The Journal of FINANCE
The Journal of THE AMERICAN FINANCE ASSOCIATION

THE JOURNAL OF FINANCE • VOL. LXVII, NO. 4 • AUGUST 2012

# Did Subjectivity Play a Role in CDO Credit Ratings?

JOHN M. GRIFFIN and DRAGON YONGJUN TANG*

## ABSTRACT

Analyzing 916 collateralized debt obligations (CDOs), we find that a top credit rating agency frequently made positive adjustments beyond its main model that amounted to increasingly larger AAA tranche sizes. These adjustments are difficult to explain by likely determinants, but exhibit a clear pattern: CDOs with smaller model-implied AAA sizes receive larger adjustments. CDOs with larger adjustments experience more severe subsequent downgrading. Additionally, prior to April 2007, 91.2% of AAA-rated CDOs only comply with the credit rating agency's own AA default rate standard. Accounting for adjustments and the criterion deviation indicates that on average AAA tranches were structured to BBB support levels.

*Griffin is at the University of Texas at Austin and Tang is at the University of Hong Kong. We thank the BSI Gamma Foundation, McCombs Research Excellence Fund, Hong Kong RGC Grant #751109, the McCombs School of Business, University of Hong Kong, and HKUST for generous support. We thank an anonymous referee, Associate Editor, and Cam Harvey for detailed and beneficial comments. We also thank Itzhak Ben-David, Efraim Benmelech, Bernie Black, Michael Brandt, Benjamin Bystrom, Eric Chang, Joshua Coval, Prachi Deuskar, David Deutsch, Jerry Dwyer, Erkan Erturk, Mark Grinblatt, Bing Han, Jean Helwege, Burton Hollifield, Philip Jorion, Cathy Kahle, Robert Kuberek, Hayne Leland, Michael Lemmon, Francis Longstaff, Evgeny Lyandres, Peter MacKay, Paul Malatesta, Joseph Mason, Frank Partnoy, Lee Partridge, Neil Pearson, Edward Rice, Michael Roberts, Kimberly Rogers, Ann Rutledge, Tony Sanders, Til Schuermann, Mark Seasholes, Amit Seru, Clemens Sialm, Jonathan Sokobin, Chester Spatt, René Stulz, Wing Suen, Sheridan Titman, Nancy Wallace, Lori Walsh, Ashley Wang, Yintian Wang, Yingzi Zhu, and seminar participants at the 16th Mitsui Finance Symposium at the University of Michigan, 2009 China International Conference in Finance, 2009 Conference on Empirical Legal Studies, 2009 NY Fed/NYU Stern Conference on Financial Intermediation, 2009 SFM Conference at National Sun Yat-Sen University, 2010 American Finance Association meetings, 2010 Atlanta Fed Financial Markets Conference, China-Europe International Business School, 2010 China International Finance Conference, 2010 Financial Intermediation Research Society Meeting, 2010 NBER Credit Rating Sessions, 20th Utah Winter Finance Conference, 4th Annual Conference on the Asia-Pacific Markets, University of Arizona, the First Shanghai Winter Finance Conference, Fudan-UNSW Joint Workshop, Hebrew University, HKUST, City University of Hong Kong, Hong Kong Baptist University, the Hong Kong Monetary Authority, the Securities and Exchange Commission, Shanghai Jiaotong University, Thammasat Business School, University of California at Irvine, University of Hawaii, University of Notre Dame Conference on the Financial Crisis, University of Texas at Austin, University of Texas at Dallas, and University of Washington for helpful discussions and Rolando Campos, Ying Deng, Garrett Fair, Kelvin Law, Dan Luo, Danny Marts, Baolian Wang, Sarah Wang, Miao Zhang, and especially Jordan Nickerson for excellent research assistance.

In discussions regarding the causes of the recent financial crisis, the role of collateralized debt obligations (CDOs) is of central interest. Securitized instruments, like CDOs, are thought to be not only a driving force behind the housing market boom, but also largely responsible for the damage to the banking sector.[1] Most CDO notes issued prior to mid-2007 were AAA rated. However, in mid-2007 CDOs began to experience large losses followed by massive downgrading of formerly AAA-rated tranches in 2008 and 2009. How could historically trusted credit ratings suddenly become so unreliable?

This paper is the first to examine "adjustments" to a credit rating agency (CRA) model. These adjustments are not our estimates, but are implied directly from the key output of a leading CRA's main quantitative model. We study the magnitude, determinants, and consequences of adjustments. Additionally, we analyze the consistency over time of the default probability standards, a key model input, which are essentially the tranche-specific assumed risk level of the CDO.

Rating agencies have been scrutinized and criticized by the media, regulators, members of Congress, investors, and even the CEOs of the CDO underwriting firms on their role in the recent credit crisis. A central question being asked is whether CRAs knowingly gave inflated CDO ratings, or if they truthfully provided their best credit risk assessment based on available information at the time. Stulz (2008) argues that knowing whether a risk was misassessed and the nature of the mistake is crucial for risk management practice. It thus seems apparent that understanding the CDO rating process is an integral part of learning economic lessons from the crisis. While there is no shortage of opinions and commentary, there has been relatively little empirical examination of the structured finance credit rating process around the time of the crisis.

