goes from May 2009 through December 2013.

	AAA	AAAp	AA	A	BBB	BBB-
Vintage 2006-1						
From Jan 06 to Dec 13	0.00	-0.37	0.09	-1.35	-2.36	-2.62
From Jan 06 to May 09	-1.08	-1.37	-4.11	-5.52	-7.07	-7.28
From May 09 To Dec 13	0.76	-0.17	3.01	1.54	0.92	0.63
Vintage 2006-2						
From June 06 to Dec 13	-0.09	-0.11	-1.77	-2.31	-2.17	-2.40
From June 06 to May 09	-3.30	-4.56	-6.55	-8.46	-9.70	-9.84
From May 09 To Dec 13	1.79	0.77	1.05	1.32	2.27	1.98
Vintage 2007-1						
From Jan 07 to Dec 13	-0.38	0.05	-2.73	-3.05	-3.62	-4.49
From Jan 07 to May 09	-4.76	-8.01	-10.86	-11.50	-12.13	-12.15
From May 09 To Dec 13	1.73	1.64	1.19	1.02	0.49	-0.80
Vintage 2007-2						
From June 07 to Dec 13	-0.41	0.24	-2.76	-2.86	-2.94	-2.83
From June 07 to May 09	-6.00	-7.94	-12.56	-12.98	-11.83	-11.31
From May 09 To Dec 13	1.68	1.85	0.91	0.94	0.39	0.35

Figure 15: *A snapshot from the Mortgage Market Statistical Annual 2013*

Figure 16: *A sample of the information provided by Bloomberg.*

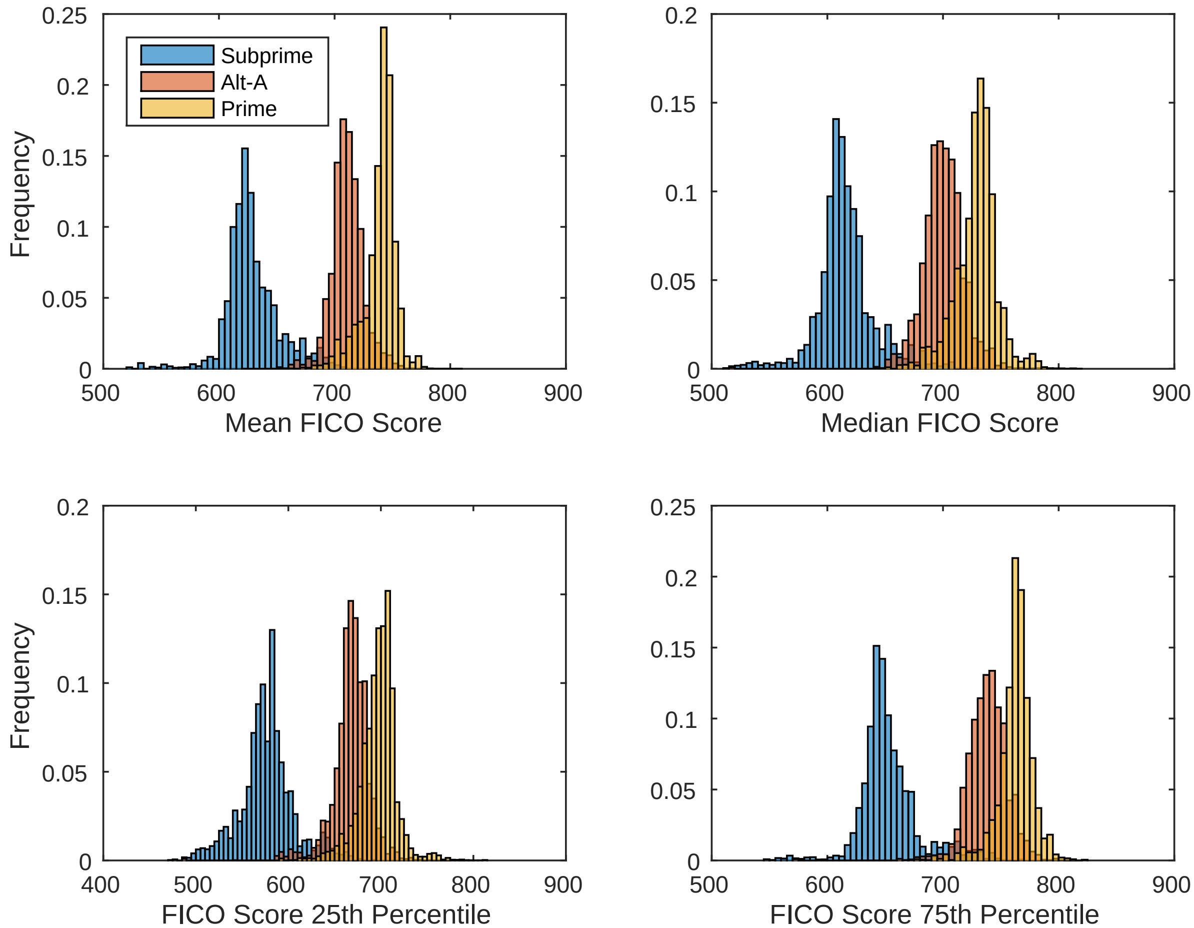
A Data Base Construction

This section provide some typical examples of deals and the data base construction. Figure 15 replicates a few lines from the Mortgage Market Statistical Annual 2013.

Armed with the security name, we download the flow of payments and losses from Bloomberg. There, we obtain the information shown in figure 16.