CDOs hold debt securities such as bonds, loans, and mortgages as collateral to issue prioritized tranche notes (see Longstaff and Rajan (2008) and Coval, Jurek, and Stafford (2009b) for detailed descriptions). Several interesting problems with CDO valuation have been raised. First, Coval, Jurek, and Stafford (2009a) show that the most senior tranches of CDOs should demand a much higher risk premium than the observed values. Second, it is conceivable that an "economic catastrophe" simply occurred, though compelling evidence from Longstaff and Rajan (2008) indicates that this is improbable.[2] Third, CDO

[1] Brunnermeier (2009) highlights the important role of CDOs and accompanying amplification mechanisms in the crisis. Along this vein, Partnoy (2009a, 2010) argues that reliance on credit ratings and credit rating agencies (CRAs) were the root cause of the crisis. Longstaff (2010) demonstrates contagion effects in 2007 from the asset-backed CDO market to the Treasury bond and stock markets. Longstaff and Myers (2009) show that CDO equity and bank stock equity are mostly driven by a common factor. Deng, Gabriel, and Sanders (2009) link the CDO market to lower spreads of subprime mortgage-backed securities (MBS) and Shivdasani and Wang (2011) find that collateralized loan obligations (CLOs) provided the dominant leveraged buyout financing.

[2] Deven Sharma, President of Standard & Poor's (S&P), explains the deterioration as a rare unanticipated event [Testimony of Deven Sharma before U.S. House of Representatives, October 22, 2008]. Longstaff and Rajan (2008) find that between 2003 and 2005 the CDX index was priced such that CDO losses of 35% could occur once every 763 years. Hence, for the rare event hypothesis to completely explain the recent crisis one might need to hold that the once in every 763 years event has just occurred.

market participants may have held unrealistic or even biased (Griffin and Tang (2011)) assumptions regarding key model inputs such as default correlations. Coval, Jurek, and Stafford (2009b) demonstrate that CDO valuation models hinged on a high degree of confidence in the parameter inputs. Fourth, lax standards (Keys et al. (2010) and Mian and Sufi (2009)), fraud (Ben-David (2009)), or increasing reliance on hard information (Rajan, Seru, and Vig (2010)) in the mortgage origination process could have inflated the collateral quality of mortgage-related CDOs (Barnett-Hart (2009)).

After an investigation of the major CRAs, a U.S. Securities and Exchange Commission (SEC (2008)) report discussed potential conflicts of interest but drew no firm conclusions. The views of the major CRAs can largely be summed up by Standard and Poor's (S&P) President in his testimony before Congress: "there is no evidence of any misconduct by our analysts or that the fundamental integrity of our ratings process has been compromised. Indeed, the SEC itself concluded that it found no evidence during its examination that S&P had compromised its standards to please issuers."[3] Despite accusations, public evidence of mishandling is limited.

To analyze rating practices, we compile a unique database of 916 CDOs, originally issued between January 1997 and December 2007, with a total note face value of $612.8 billion. The data contain detailed information including key inputs and outputs used in the rating process from one of the top three major CRAs. Interestingly, the proportion of the CDOs eligible for AAA status under the CRA credit risk model exhibits a correlation of only 0.49 with the actual proportion rated AAA—the reason the link is not tighter is due to the prevalence of adjustments. We define an AAA "adjustment" as the difference between the proportion of a CDO-rated AAA in practice and the proportion implied by the CRA main quantitative model output. We find that 84.6% of adjustments are positive and that, on average, adjustments amount to an additional 6.2% of AAA in 2003–2004, and increasing to 18.2% by 2009.

We examine whether manager experience and credit enhancements such as insurance, liquidity provisions, overcollateralization, reliance on other commonly used models, or excess spread can explain the AAA adjustment. We find that they do not. However, over half of the cross-sectional variation in adjustments can simply be explained by, and is negatively related to, the AAA proportions assigned by the CRA model. For example, for CDOs in the smallest quintile of AAA implied by the CRA model, the model yields 42.6% AAA, but the adjustment adds another 26.8% for a total issuance amount of 69.4% AAA. From a Bayesian perspective, we find that adjustments are consistent with CDOs being rated with a prior of 82.0% AAA. Adjustments can help explain why AAA CDO tranches are large and similar in size despite varying CDO structures.

We ask whether adjustments are beneficial for future performance by examining their relation to future downgrading. Ordered logit and probit regressions indicate that the amount of adjustment at the time of CDO issuance

[3] Direct quotes of Deven Sharma, President of S&P, from testimony before the U.S. House of Representatives on October 22, 2008.

is positively related to future downgrades. A hazard model also shows that adjustments to the rating agency model appear to have been harmful for future CDO performance.

Are adjustments to the AAA tranche size the only problem with CDO credit ratings? We next examine one of the key model inputs, namely, whether AAA ratings have the stipulated level of default risk. We document an empirical irregularity with respect to the default probability criterion: only 1.3% of AAA CDOs closed between January 1997 and March 2007 met the rating agency's reported AAA default probability standard; the rest fell short. In 92.4% of the cases, the AAA-rated tranches only met the AA default standard. This practice changed sharply around April 1, 2007, when most CDOs began to comply exactly with the stated default criterion. For CDOs issued prior to April 1, 2007, their follow-up surveillance reports (after April 2007) continued to adhere to the old criterion—effectively indicating that the CRA was using two different CDO rating standards simultaneously.

Finally, we assess the dollar value of adjustments and the criterion deviation to the AAA tranche using two different methods. If CDOs had been structured to meet smaller AAA thresholds according to the CRA's model, each CDO would have been $14.7 million more costly to structure. However, if viewing the AAA tranches as they were structured, AAA tranches were rated to what the CRA model classified as approximately BBB support levels. Hence, if junior AAA (and some senior AAA) tranches were rated BBB, investors could have demanded $42.2 million more payoffs per CDO. For the sample of 916 CDOs, this cumulates to $38.7 billion in cost to investors. Most of the valuation impact is driven by adjustments. Although these value differences are considerable, they are likely a large understatement, as we scrutinize only one aspect of the credit rating process.

Our study adds to several strands of literature. Longstaff and Rajan (2008) present the first empirical evidence on CDO valuation. An, Deng, and Sanders (2008) find that commercial mortgage-backed securities (CMBS) ratings are hard to fully explain and Stanton and Wallace (2011) find that CMBS subordination levels gradually decreased through 2007. Ashcraft, Goldsmith-Pinkham, and Vickery (2009) show that mortgage-backed security (MBS) ratings underperform their simple model. Benmelech and Dlugosz (2009b) and He, Qian, and Strahan (2011) find evidence of potential CDO and MBS rating shopping and market power. Our empirical focus complements recent theoretical models of credit ratings[4] and is related to the more general debate regarding rating standards.[5]

[4] This recent but growing body of work includes: Bolton, Freixas, and Shapiro (2009), Damiano, Li, and Suen (2008), Farhi, Lerner, and Tirole (2011), Mathis, McAndrews, and Rochet (2009), Opp, Opp, and Harris (2010), Skreta and Veldkamp (2009), Sangiorgi and Spatt (2010), and Bar-Isaac and Shapiro (2011).

[5] With respect to bond ratings, Cheng and Neamtiu (2009) find that rating agencies have been improving in their accuracy, timeliness, and volatility after the enactment of the Sarbanes-Oxley Act and, in contrast to Blume, Lim, and MacKinlay (1998), Jorion, Shi, and Zhang (2009), find no evidence of tightening standards after controlling for accounting quality. Bongaerts, Cremers, and Goetzmann (2012) find that multiple CRAs provide certification, and Becker and Milbourn (2011)

The rest of this paper is organized as follows. Section I provides industry background on CDO credit ratings. Section II describes the data, and Section III documents adjustments. Section IV analyzes the connection between adjustment and downgrading. A deviation from the publicized default criterion is discovered and discussed in Section V, and Section VI calculates the economic importance of these effects. Section VII concludes.

## I. Key Aspects of the CDO Modeling and Rating Process

This section explains key aspects of the CDO modeling and rating process to facilitate understanding of our empirical analysis. Our discussion is based on publicly released official documents from rating agencies as well as numerous conversations with CDO industry practitioners, including current or former structured finance analysts with major CRAs and related parties privy to interactions with CRAs.

### *A. Issuance and Rating Process*

CDOs operate like highly leveraged investment companies with multilayer debt structures of different seniorities and a nominal "equity" tranche.[6] Underwriters are often in charge of both structuring the deal and arranging the notes placement. Unlike conventional security issuances, the entire deal structure is subject to modification before issuance, and CDO structurers have free access to rating agency software, so probable rating model outcomes are often known a priori. Ratings are a focal point of primary offerings for CDO notes. It is almost always critical for issuers to secure target ratings before the notes issuance, and CDO prospectuses typically specify minimum ratings from particular rating agencies as preconditions to the issuance. Hence, ratings may play both evaluation and certification roles.

Usually, the structuring team of the underwriter submits the CDO term sheet to the business manager of one or multiple rating agencies. The collateral asset pool is typically incomplete, and the rating analyst will conduct credit risk analysis based on projected collateral characteristics. The CRA and underwriter may engage in discussion and iteration over assumptions made in the valuation process. If the underwriter and CRA cannot agree, then the underwriter can pay a small contract-breaking fee and potentially use ratings from another rating agency.

Once the rating committee is ready to release preliminary ratings, a presale report is usually published on the deal and distributed to potential investors.[7]

argue that competition has hurt rating quality. John, Ravid, and Reisel (2010) find suboptimal notching practices, and Kraft (2011) finds some evidence that rating agencies may cater to the interests of bond issuers.

[6] Longstaff and Rajan (2008), Benmelech and Dlugosz (2009a), Sanders (2009), and Coval, Jurek, and Stafford (2009b) present overviews of CDO structure and mechanics. Mason and Rosner (2007) discuss conflicts of interest. In their handbooks, Rutledge and Raynes (2003, 2010) comprehensively explain CDOs.

[7] The CRA may release a new-issue report shortly after the closing date when the collateral assets are fully ramped.

After closing, the CDO manager uses the proceeds raised from investors to "ramp up" the collateral pool. The trustee oversees the operation of the CDO and keeps relevant parties informed. The surveillance analyst assigned by the rating agency monitors the performance of the CDO using data from the trustee and the manager.

### B. Credit Rating Methodology

Rating agencies assign credit ratings according to probabilities of default or expected loss rates. To judge the probability of default for each tranche, one needs to compare future cash inflows generated by collateral assets to the liability payments. Simulations such as the Gaussian Copula method (described in the Internet Appendix)[8] are used to derive default rates associated with the collateral pool under different scenarios. These rates are known as scenario default rates (SDRs) by S&P terminology or default scenario collateral loss rates by Moody's.[9] We follow S&P's terminology hereafter. The calculation of SDR is analogous to finding Value-at-Risk (VaR) at a given confidence level. For a scenario with occurrence probability $D$, one can back out the SDR such that $\Pr(\textit{default rate} \geq \textit{SDR}) = D$ using the default probability distribution of the given asset pool. For example, the AAA scenario is the rarest scenario with an extremely low $D$. CDO rating software (such as Fitch's VECTOR, Moody's CDO ROM, and S&P's CDO Evaluator) specifically incorporates these maturity-specific "default criteria" ($D$) as inputs. The Internet Appendix contains the AAA CDO default criterion assumptions for maturities from 1 to 10 years from Fitch, Moody's, and S&P. The AAA default criterion is fixed for a given maturity, but SDRs vary across CDOs.