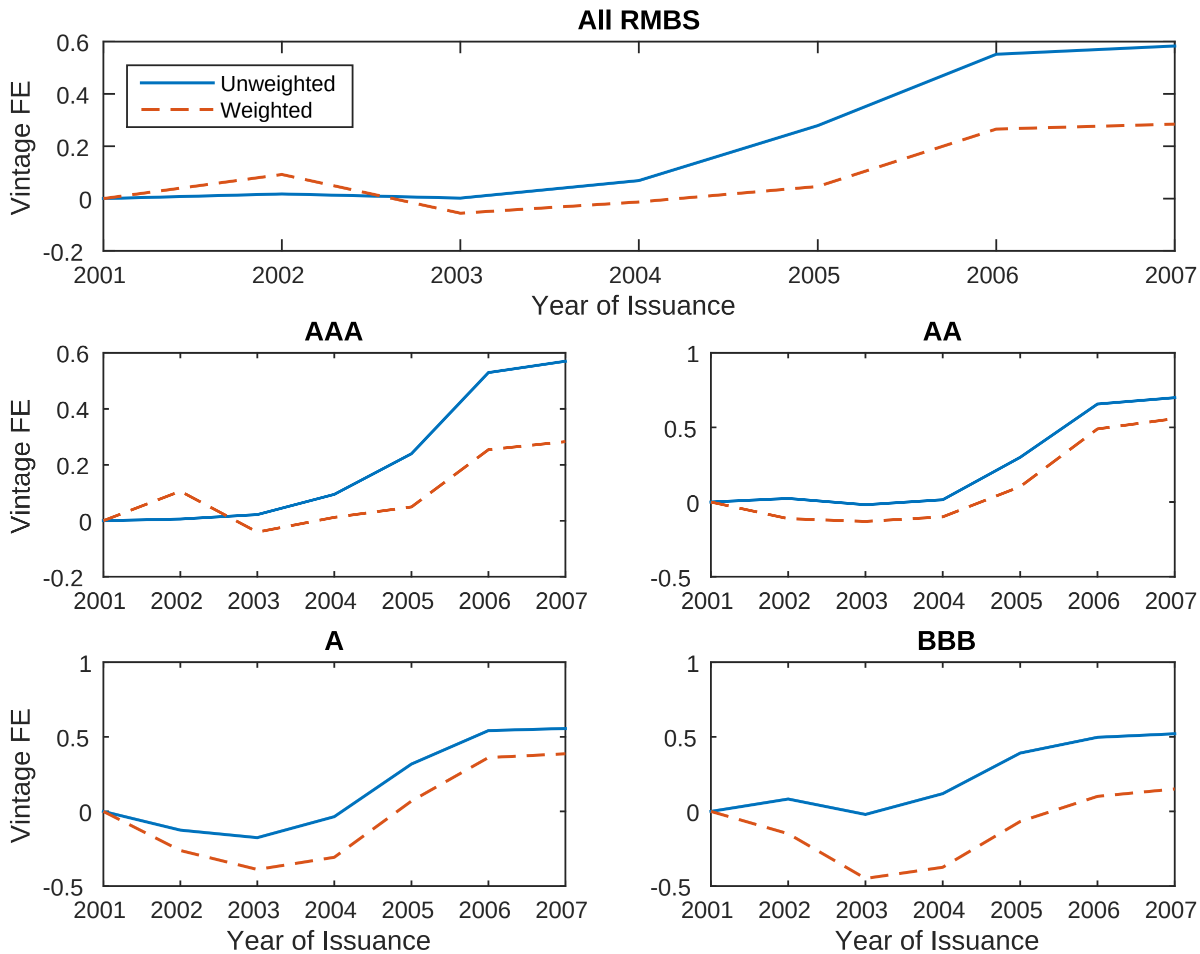
B Appendix Figures

Figure A1: **Distribution of FICO Scores by Type of Mortgage**



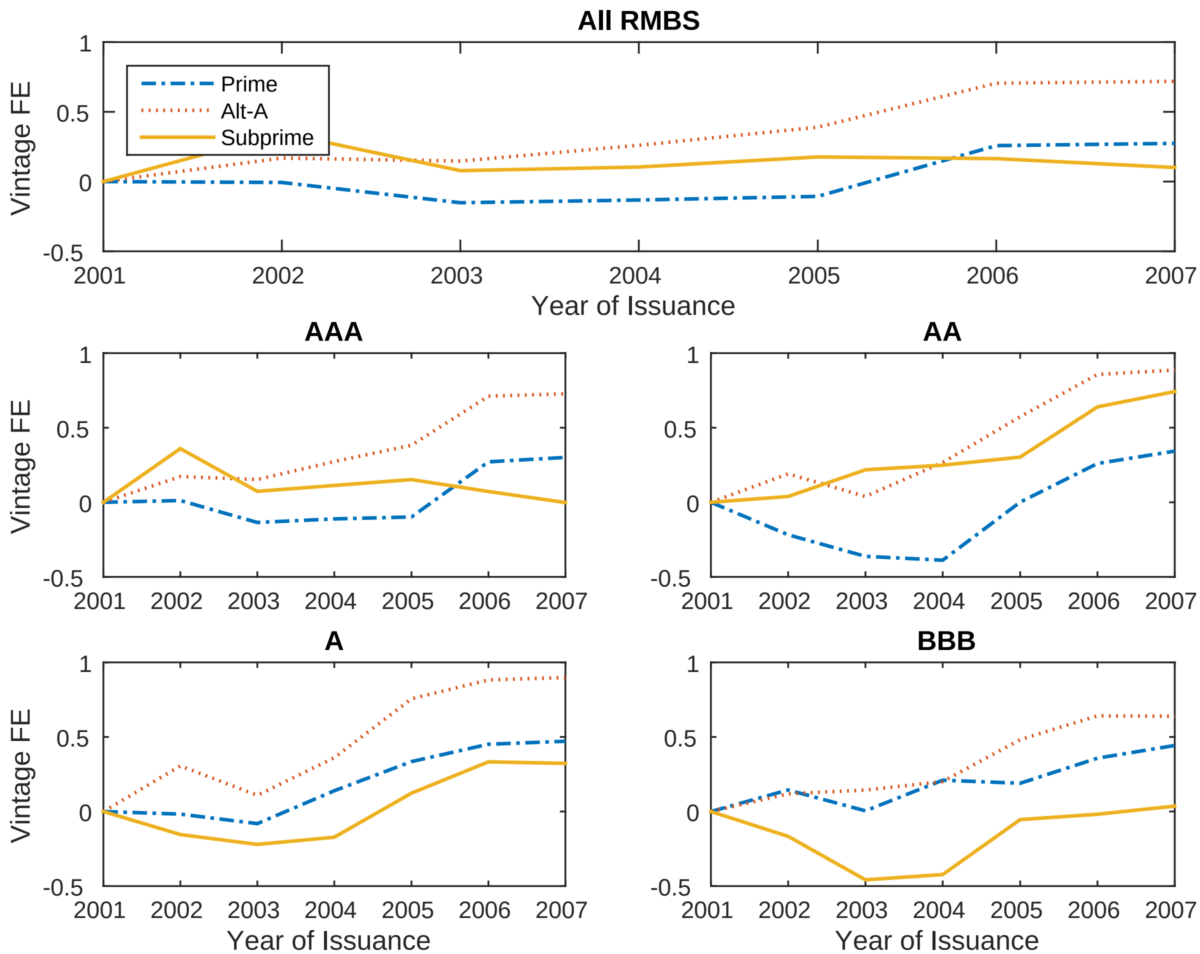
This figure plots histograms for different moments of the distribution of FICO Scores of the mortgage loans underlying the Residential Mortgage Backed Securities in our database. These moments correspond to the value-weighted average, the median, 25th and 75th percentiles of FICO scores upon issuance of the MBS. The corresponding Bloomberg fields are MTG_WAOCS, MTG_QRT_SCORE_MED, MTG_QRT_SCORE_25, and MTG_QRT_SCORE_75. The histograms are shown by type of mortgage loan (Prime, Alt-A, and Subprime) according to the classification provided by the Mortgage Market Statistical Annual 2013 Edition. Only securities issued in the period 2006-2012 are included.