Apart from the credit risk modeling over the collateral pool, each tranche must undergo a separate cash flow analysis for cash CDOs but not synthetics. Many scenarios with various market conditions such as default timing patterns, interest rates, and recovery rates are considered. Under each scenario, a number (say 10,000) of portfolio loss rates are simulated. The highest collateral pool loss rate associated with a zero loss rate for the tranche is the break-even default rate (BDR) for the tranche under this scenario. If 64 scenarios are considered, then the minimum of the 64 BDRs is the maximum loss rate the tranche can withstand under any scenario. In other words, the BDR is the highest loss rate resulting from the worst cash flow scenario under which the tranche will still receive timely interest payments and ultimate principal.

[8] An Internet Appendix for this article is available online in the "Supplements and Datasets" section at http://www.afajof.org/supplements.asp.

[9] Our descriptions are based on CRA published documents, such as Moody's (1998), S&P (2002), and Fitch (2006), in addition to discussions with industry insiders. Moody's uses the Binomial Expansion Technique and models expected loss rates, whereas S&P and Fitch use the Gaussian Copula simulation method and start with default probabilities. Brennan, Hein, and Poon (2009) analyze rating arbitrage across different methods. Because of its simplicity and widespread use, we follow S&P's terminology.

The collateral pool credit risk analysis generating the SDRs is based on probabilities of default. Cash flow analysis incorporates the timing of defaults and recovery patterns to allocate expected losses across different tranches to determine the BDRs. A challenge with default probability-based CDO credit ratings is that default and recovery are separately considered. The most direct condition to grant a rating on a tranche is that the BDR from the cash flow analysis be greater than the corresponding SDR from the default risk analysis (BDR $>$ SDR). For example, if a tranche can withstand a 30.72% ($BDR^{AAA}$) loss according to the cash flow analysis but the collateral pool is not expected to lose more than 30.71% under the AAA scenario ($SDR^{AAA}$), then the tranche can obtain an AAA rating.

### *C. Adjustments*

For a generic credit portfolio, the tranche amount admissible for an AAA rating according to the level of expected default rate specified by the CRA credit risk model is $1-SDR^{AAA}$. Hence, we define $1-SDR^{AAA}$ for a given CDO as the AAA "CRA model fraction" as this is literally the most AAA that can be justified solely under the CRA's credit risk model. The CRA model fraction (1–SDR) and the actual tranche size often do not match. We refer to this difference as the adjustment (to the CRA credit risk model). For further clarification, we demonstrate the use of SDR, BDR, and adjustment of an actual CDO in the Internet Appendix.

Historically, CRAs indicate that the quality (or experience) of the collateral manager, legal documentation, structure of the cash flow waterfall, insurance, hedges, and liquidity considerations are important considerations.[10] For example, the structure of a CDO may include insurance from an outside insurer ("wrap") for certain (senior) tranches, making them less risky by transferring the credit risk to the insurer. The features of CDOs described earlier are not incorporated as inputs into the collateral asset risk model. These CDO features could be quantitatively incorporated into tranche-specific cash flow analysis and might lead to larger BDRs. However, for synthetic CDOs there is typically no cash flow analysis and hence the exact maximum tranche size should correspond to 1–SDR.[11] For cash deals, it is also possible that, due to greater flexibility in modeling choices, the cash flow modeling is more susceptible to influence from the investment bank.[12] In such a case, it would be better

[10] See, Moody's (2003, pp. 11, 18), S&P (2002, pp. 15–16, 54–60), and Fitch (2006, pp. 1, 17–19). Fitch (2006, p. 1) states that "ratings are ultimately the result of a formal committee process and not simply model output." Moody's (2003, p. 18) states, "Clearly, the relationship between the quantitative and qualitative analyses for synthetic CDOs is especially crucial."

[11] SDR is also the main credit risk output. This is also referred to as Scenario Loss Rate or SLR for synthetic CDOs.

[12] We thank former employees of two separate investment banks for making us aware of this issue. The CRA has little public documentation on the specifics of its cash flow modeling. This could lead to tailoring of a model by an investment bank or analysts at the CRA trying to please the issuer.

for the empiricist to focus on the outputs (SDR) from the more standardized credit risk model rather than a potentially biased cash flow model. Alternatively, adjustments could be made qualitatively beyond any model or completely "out-of-model."

### D. Empirical Implications

The above discussion of the CDO credit rating process points to several natural directions for empirical investigation. First, using data from a leading CRA, we examine if there are adjustments to the CRA's main risk model and, if present, the direction of the adjustments. Second, we examine if these adjustments are related to more quantitative structural elements such as insurance and liquidity provisions. Third, we also separately examine the pattern of adjustments for synthetic CDOs as no cash flow analysis is typically used here. Finally, we examine the consistency of the application of the default risk criterion ($D$).

## II. Data and Descriptive Statistics

Rating agencies compile data from trustee reports and host online CDO data services. These are often a main investment tool for CDO investors and managers without an in-house CDO research team. We obtain our data set directly from access to one of the three major CRAs. We begin with the set of all CDOs covered by the CRA, but restrict our sample to all CDOs with default risk estimates (SDR) data and main asset information available. This requirement results in a data set of 916 CDOs issued between January 1997 and December 2007. For our main analysis, we use data from the first available surveillance report that is typically released after the CDO collateral pool is fully ramped (as illustrated in the Internet Appendix). We find that 530 of our surveillance observations have collateral pool dates within the first 6 months after the closing date and a total of 663 within the first year.[13] We also use subsequent year-end and last available (as of September 2008) surveillance data in Section V.B. The total dollar principal value of all CDO notes represented by our sample is \$612.8 billion. The Securities Industry and Financial Markets Association (SIFMA) keeps track of global CDO issuance since 2000. Over the 2000 to 2007 period, our sample consists of 891 CDOs with a principal value of \$603.3 billion, which represents 34.9% of the \$1,727.5 billion Global CDO Issuance reported by SIFMA over the same period. The most unique element of our data is the detailed description of the CDO asset pool (collateral information), summary average value of the inputs, and key parameters going into the rating agency's model, including the default probability criterion reported for each CDO at each rating level. Additionally, the CRA data include the rating agency model primary outputs. We obtain ratings histories from Bloomberg and supplement with data from the CRA. From SDC Platinum, we verify coarser deal structure data (such as tranche size, deal type, payment frequency, etc.) and ratings. To

[13] We report results for these smaller samples in the Internet Appendix figure.