Figure A2: **Vintage Fixed Effects on Probability of Loss**



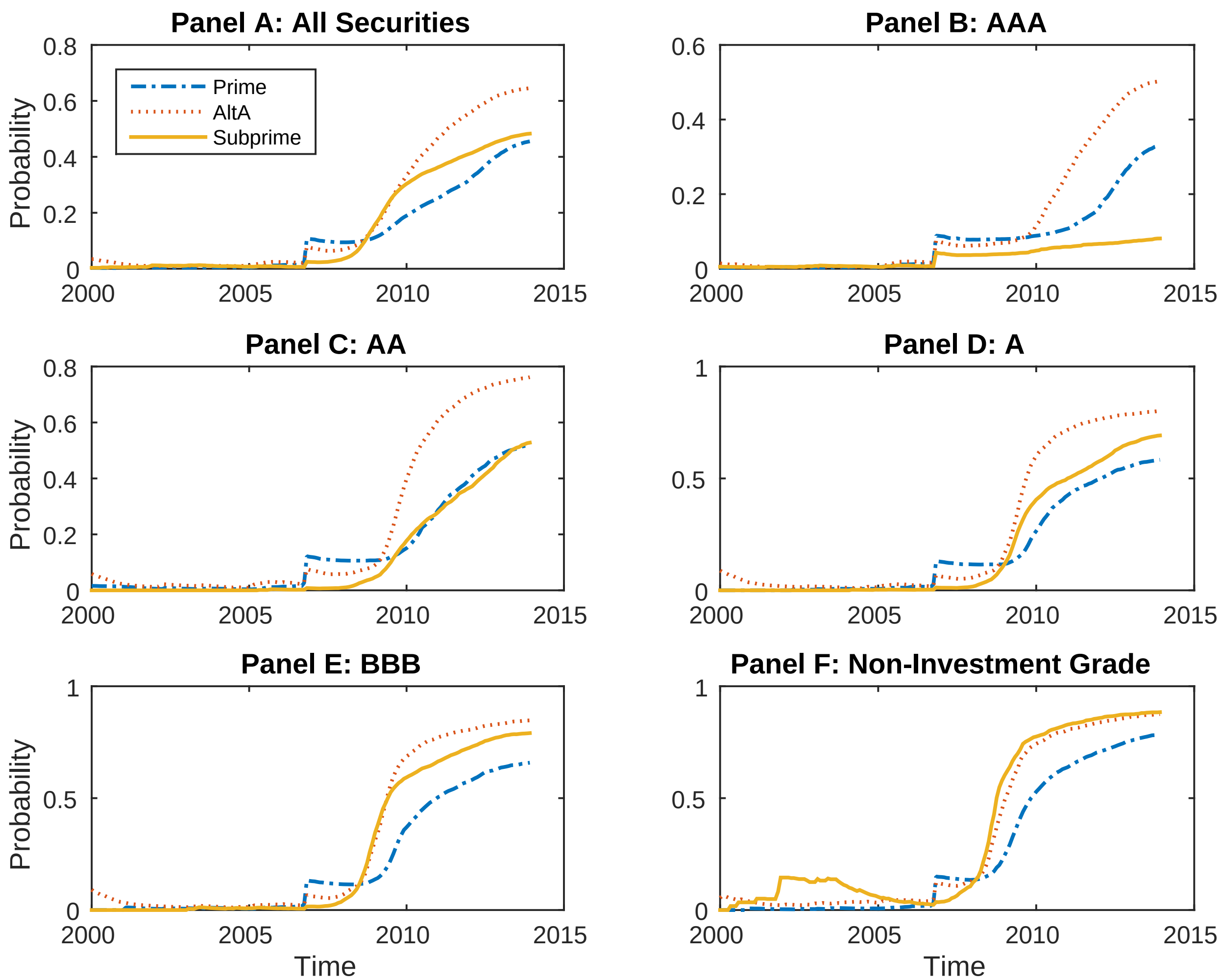
This figure plots the coefficient estimates corresponding to issue year (vintage) dummy variables in linear regressions that have as left hand side variable a dummy variable that takes the value one if the cumulative losses as of December 2013 are strictly greater than zero, and takes the value zero otherwise. The right hand side have all the covariates available in our database as controls, including issue year dummies. The solid line corresponds to the point estimate in non-weighted regressions and the dashed line to the point estimates in principal-weighted regressions. The coefficients are measured with respect to year 2001, whose coefficient is normalized to zero. The top panel shows the results including all credit ratings. The bottom four panels present the results for regressions for each credit rating. The LHS of the regression is computed by accumulating the time series of losses for each MBS (Bloomberg field HIST_LOSSES) up to December 2013 and assigning the value one to those securities with strictly positive losses.The credit rating is based on the credit ratings assigned upon issuance of the security (for example, for the rating by Moody's we use the Bloomberg field RTG_MDY_INITIAL). The calculations include all the bonds issued since 1987. We exclude all the MBS bonds for which the original principal amount is only a reference or that can distort our computations. The excluded bonds include bonds with zero original balance, excess tranches, interest-only bonds, and Net Interest Margin deals (NIM).

Figure A3: **Vintage Fixed Effects on Weighted Probability of Loss by Type of Mortgage Loan**



This figure plots the coefficient estimates corresponding to issue year (vintage) dummy variables in linear regressions that have as left hand side variable a dummy variable that takes the value one if the cumulative losses as of December 2013 are strictly greater than zero, and takes the value zero otherwise. The right hand side have all the covariates available in our database as controls, including issue year dummies. Each panel shows the coefficients for regressions run separately for different categories of mortgage loan. Each MBS is assigned to one of three categories (Prime, Alt-A, and Subprime) based on different moments of the distribution of FICO scores of the underlying mortgage loans using the classification of bonds issued after 2005 by the Mortgage Market Statistical Annual Edition 2013. See figures 1 and A1 to understand the basis of the classification. The regressions are weighted by the original principal amount and the coefficients are measured with respect to year 2001, whose coefficient is normalized to zero. Year 2001 was the earliest year for which we could estimate a coefficient for the three types. The top panel shows the results including all credit ratings. The bottom four panels present the results for regressions for each credit rating.The LHS of the regression is computed by accumulating the time series of losses for each MBS (Bloomberg field HIST_LOSSES) up to December 2013 and assigning the value one to those securities with strictly positive losses. The credit rating is based on the credit ratings assigned upon issuance of the security (for example, for the rating by Moody's we use the Bloomberg field RTG_MDY_INITIAL). The calculations include all the bonds issued from 1987 through 2012. We exclude all the MBS bonds for which the original principal amount is only a reference or that can distort our computations. The excluded bonds include bonds with zero original balance, excess tranches, interest-only bonds, and Net Interest Margin deals (NIM).

Figure A4: **Non-weighted Probability of Loss Over Time by Type of Mortgage and by Credit Rating**



This figure plots the fraction of securities that incurred losses for all Residential Mortgage Backed Securities in our database during the period 2000-2013 by credit rating and by type of mortgage loan. Each bond is assigned to one of three categories (Prime, Alt-A, and Subprime) based on different moments of the distribution of FICO scores of the underlying mortgage loans using the classification of bonds issued after 2005 by the Mortgage Market Statistical Annual Edition 2013. See figures 1 and A1 to understand the basis of the classification.. Each panel shows the calculations by different credit ratings or groups of ratings for the three categories. Both the principal amount and the ratings refer to their values upon issuance of the security. At every point in time, all securities that have been issued at that point in time or before enter the calculations. The calculations include all the bonds issued from 1987 through 2008 as long as they had a credit rating available, but we only plot the results starting in year 2000. We exclude all the MBS bonds for which the original principal amount is only a reference or that can distort our computations. The excluded bonds include bonds with zero original balance, excess tranches, interest-only bonds, and Net Interest Margin deals (NIM). We also exclude all bonds that have no positive cash-flow information (principal, interest, and losses all equal to zero), those that have no credit rating assigned (either because it was missing or because it was not rated), and those issued in 2013 or later.

Figure A5: **Moodys Idealized Cumulative Expected Loss Rates**

	Year									
Rating	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Aaa	0.000028%	0.000110%	0.000390%	0.000990%	0.001600%	0.002200%	0.002860%	0.003630%	0.004510%	0.005500%
Aa1	0.000314%	0.001650%	0.005500%	0.011550%	0.017050%	0.023100%	0.029700%	0.036850%	0.045100%	0.055000%
Aa2	0.000748%	0.004400%	0.014300%	0.025850%	0.037400%	0.048950%	0.061050%	0.074250%	0.090200%	0.110000%
Aa3	0.001661%	0.010450%	0.032450%	0.055500%	0.078100%	0.100650%	0.124850%	0.149600%	0.179850%	0.220000%
A1	0.003196%	0.020350%	0.064350%	0.103950%	0.143550%	0.181500%	0.223300%	0.264000%	0.315150%	0.385000%
A2	0.005979%	0.038500%	0.122100%	0.189750%	0.256850%	0.320650%	0.390500%	0.455950%	0.540100%	0.660000%
A3	0.021368%	0.082500%	0.198000%	0.297000%	0.401500%	0.500500%	0.610500%	0.715000%	0.836000%	0.990000%
Baa1	0.049500%	0.154000%	0.308000%	0.456500%	0.605000%	0.753500%	0.918500%	1.083500%	1.248500%	1.430000%
Baa2	0.093500%	0.258500%	0.456500%	0.660000%	0.869000%	1.083500%	1.325500%	1.567500%	1.782000%	1.980000%
Baa3	0.231000%	0.577500%	0.940500%	1.309000%	1.677500%	2.035000%	2.381500%	2.733500%	3.063500%	3.355000%
Ba1	0.478500%	1.111000%	1.721500%	2.310000%	2.904000%	3.437500%	3.883000%	4.339500%	4.779500%	5.170000%
Ba2	0.858000%	1.908500%	2.849000%	3.740000%	4.625500%	5.373500%	5.885000%	6.413000%	6.957500%	7.425000%
Ba3	1.545500%	3.030500%	4.328500%	5.384500%	6.523000%	7.419500%	8.041000%	8.640500%	9.190500%	9.713000%
B1	2.574000%	4.609000%	6.369000%	7.617500%	8.866000%	9.839500%	10.521500%	11.126500%	11.682000%	12.210000%
B2	3.938000%	6.418500%	8.552500%	9.971500%	11.390500%	12.457500%	13.205500%	13.832500%	14.421000%	14.960000%
B3	6.391000%	9.135500%	11.566500%	13.222000%	14.877500%	16.060000%	17.050000%	17.919000%	18.579000%	19.195000%
Caa	14.300000%	17.875000%	21.450000%	24.134000%	26.812500%	28.600000%	30.387500%	32.175000%	33.962500%	35.750000%