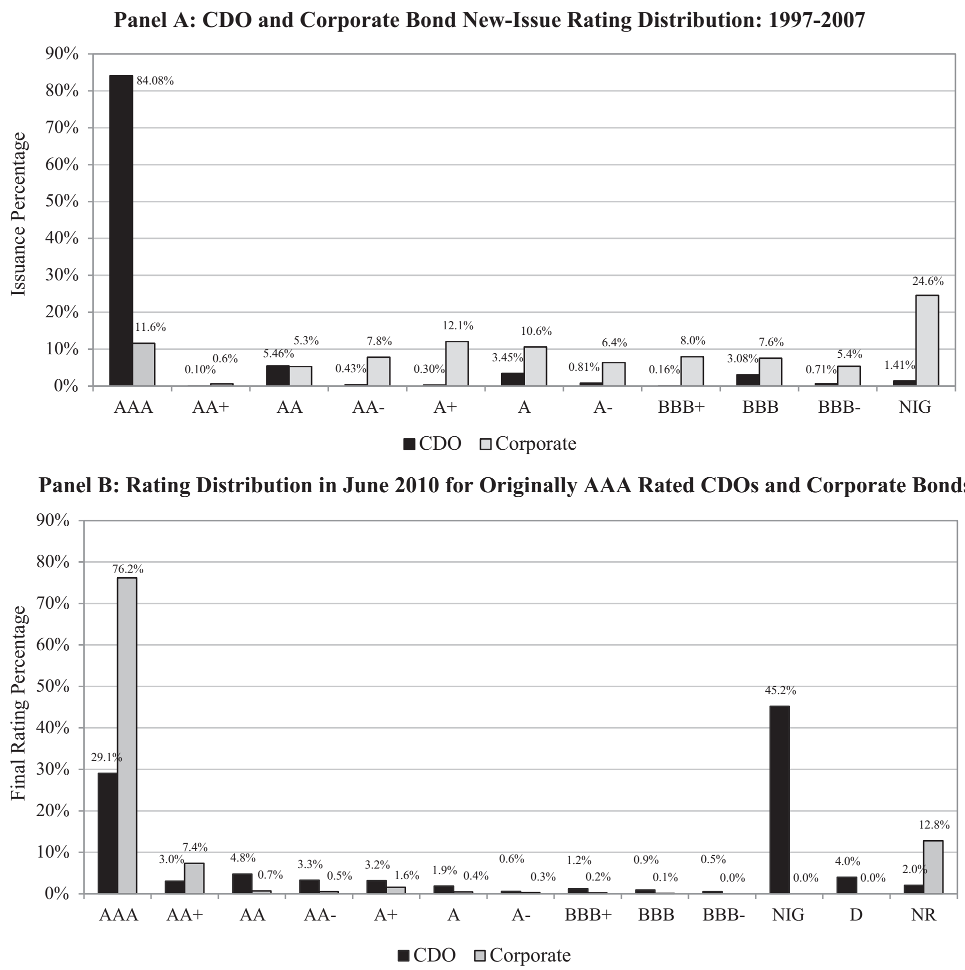



**Figure 1. Credit rating distribution.** The top figure (Panel A) plots the new-issue dollar value rating distribution for CDOs and corporate debentures issued between January 1997 and December 2007. The vertical axis is the issuance fraction in dollar value with the corresponding credit rating. "NIG" refers to noninvestment grade (ratings below BBB–). The corporate debentures consist of 160,689 rated issues from global rated debt issues in the Fixed Income Securities Database (FISD). The CDO sample includes 5,466 rated tranches of 916 CDOs from CRA. The bottom graph (Panel B) illustrates the dollar value rating distribution as of June 30, 2010 for all CDOs and corporate bonds with initial AAA rating (issued between 1997 and 2007; the AAAs from Panel A). "D" refers to default. "NR" refers to not rated; either the security has already matured, or the rating agency withdrew the rating prematurely.

put the CDO data in the greater debenture universe, we also gather corporate debentures from the Fixed Income Securities Database.

Panel A of Figure 1 shows the global new-issue rating distribution of corporate debentures (160,689 rated issues) and CDOs from the CRA database (5,466 rated tranches from the sample of 916 CDOs) over the same January 1997 to December 2007 period. For corporate debentures, the top rating of AAA counts for 11.6% of the total rating issuance value, non-AAA investment grade for 63.8% (13.7% AA, 29.1% A, and 21.0% BBB), and below investment grade for 24.6%. Nevertheless, over the same time period, the rating distribution for CDOs paints a starkly different picture: among all rated issuances, 84.1% are AAA, 14.5% are non-AAA investment grade (6.0% AA, 4.6% A, and 4.0% BBB), and 1.4% are below investment grade.[14]

We next examine the subsequent performance of the AAA-rated debt (both corporate and CDO tranches) from Panel A as of June 30, 2010. In Panel B, we find that corporate bond AAA ratings are very stable with 76.2% of corporate debt issued between 1997 and 2007 maintaining their AAA status, and another 8.1% at AA or AA+. About one-eighth (12.8%) become nonrated because the debt matured/retired, or the rating agencies withdrew the rating. In contrast, only 29.1% of the CDOs' original AAA ratings were intact, whereas 45.2% were downgraded to junk grade and 4.0% to D. A natural question is: What caused AAA CDO capital to be downgraded so severely?