This figure presents a table that relates credit ratings with the loss rates (loss as fraction of principal) that asset backed securities would be expected to have. The table was used up to the crisis as a reference and it was produced by Moody's. Importantly, Moody's would use this table as part of the risk and valuation analysis, but not as summary statistic that would completely determine its rating. The table is available here `https://www.moodys.com/sites/products/productattachments/marvel_user_guide1.pdf`

C Appendix Tables

Table A1: **Unweighted Losses in RMBS and Credit Ratings**

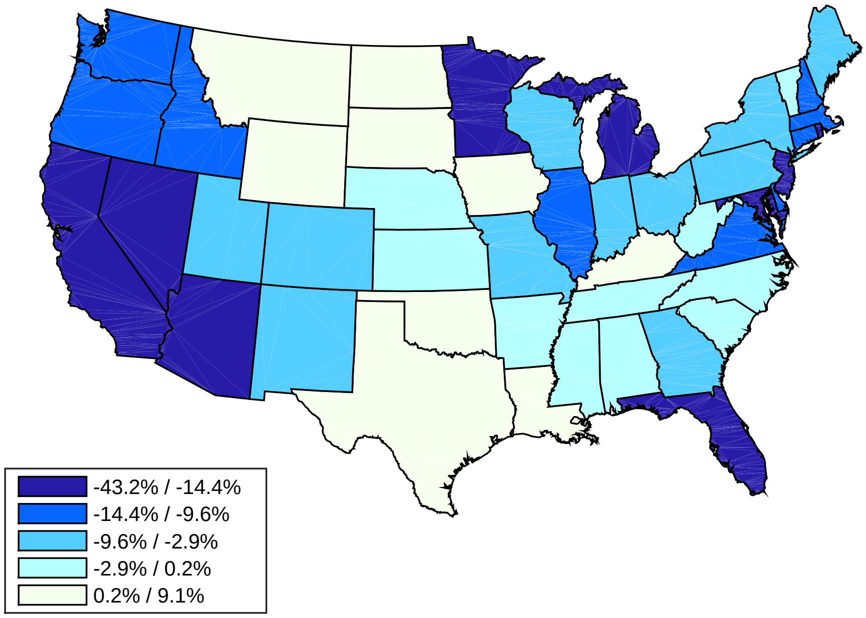
This table shows regressions of the cumulative loss as fraction of initial principal as of December 2013 on credit rating dummy variables. The first column shows the results for all securities issued from 1987 through 2008. The next 3 columns split the sample by year of issuance into three periods. In these regressions we only include bonds that have a rating. In this way the constant of the regression corresponds to AAA securities, and we have renamed the constant as AAA. To interpret correctly the other coefficients, one must take into account the constant. In the calculations we exclude all the MBS bonds for which the original principal amount is only a reference or can distort our computations. The excluded bonds include bonds with zero original balance, excess tranches, interest-only bonds, and Net Interest Margin deals (NIM). The LHS of the regression is computed by accumulating the time series of losses for each MBS (Bloomberg field HIST_LOSSES) and dividing it by the original principal balance (Bloomberg field MTG_ORIG_AMT). The RHS of the regression is based on the credit ratings assigned upon issuance of the security (for example, for the rating by Moody's we use the Bloomberg field RTG_MDY_INITIAL).

Credit Rating	Full Sample	Before 2003	2003 - 2005	2006-2008
AAA	0.0436***	0.0004	0.0100***	0.1096***
	(0.0015)	(0.0007)	(0.0020)	(0.0020)
AA	0.3628***	0.0019	0.1466***	0.6562***
	(0.0034)	(0.0019)	(0.0045)	(0.0041)
A	0.4564***	0.0117***	0.2690***	0.7823***
	(0.0035)	(0.0019)	(0.0046)	(0.0043)
BBB	0.5162***	0.0315***	0.3885***	0.7998***
	(0.0034)	(0.0020)	(0.0043)	(0.0043)
BB	0.5510***	0.0484***	0.5375***	0.7635***
	(0.0047)	(0.0026)	(0.0058)	(0.0060)
B	0.5487***	0.0836***	0.6176***	0.7926***
	(0.0058)	(0.0027)	(0.0071)	(0.0083)
CCC	0.6340***	0.4353***	0.4661***	0.8582***
	(0.0482)	(0.0372)	(0.0575)	(0.0597)
CC	0.2837***	0.1335**	0.104	0.6020***
	(0.0810)	(0.0526)	(0.0938)	(0.1089)
C or Below	0.4670***	0.2478***	0.7173***	0.3846***
	(0.0522)	(0.0526)	(0.1259)	(0.0458)
Observations	93,902	19,230	38,381	36,291
R-squared	0.3374	0.0748	0.3396	0.666

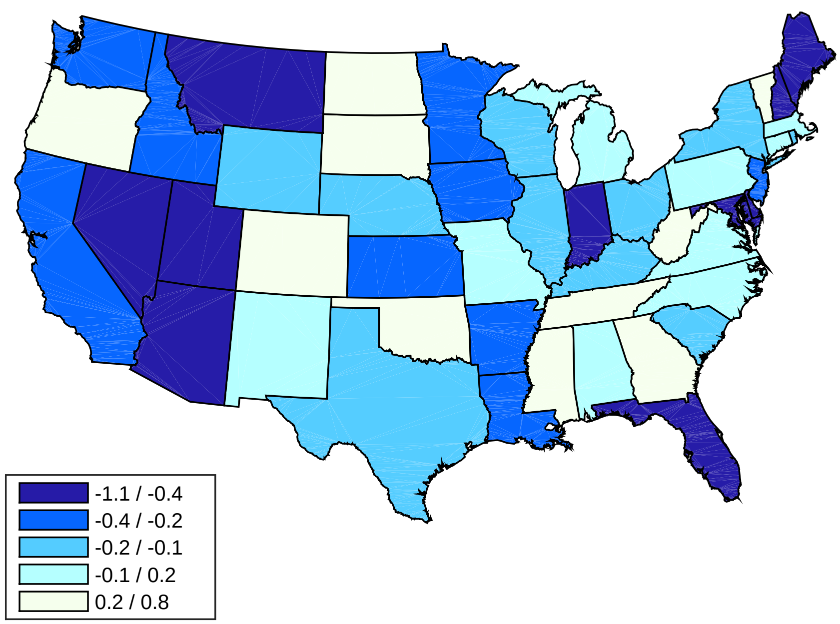
Standard errors in parentheses
$*p < 0.10, **p < 0.05, ***p < 0.01$

Figure A6: **House Price Bust and State-Level Dummies on Loss Rates**

Panel A. Bust: 2006-Q4 to 2009-Q4



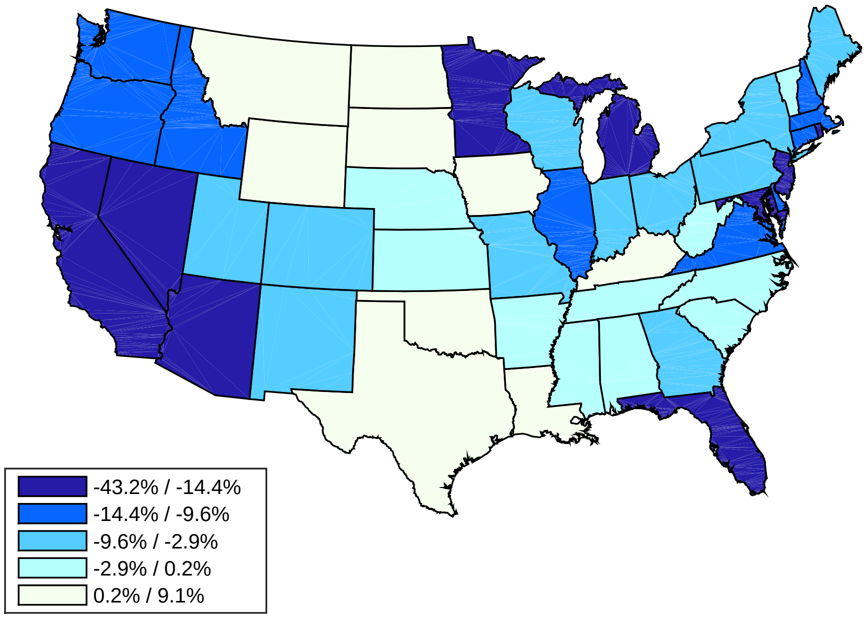
Panel B. Dummy Coefficients Regression without Controls



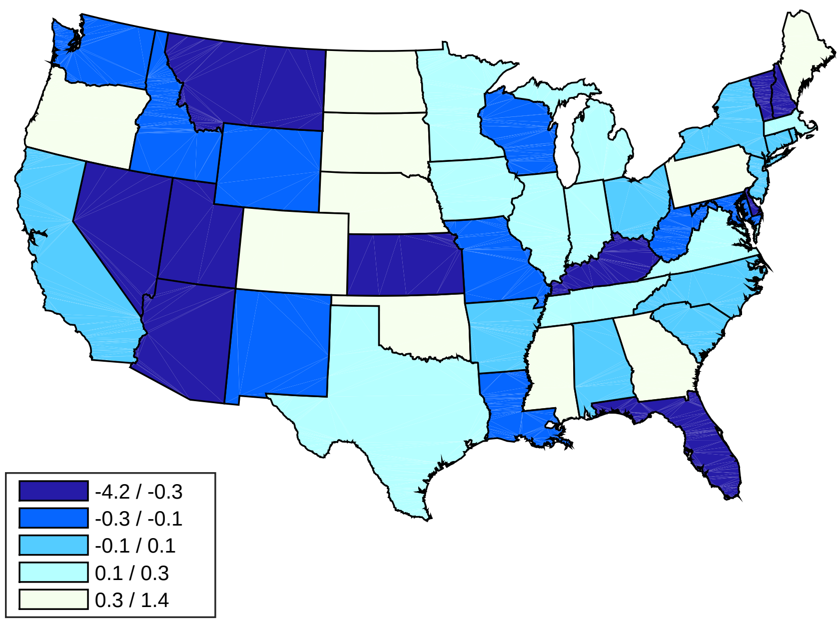
The map at the top colors states according to the quintiles of house price change between the fourth quarter of 2006 and the fourth quarter of 2009. Darker colors represent states with bigger house price declines. The map at the bottom colors states according to the coefficients on state-level dummy variables weighted by the concentration of mortgages of a given state in a given MBS from a regression of loss rates (cumulative loss as of December 2013 divided by original principal amount) on only the state dummy variables. The coefficients of the dummy variables are then colored by quintiles. Darker colors represent larger coefficients. The house price data comes from the Federal Housing Agency and corresponds to the State-Level All-transaction indexes available here `http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index-Datasets.aspx#qexe`.

Figure A7: **House Price Bust and State-Level Dummies on Loss Rates**

Panel A. Bust: 2006-Q4 to 2009-Q4



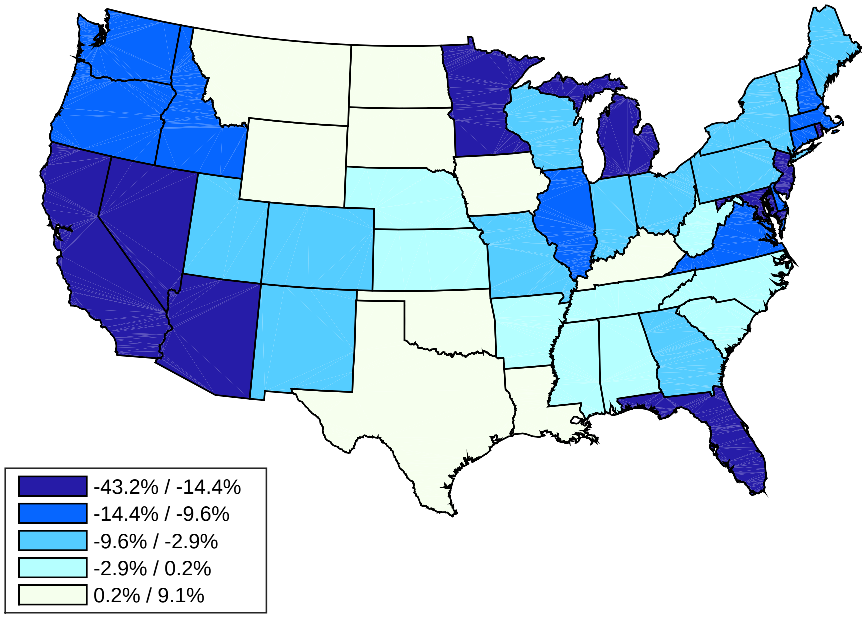
Panel B. Dummy Coefficients Regression with Controls



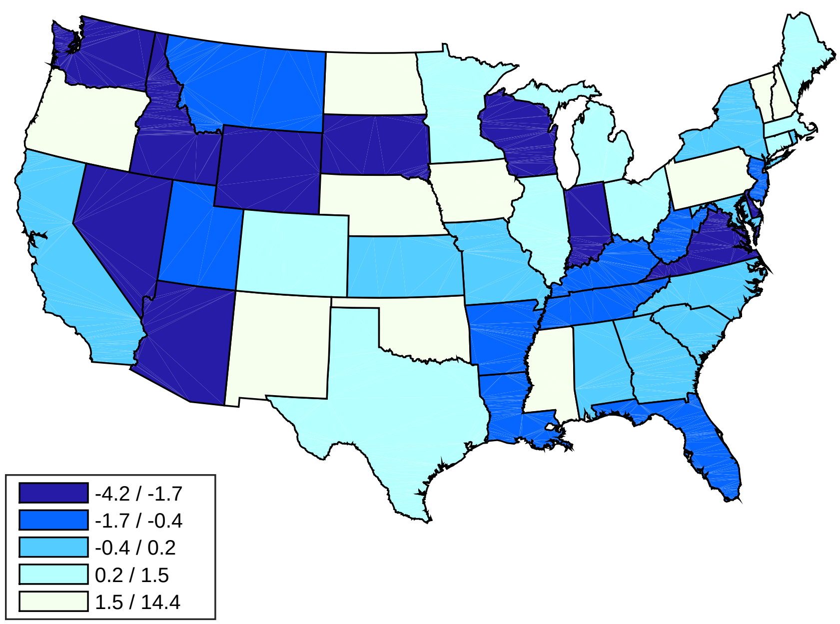
The map at the top colors states according to the quintiles of house price change between the fourth quarter of 2006 and the fourth quarter of 2009. Darker colors represent states with bigger house price declines. The map at the bottom colors states according to the coefficients on state-level dummy variables weighted by the concentration of mortgages of a given state in a given MBS from a regression of loss rates (cumulative loss as of December 2013 divided by original principal amount) on state dummy variables, dummy variables representing credit ratings and dummy variables for Prime, Alt-A, Subprime to control for FICO score. The coefficients of the dummy variables are then colored by quintiles. Darker colors represent larger coefficients. The house price data comes from the Federal Housing Agency and corresponds to the State-Level All-transaction indexes available here `http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index-Datasets.aspx#qexe`.