Table I provides summary statistics of the profiles at closing time for our sample of 916 CDOs. We group CDOs by collateral asset type. Collateralized bond obligations (CBOs) are securitized with bonds. Collateralized loan obligations (CLOs) are securitized with loans. CDOs of asset-backed security (ABS) are securitized with asset-backed securities (mostly MBS). $\text{CDO}^2$ are securitized with existing CDO notes. (ABS CDOs and $\text{CDO}^2$s are often referred to as structured finance CDOs.) Table I shows that our sample is dominated by CLOs (393 of 916) and ABS CDOs (373 of 916). CBOs (96 of 916) and $\text{CDO}^2$s (54 of 916) comprise a smaller portion.

The average collateral rating is BB+ in the overall sample. CBOs and CLOs are smaller than ABS CDOs and $\text{CDO}^2$s in size. CLOs have the largest number of collateral assets, whereas $\text{CDO}^2$s have the fewest number of collateral assets. Synthetic CDOs account for 14% of the sample, with most of these being ABS CDOs. Notwithstanding the variation in composition, the AAA portion of the CDOs is highly consistent across collateral types. The average CDO has 75.5% rated AAA (super-senior tranches are counted as AAA rated). This portion ranges from 71.5% for $\text{CDO}^2$s, 72.6% for CLOs, 72.8% for CBOs, and 79.8% for ABS CDOs.

## III. Understanding Adjustments

In this section, we examine the difference between the fraction of AAA according to the CRA model and the fraction rated AAA in practice. We document these adjustments by examining their magnitude, stylized features, and potential determinants.

[14] Note that these numbers do not include the unrated equity portion.

**Table I**

**CDO Sample Description**

This table reports the average value of the collateral asset characteristics and liability structure for CDOs in our sample. Data are from the first CRA surveillance reports after closing. CDOs are issued over the January 1997 to December 2007 period. The last reporting date is September 2008. Data are grouped by collateral asset type (CBO for collateralized bond obligations, CLO for collateralized loan obligations, ABS CDO for CDOs of asset-backed securities, and CDO$^2$ for CDOs of CDOs). *Col. Rating* is the collateral asset average credit rating (average is calculated after numerical conversion AAA = 1, AA+ = 2, AA = 3, . . . C = 21). *Col. Default Rate* is the average expected collateral asset default rate in percentage. *Col. Maturity* is the collateral asset weighted average maturity. *Col. Size* is the total principal value of collateral assets. # *Assets* is the average number of assets in the collateral pool. # *Obligors* is the average number of distinctive obligors for the collateral assets. *Synthetic Dummy* equals one if the CDO is structured synthetically (using credit default swap, CDS, contracts), and zero if the CDO is a cash deal. *Mgr Deal* # is the average number of CDOs that the collateral manager has managed including the current CDO. *Overcollateralization* is the ratio of total collateral asset principal value over total liability principal value. *Insurance Dummy* equals one if the AAA tranche of the CDO is insured, and zero otherwise. *Liquidity Dummy* equals one if the CDO has liquidity facility (such as a revolving credit line or reserve account), and zero otherwise. *AAA Fraction* is the fraction of the CDO liability rated AAA; it counts super-senior tranches as AAA rated.

| | CDO Type | | | | |
|---|---|---|---|---|---|
| Variables | All | CBO | CLO | ABS CDO | CDO$^2$ |
| # Obs. | 916 | 96 | 393 | 373 | 54 |
| Col. Rating | BB+ | BB– | B+ | A– | BBB |
| Col. Default Rate (%) | 2.69 | 3.83 | 4.32 | 0.86 | 1.47 |
| Col. Maturity (Years) | 6.45 | 5.30 | 5.74 | 7.23 | 8.32 |
| Col. Size ($ millions) | 634.3 | 394.4 | 479.3 | 865.9 | 589.4 |
| # Assets | 218.3 | 139.2 | 325.9 | 144.7 | 84.02 |
| # Obligors | 130.0 | 104.3 | 158.1 | 115.3 | 72.1 |
| Synthetic Dummy | 0.14 | 0.25 | 0.00 | 0.25 | 0.15 |
| Mgr Deal # | 7.9 | 4.4 | 8.6 | 7.9 | 8.5 |
| Overcollateralization | 1.004 | 0.886 | 0.948 | 1.046 | 1.335 |
| Insurance Dummy | 0.061 | 0.188 | 0.043 | 0.048 | 0.056 |
| Liquidity Dummy | 0.235 | 0.469 | 0.112 | 0.284 | 0.370 |
| AAA Fraction | 0.755 | 0.728 | 0.726 | 0.798 | 0.715 |

### *A. AAA Adjustments*

Panel A of Table II shows that, for the 916 CDOs, on average the CRA model yields 63.4% AAA according to the first surveillance report in the data set, but the actual fraction of the CDO issued AAA is 75.5%. Hence, the difference between the amount of AAA issued and that allowed by the CRA model (the adjustment) is 12.1% on average. The adjustment is smallest for ABS CDOs (8.1%) and CBOs (10.4%), and largest for CDO$^2$s (14.7%) and CLOs (16.0%).

The adjustments are large in the early years of the sample, but there are also few observations here. Adjustments are at their lowest in 2003 to 2004, but increase each year until 2007, the last year we have new issues. In 2007, the average adjustment is 18.2%. The adjustments in 2007 are also higher in all the different types of CDOs as well.