Figure A8: **House Price Bust and State-Level Dummies on Probability of Loss**

Panel A. Bust: 2006-Q4 to 2009-Q4



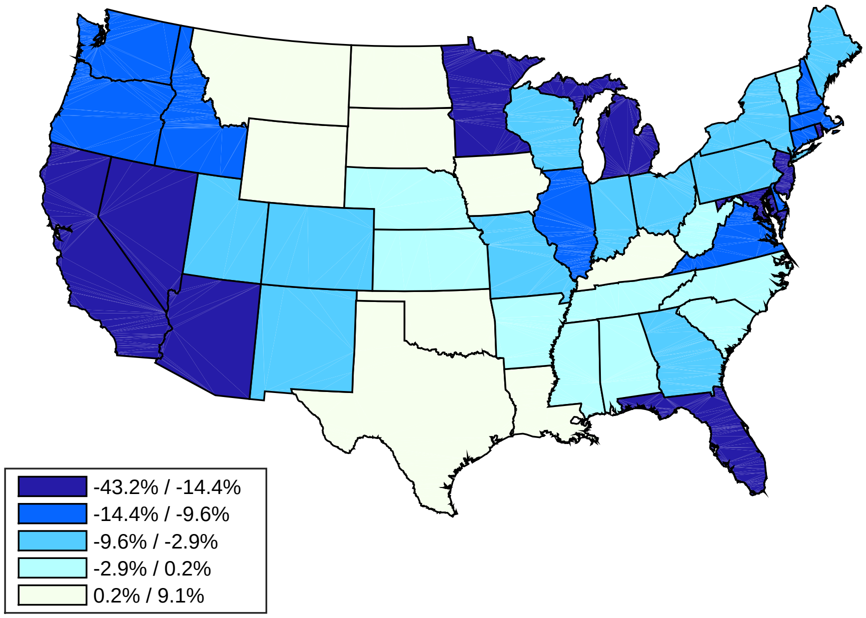
Panel B. Dummy Coefficients Regression without Controls



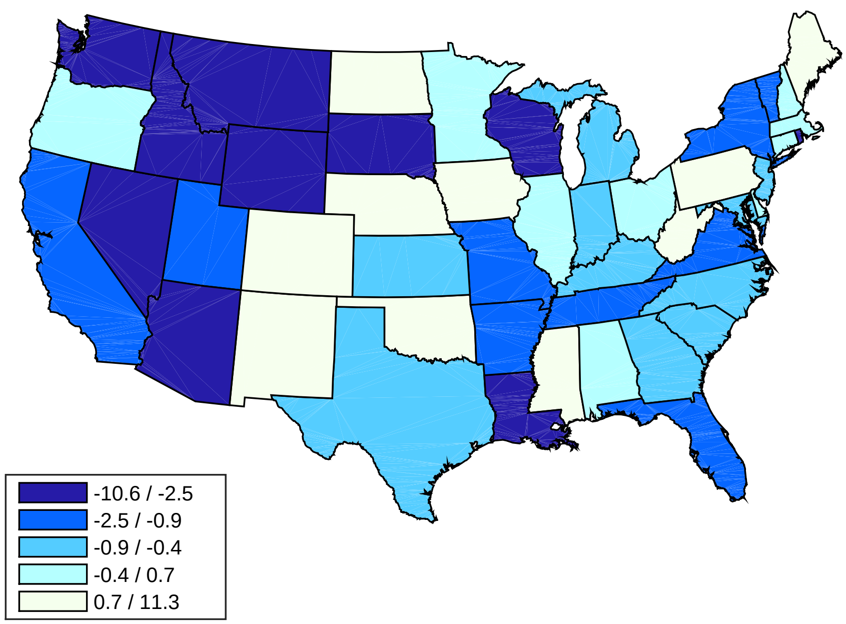
The map at the top colors states according to the quintiles of house price change between the fourth quarter of 2006 and the fourth quarter of 2009. Darker colors represent states with bigger house price declines. The map at the bottom colors states according to the coefficients on state-level dummy variables weighted by the concentration of mortgages of a given state in a given MBS from a regression of a dummy variable that takes the value 1 if the cumulative loss of a security was larger than zero (and zero otherwise) on only the state dummy variables. The coefficients of the dummy variables are then colored by quintiles. Darker colors represent larger coefficients. The house price data comes from the Federal Housing Agency and corresponds to the State-Level All-transaction indexes available here `http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index-Datasets.aspx#qexe`.

Figure A9: **House Price Bust and State-Level Dummies on Probability of Loss**

Panel A. Bust: 2006-Q4 to 2009-Q4



Panel B. Dummy Coefficients Regression with Controls



The map at the top colors states according to the quintiles of house price change between the fourth quarter of 2006 and the fourth quarter of 2009. Darker colors represent states with bigger house price declines. The map at the bottom colors states according to the coefficients on state-level dummy variables weighted by the concentration of mortgages of a given state in a given MBS from a regression of of a dummy variable that takes the value 1 if the cumulative loss of a security was larger than zero (and zero otherwise) on state dummy variables, dummy variables representing credit ratings and dummy variables for Prime, Alt-A, Subprime to control for FICO score. The coefficients of the dummy variables are then colored by quintiles. Darker colors represent larger coefficients. The house price data comes from the Federal Housing Agency and corresponds to the State-Level All-transaction indexes available here `http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index-Datasets.aspx#qexe`.

Table A2: **Principal-Weighted Probability of Loss in RMBS and Credit Ratings**

This table presents linear regressions to study the relation between the probability of incurring losses and credit ratings. The regressions are weighted by the principal dollar amount upon issuance of each RMBS. The LHS in the regression is a dummy variable that takes the value one if the cumulative losses as of December 2013 are strictly greater than zero, and takes the value zero otherwise. The RHS of the regression includes a constant and credit rating dummy variables. In these regressions we only include bonds that have a rating. In this way the constant of the regression corresponds to AAA securities, and we have renamed the constant as AAA. To interpret correctly the other coefficients, one must take into account the constant. The first column shows the results for all securities issued from 1987 through 2008. The next 3 columns split the sample by year of issuance into three periods. In the calculations we exclude all the MBS bonds for which the original principal amount is only a reference or can distort our computations. The excluded bonds include bonds with zero original balance, excess tranches, interest-only bonds, and Net Interest Margin deals (NIM). The LHS of the regression is computed by accumulating the time series of losses for each MBS (Bloomberg field HIST_LOSSES) and assigning the value one to those securities with strictly positive losses. The RHS of the regression is based on the credit ratings assigned upon issuance of the security (for example, for the rating by Moody's we use the Bloomberg field RTG_MDY_INITIAL).

Credit Rating	**Full Sample**	**Before 2003**	**2003 - 2005**	**2006-2008**
AAA	0.2747***	0.0639***	0.1667***	0.4636***
	(0.0016)	(0.0019)	(0.0021)	(0.0028)
AA	0.1603***	0.0207*	0.1010***	0.1667***
	(0.0066)	(0.0107)	(0.0088)	(0.0106)
A	0.2073***	0.0178	0.1472***	0.3351***
	(0.0087)	(0.0111)	(0.0114)	(0.0155)
BBB	0.3177***	0.1690***	0.3168***	0.3136***
	(0.0104)	(0.0170)	(0.0131)	(0.0179)
BB	0.5943***	0.2203***	0.6514***	0.4819***
	(0.0169)	(0.0389)	(0.0238)	(0.0253)
B	0.5885***	0.2264***	0.7656***	0.4303***
	(0.0308)	(0.0560)	(0.0466)	(0.0452)
CCC	0.5822**	0.9361	0.4627	0.5364
	(0.2272)	(0.7475)	(0.3134)	(0.3381)
CC	0.6340***	0.4459	-0.0239	0.5364***
	(0.1472)	(1.2919)	(0.3900)	(0.1785)
C or Below	0.7176***	0.0696	0.8333	0.5364***
	(0.0589)	(0.3045)	(0.5286)	(0.0681)
Observations	93,902	19,230	38,381	36,291
R-squared	0.0370	0.0079	0.0451	0.0376