**Table II**

**CDO AAA Fraction: Actual, Credit Rating Agency Model, and Adjustment**

This table reports the average value of the actual AAA fraction, the CRA model–predicted AAA fraction, and the adjustment (difference between actual and CRA model) for CDOs in our sample. Data are from first CRA CDO surveillance reports and the CDO rating databases. CDOs are issued over the January 1997 to December 2007 period. *Actual AAA* is the actual fraction of the CDO liability rated AAA, treating super-senior tranches as AAA. *CRA Model AAA* is the fraction of the CDO that can be rated AAA according to the rating agency model, defined as $1\text{–}SDR^{AAA}$. *CRA Adjustment* is the difference between the actual AAA fraction and CRA model AAA fraction. Panel A displays the sample average value. Data are grouped by collateral asset type (CBO for collateralized bond obligations, CLO for collateralized loan obligations, ABS CDO for CDOs of asset-backed securities, and $CDO^2$ for CDOs of CDOs) from the first CRA surveillance reports. Panel B displays the Pearson correlation matrix with *t*-statistics of the correlation coefficients in parentheses.

Panel A: Sample Average Value

| Variables | All | CBO | CLO | ABS CDO | $CDO^2$ |
|---|---|---|---|---|---|
| Obs. | 916 | 96 | 393 | 373 | 54 |
| Actual AAA | 0.755 | 0.728 | 0.726 | 0.798 | 0.715 |
| CRA Model AAA | 0.634 | 0.625 | 0.566 | 0.717 | 0.568 |
| CRA Adjustment | 0.121 | 0.104 | 0.160 | 0.081 | 0.147 |
| Positive/Total | 770/916 | 75/96 | 384/393 | 263/373 | 48/54 |
| CRA Adjustment $\leq$ 2002 | 0.107 | 0.106 | 0.127 | 0.066 | 0.127 |
| Positive/Total | 102/131 | 52/65 | 21/25 | 24/36 | 21/25 |
| CRA Adjustment 2003 to 2004 | 0.062 | 0.064 | 0.129 | 0.003 | 0.129 |
| Positive/Total | 118/155 | 3/4 | 67/69 | 42/74 | 67/69 |
| CRA Adjustment 2005 | 0.097 | –0.035 | 0.149 | 0.057 | 0.019 |
| Positive/Total | 136/156 | 1/2 | 73/73 | 55/73 | 7/8 |
| CRA Adjustment 2006 | 0.128 | 0.091 | 0.154 | 0.101 | 0.128 |
| Positive/Total | 223/261 | 8/11 | 126/127 | 79/110 | 10/13 |
| CRA Adjustment 2007 | 0.182 | 0.133 | 0.206 | 0.153 | 0.219 |
| Positive/Total | 194/213 | 11/14 | 98/99 | 65/80 | 20/20 |

Panel B: Pearson Correlations

| Variables | Actual AAA | CRA Model AAA |
|---|---|---|
| CRA Model AAA | 0.49(14.09) | |
| CRA Adjustment | 0.27(5.34) | −0.71(−16.34) |

To examine the effect of the adjustment on the overall AAA graphically, we plot the distribution of the size of the AAA tranche before and after the adjustment. Figure 2 shows that, according to the CRA risk model, most of the AAA tranche sizes would have been between 55% and 65% of the CDO. For the actual AAA tranche sizes, which include the adjustment, we see that the left tail is thinner—the adjustment has the effect of drastically reducing the amount of AAA-rated tranches to less than 65%. Indeed, the actual AAA amount issued per CDO groups tightly between 70% and 80%. The test for differences in the distribution of the AAA fraction across the two groups is

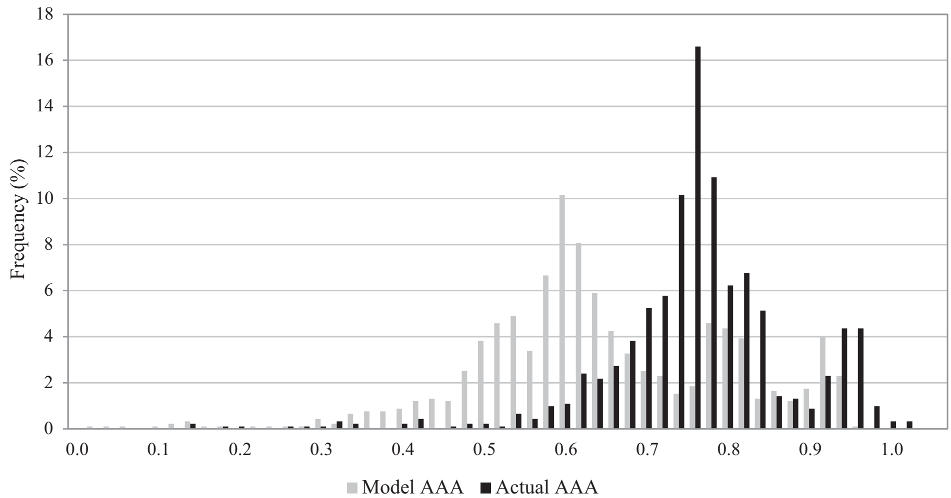



**Figure 2. Distribution of AAA fraction from credit rating agency model and actual AAA fraction in the capital structure of the CDO.** This figure reports the histograms of the AAA fraction from the output of the CRA model (gray bars) and the fraction of the CDO actually rated AAA (black bars). The sample includes 916 CDOs issued between January 1997 and December 2007. The test for differences in the distribution of AAA fraction across two groups is conducted by calculating the corrected Kolmogorov–Smirnov $D$-statistic, with $p$-values of the test less than 0.0001. The simple mean difference test between model AAA and actual AAA has a $t$-statistic of 25.93.

conducted by calculating the corrected Kolmogorov–Smirnov $D$-statistic, with the $p$-values of the test set to $p < 0.0001$. The distribution after adjustment is more concentrated (the standard deviation of the actual AAA size is 0.114, compared to 0.156 for model AAA standard deviation), suggesting that the AAA fraction across CDOs, post-adjustment, is more similar.