Standard errors in parentheses
$*p < 0.10, **p < 0.05, ***p < 0.01$

Table A3: **House Prices and Probability of Loss**

This table presents regressions to study the relation between the probability of incurring losses and changes in house prices. The LHS in the regression is a dummy variable that takes the value one if the cumulative losses as of December 2013 are strictly greater than zero, and takes the value zero otherwise. We show 8 regression specifications, all of them weighted by original principal amount. The variables on the RHS include the variables ΔHP 2000-2006 and ΔHP 2006-2009 which is the appreciation of house prices in the five states that make up most of the underlying mortgages between 2000 and 2006 and between 2006 and 2009. They also include a measure of the reversal of prices between 2006 and 2009 with respect to the boom period from 2000 through 2006. Other regressors include credit rating dummies with AAA being the omitted group and dummies fro Subprime and Alt-A with Prime being the omitted group to control for FICO score. The state dummy variables are weighted by the importance of the state in terms of the principal amount of mortgages that come from the state. We include the same bonds as in the other tables of the paper.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔHP 2000-2006	0.338***		-0.510***		-0.376***	-0.551***		
	0.007		0.022		0.030	0.069		
ΔHP 2006-2009		-0.0834***	-1.828***		-1.288***	-1.320***		
		0.014	0.045		0.052	0.155		
Price Reversal				-0.816***				
				0.015				
AA					0.318***	0.310***	0.309***	0.321***
					0.008	0.008	0.008	0.008
A					0.394***	0.382***	0.379***	0.39***
					0.010	0.010	0.010	0.010
BBB					0.45***	0.439***	0.437***	0.452***
					0.012	0.012	0.012	0.012
BB					0.601***	0.575***	0.573***	0.605***
					0.018	0.017	0.017	0.018
B					0.502***	0.486***	0.483***	0.519***
					0.032	0.032	0.032	0.033
CCC					0.633***	0.596***	0.597***	0.629***
					0.224	0.217	0.218	0.225
CC					0.317	0.252	0.263	0.354***
					0.227	0.221	0.221	0.228
C or Below					0.458***	0.397***	0.393***	0.52***
					0.058	0.057	0.057	0.058
Subprime					-0.255***	-0.282***	-0.282***	-0.261
					0.004	0.005	0.005	0.004
Alt-A					0.095***	0.051***	0.051***	0.12***
					0.004	0.004	0.004	0.004
Contstant	0.062***	0.038***	0.084***	-0.326***	0.217***	0.454***	0.475***	0.363***
	0.005	0.005	0.005	0.012	0.013	0.017	0.011	0.003
State Dummies	No	No	No	No	No	Yes	Yes	No
Weighted Dummies	No	No	No	No	No	Yes	Yes	No
Observations	93,902	93,902	93,902	93,902	71,316	71,316	71,316	71,316
R-squared	0.0257	0.0372	0.0428	0.0317	0.1634	0.2086	0.2078	0.1524
Weighted Regression	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
$*p < 0.10, **p < 0.05, ***p < 0.01$

Table A4: **Return Calculations From Issuance to 2013 by Credit Rating**

This table presents Internal Rate of Return (IRR) calculations for the RMBS in our database by credit rating. The IRR solves equation 4. Here we report annualized rates. We present the computation under different assumptions about the terminal value of each security as of December 2013. The first 3 columns assume that the security is sold at 80%, 90% and 100% of the outstanding principal amount in December 2013 respectively. The fourth column assumes that the loss in the terminal value is equal to the loss as a fraction of principal suffered by the security up to that point. The fifth and sixth columns assume that the loss in the terminal value is equal to the mean and the median of the losses as a fraction of principal suffered by all securities with the same rating and the same vintage (issue year). Panel A shows the principal value weighted mean and weighted median return for different groups of MBS based on their credit rating upon issuance. Panel B shows unweighted mean and median return for the same groups of securities. The cash flow information is monthly from Bloomberg's field HIST_CASH_FLOW and includes both interest and principal payments. The terminal value is based on the outstanding principal balance as of December 2013 which is also available in the same Bloomberg field.

	Terminal Value Assumption					
Return Statistic	**80% TV**	**90% TV**	**100% TV**	**Same Loss**	**Mean Loss**	**Median Loss**
Panel A: Principal Value - Weighted						
AAA-Rated						
Mean	1.3	1.6	2.0	1.9	2.0	1.8
Median	3.1	3.5	3.7	3.7	3.7	3.7
Std. Dev.	20.2	20.1	20.1	20.1	20.1	20.1
AA-Rated						
Mean	-1.6	-1.6	-1.6	-1.6	-1.8	-1.7
Median	-0.2	1.2	2.4	2.4	-0.3	-0.4
Std. Dev.	52.2	52.5	52.7	52.6	52.0	51.9
A-Rated						
Mean	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Median	0.3	1.5	2.6	2.6	-2.5	-3.0
Std. Dev.	52.2	52.5	52.7	52.6	52.0	51.9
BBB-Rated						
Mean	-1.0	-1.0	-1.0	-1.0	-1.1	-1.0
Median	-5.3	-5.1	-4.9	-5.7	-17.8	-9.8
Std. Dev.	66.8	67.0	67.1	67.1	65.6	66.2
Panel B: Unweighted						
AAA-Rated						
Mean	-0.7	-0.5	-0.2	-0.3	-0.2	-0.3
Median	3.6	4.1	4.4	4.3	4.4	4.3
Std. Dev.	34.7	34.7	34.7	34.8	34.7	34.7
AA-Rated						
Mean	-5.4	-5.4	-5.3	-5.4	-5.7	-5.5
Median	-1.4	0.1	1.3	0.4	-7.1	-7.8
Std. Dev.	58.0	58.3	58.5	58.4	57.7	57.8
A-Rated						
Mean	-7.1	-7.1	-7.0	-7.1	-7.2	-7.2
Median	-24.2	-24.1	-23.9	-25.2	-32.3	-25.3
Std. Dev.	58.0	58.3	58.5	58.4	57.7	57.8
BBB-Rated						
Mean	-8.5	-8.4	-8.4	-8.4	-8.7	-8.5
Median	-40.1	-40.1	-40.1	-40.2	-43.1	-40.2
Std. Dev.	69.7	69.8	69.9	69.8	69.2	69.3

Table A5: **Principal Value Weighted Return Calculations by Vintage**

This table presents Internal Rate of Return (IRR) calculations for the RMBS in our database by vintage (year of issuance). The IRR solves equation 4. Here we report annualized rates. We present the computation under different assumptions about the terminal value of each security as of December 2013. The first 3 columns assume that the security is sold at 80%, 90% and 100% of the outstanding principal amount as of December 2013 respectively. The fourth column assumes that the loss in the terminal value is equal to the loss as a fraction of principal suffered by the security up to that point. The fifth and sixth columns assume that the loss in the terminal value is equal to the mean and the median of the losses as a fraction of principal suffered by all securities with the same rating and the same vintage (issue year). In this table we present principal value weighted return summary statistics for different vintages. The cash flow information is monthly from Bloomberg using the field HIST_CASH_FLOW and includes both interest and principal payments. The terminal value is based on the outstanding principal balance as of December 2013, which is also available in the same Bloomberg field.

	Terminal Value Assumption					
Return Statistic	**80% TV**	**90% TV**	**100% TV**	**Same Loss**	**Mean Loss**	**Median Loss**
Vintage 2000						
Mean	0.0	0.0	0.0	0.0	0.0	0.0
Median	5.1	5.1	5.1	5.1	5.1	5.1
Std. Dev.	22.1	22.1	22.1	22.1	22.1	22.1
Vintage 2001						
Mean	0.1	0.1	0.1	0.1	0.1	0.1
Median	5.4	5.4	5.4	5.4	5.4	5.4
Std. Dev.	19.8	19.8	19.7	19.7	19.7	19.7
Vintage 2002						
Mean	0.1	0.1	0.1	0.1	0.1	0.1
Median	3.9	3.9	3.9	3.9	3.9	3.9
Std. Dev.	21.5	21.5	21.5	21.5	21.5	21.5
Vintage 2003						
Mean	0.2	0.2	0.2	0.2	0.2	0.2
Median	3.4	3.6	3.7	3.7	3.7	3.7
Std. Dev.	10.6	10.7	10.7	10.7	10.7	10.7
Vintage 2004						
Mean	0.3	0.3	0.3	0.3	0.3	0.3
Median	3.2	3.3	3.5	3.5	3.5	3.5
Std. Dev.	17.1	17.1	17.2	17.2	17.2	17.2
Vintage 2005						
Mean	0.1	0.2	0.2	0.2	0.2	0.2
Median	3.4	3.8	4.0	4.0	4.0	4.0
Std. Dev.	16.7	16.6	16.5	16.6	16.5	16.5
Vintage 2006						
Mean	-1.9	-1.8	-1.7	-1.8	-1.9	-1.8
Median	1.6	2.2	2.8	2.7	2.8	2.5
Std. Dev.	33.8	33.9	34.0	34.0	34.6	34.0
Vintage 2007						
Mean	-1.3	-1.2	-1.1	-1.1	-1.2	-1.2
Median	1.3	1.9	2.5	2.4	2.3	2.0
Std. Dev.	39.9	40.0	40.2	40.2	40.2	40.1

Table A6: **Return Calculations From Issuance to 2013 by Type of Mortgage Loan**

This table presents Internal Rate of Return (IRR) calculations for the RMBS in our database by type of mortgage loan. The IRR solves equation 4. Here we report annualized rates. We present the computation under different assumptions about the terminal value of each security as of December 2013. The first 3 columns assume that the security is sold at 80%, 90% and 100% of the outstanding principal amount as of December 2013 respectively. The fourth column assumes that the loss in the terminal value is equal to the loss as a fraction of principal suffered by the security up to that point. The fifth and sixth columns assume that the loss in the terminal value is equal to the mean and the median of the losses as a fraction of principal suffered by all securities with the same rating and the same vintage (issue year). Panel A shows the principal value weighted return summary statistics for different type of MBS. Panel B shows unweighted return summary statistics for the same types of MBS. Each bond is assigned to one of three categories (Prime, Alt-A, and Subprime) based on different moments of the distribution of FICO scores of the underlying mortgage loans using the classification of bonds issued after 2005 by the Mortgage Market Statistical Annual Edition 2013. See figures 1 and A1 to understand the basis of the classification. The cash flow information is monthly from Bloomberg using the field HIST_CASH_FLOW and includes both interest and principal payments. The terminal value is based on the outstanding principal balance as of December 2013, which is also available in the same Bloomberg field.

	Terminal Value Assumption					
Return Statistic	**80% TV**	**90% TV**	**100% TV**	**Same Loss**	**Mean Loss**	**Median Loss**
Panel A: Principal Value - Weighted						
Subprime						
Mean	-1.9	-1.8	-1.7	-1.7	-2.0	-1.8
Median	1.9	2.2	2.6	2.6	2.5	2.4
Std. Dev.	35.3	35.4	35.5	35.6	36.0	35.5
Alt-A						
Mean	-1.3	-1.2	-1.0	-1.1	-1.0	-1.1
Median	2.3	2.8	3.3	3.1	3.2	3.1
Std. Dev.	35.5	35.6	35.6	35.6	35.7	35.6
Prime						
Mean	0.5	0.6	0.7	0.7	0.7	0.7
Median	4.0	4.4	4.7	4.7	4.7	4.6
Std. Dev.	15.5	15.3	15.2	15.2	15.3	15.2
Panel B: Unweighted						
Subprime						
Mean	-8.5	-8.4	-8.4	-8.4	-9.0	-8.6
Median	-0.8	0.5	1.7	1.7	0.8	-0.9
Std. Dev.	63.9	64.2	64.4	64.3	63.9	63.7
Alt-A						
Mean	-9.8	-9.7	-9.6	-9.7	-9.6	-9.7
Median	0.0	0.9	1.8	1.5	1.6	1.0
Std. Dev.	63.5	63.7	63.8	63.7	63.8	63.7
Prime						
Mean	-2.1	-2.0	-1.9	-1.9	-1.9	-1.9
Median	3.7	4.2	4.6	4.5	4.5	4.5
Std. Dev.	38.0	38.0	38.1	38.1	38.1	38.1

Table A7: **Median Return for AAA RMBS by Vintage, Loan Type and Bond Type**

This table presents Internal Rate of Return (IRR) calculations for the AAA RMBS in our database by type of mortgage loan, vintage, and by type of bond (floating rate or fixed rate). The IRR solves equation 4. Here we report only median annualized rates, and the calculations are all weighting by the original principal amount. We present the computation under different assumptions about the terminal value of each security as of December 2013. The assumptions are that the security is sold at 80%, 90% and 100% of the outstanding principal amount as of December 2013 respectively. The last column reports the daily average 3-month Libor rate between the beginning of each vintage year and December 2013. Each bond is assigned to one of three categories (Prime, Alt-A, and Subprime) based on different moments of the distribution of FICO scores of the underlying mortgage loans using the classification of bonds issued after 2005 by the Mortgage Market Statistical Annual Edition 2013. See figures 1 and A1 to understand the basis of the classification.The cash flow information is monthly from Bloomberg using the field HIST_CASH_FLOW and includes both interest and principal payments. The terminal value is based on the outstanding principal balance as of December 2013, which is also available in the same Bloomberg field.

	Fixed Rate			**Floating Rate**			**3-Month**
Loan Type	**80% TV**	**90% TV**	**100% TV**	**80% TV**	**90% TV**	**100% TV**	**Libor**
Vintage 2000							
Subprime	5.9	5.9	5.9	3.5	3.5	3.5	
Alt-A	6.0	6.0	6.0	4.7	4.7	4.7	2.4
Prime	6.1	6.1	6.1	5.3	5.3	5.3	
Vintage 2001							
Subprime	4.3	4.3	4.3	2.0	2.1	2.1	
Alt-A	6.5	6.5	6.5	5.6	5.6	5.6	2.1
Prime	6.0	6.0	6.0	5.8	5.8	5.8	
Vintage 2002							
Subprime	4.0	4.0	4.0	1.9	1.9	2.0	
Alt-A	6.0	6.0	6.0	3.4	3.4	3.5	2.0
Prime	5.7	5.7	5.7	4.6	4.6	4.6	
Vintage 2003							
Subprime	6.7	6.9	7.0	1.9	2.0	2.0	
Alt-A	5.0	5.2	5.2	3.4	3.6	3.8	2.4
Prime	4.7	4.8	5.0	3.2	3.4	3.6	
Vintage 2004							
Subprime	5.8	5.9	6.3	2.7	2.8	2.9	
Alt-A	5.2	5.2	5.5	3.3	3.5	3.7	2.0
Prime	5.0	5.0	5.2	3.4	3.6	3.9	
Vintage 2005							
Subprime	5.9	6.4	6.5	4.2	4.2	4.2	
Alt-A	4.6	5.0	5.5	2.8	3.2	3.6	2.1
Prime	4.8	5.1	5.5	3.4	3.8	4.3	
Vintage 2006							
Subprime	4.5	5.2	6.0	1.8	2.3	2.8	
Alt-A	3.5	4.2	4.9	0.4	1.3	2.1	2.1
Prime	4.9	5.3	5.7	3.3	3.9	4.5	
Vintage 2007							
Subprime	4.5	5.3	6.0	-0.4	0.8	1.8	
Alt-A	3.1	3.9	4.7	-0.8	0.3	1.4	1.9
Prime	4.7	5.2	5.7	2.6	3.3	4.0	