Panel B of Table II reports the cross-sectional correlation between the CRA model and the actual amount of AAA given. The correlation is only 0.49. Since the actual amount of AAA given and that from the CRA model differ only by the adjustment, this indicates that the underlying model can only explain 25% of the final proportion of rated AAA. However, the adjustment is more strongly negatively correlated (correlation coefficient –0.71) with the amount of AAA given by the CRA model.

### *B. Explaining Adjustments*

To understand the potential driver of this adjustment, in Table III we regress the AAA adjustment on variables that CRAs stress to be important, but that are likely not incorporated in the credit risk model (as discussed in Section I.C). Our first variable is collateral manager experience as reported by a commonly discussed proxy—the number of past deals performed by the collateral manager. The variable enters with some statistical significance but a trivial adjusted $R^2$.

**Table III**

## CRA AAA Fraction Adjustment and CDO Characteristics

This table shows the results of OLS regressions. The dependent variable is the CRA AAA fraction adjustment. The adjustment is defined as the difference between the actual AAA fraction and the CRA model–predicted AAA fraction explained in Table II. The independent variables are described in Table I except the following: *Vasicek AAA* is the AAA fraction of the CDO predicted by the Vasicek model, *Simulation AAA* is the AAA fraction predicted by a Monte Carlo simulation, *Multiple CRA* is a dummy variable with one for multiple rating on the CDO, and zero otherwise, *Excess Spread* is the ratio of the average collateral coupon rate over the average CDO note coupon rate, and *BDR − SDR* is the difference between the break-even default rate (BDR) and scenario default rate (SDR) in the presale or new-issue reports. Data are from CRA CDO presale, new-issue, and surveillance reports, as well as CDO rating databases. CDOs are issued over the January 1997 to December 2007 period. White (1980) heteroskedasticity-adjusted $t$-statistics are in parentheses.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.107 | 0.182 | 0.529 | 0.559 | 0.574 | 0.531 | 0.498 | 0.654 | 0.414 |
| | (13.23) | (16.14) | (38.03) | (38.46) | (41.93) | (24.90) | (22.81) | (17.68) | (10.61) |
| Log(Mgr Deal #) | 0.010 | 0.012 | | 0.007 | | 0.005 | 0.003 | 0.001 | 0.005 |
| | (2.21) | (2.82) | | (2.44) | | (1.60) | (0.87) | (0.34) | (1.23) |
| Overcollateralization | | −0.079 | | −0.061 | −0.061 | −0.063 | −0.060 | −0.097 | −0.030 |
| | | (−10.07) | | (−11.00) | (−11.03) | (−11.20) | (−10.89) | (−13.21) | (−5.48) |
| Insurance Dummy | | 0.034 | | 0.040 | | 0.045 | 0.049 | 0.055 | 0.035 |
| | | (1.83) | | (3.10) | | (3.47) | (3.79) | (3.99) | (1.69) |
| Liquidity Dummy | | −0.005 | | 0.006 | | 0.008 | 0.014 | 0.013 | −0.002 |
| | | (−0.43) | | (0.75) | | (1.06) | (1.84) | (1.77) | (−0.21) |
| CRA AAA | | | −0.642 | −0.618 | −0.618 | −0.737 | −0.721 | −0.778 | −0.596 |
| | | | (−30.18) | (−30.83) | (−30.74) | (−19.57) | (−19.31) | (−19.58) | (−9.91) |
| Vasicek AAA | | | | | | 0.030 | −0.022 | −0.017 | 0.054 |
| | | | | | | (1.46) | (−1.01) | (−0.73) | (1.48) |
| Simulation AAA | | | | | | 0.112 | 0.139 | 0.042 | 0.032 |
| | | | | | | (2.55) | (3.17) | (0.91) | (0.53) |
| CLO | | | | | | 0.035 | 0.025 | 0.029 | 0.073 |
| | | | | | | (2.81) | (1.97) | (1.95) | (2.31) |
| ABS CDO | | | | | | 0.031 | 0.054 | 0.085 | 0.032 |
| | | | | | | (1.81) | (3.09) | (4.28) | (0.83) |
| $CDO^2$ | | | | | | 0.017 | 0.033 | 0.012 | 0.005 |
| | | | | | | (0.79) | (1.55) | (0.53) | (0.13) |
| Synthetic Dummy | | | | | | −0.009 | −0.025 | −0.035 | −0.028 |
| | | | | | | (−0.81) | (−2.20) | (−2.95) | (−1.09) |
| Closing Year 2005 | | | | | | | 0.020 | 0.011 | 0.027 |
| | | | | | | | (2.04) | (1.13) | (2.51) |
| Closing Year 2006 | | | | | | | 0.029 | 0.011 | 0.045 |
| | | | | | | | (3.15) | (1.25) | (4.28) |
| Closing Year 2007 | | | | | | | 0.059 | 0.035 | 0.069 |
| | | | | | | | (5.56) | (3.28) | (4.97) |
| Multiple CRAs | | | | | | | | −0.001 | 0.021 |
| | | | | | | | | (−0.08) | (1.70) |
| Excess Spread | | | | | | | | −0.013 | |
| | | | | | | | | (−2.51) | |
| BDR − SDR | | | | | | | | | −0.004 |
| | | | | | | | | | (−3.63) |
| $N$ | 903 | 903 | 903 | 903 | 903 | 903 | 903 | 669 | 408 |
| Adjusted $R^2$ | 0.005 | 0.112 | 0.503 | 0.569 | 0.562 | 0.584 | 0.598 | 0.696 | 0.638 |

Manager experience becomes insignificant in the presence of other controls (specifications 6 through 9). Other important CDO credit enhancements are overcollateralization, insurance, and liquidity (such as third-party revolving line of credit and reserve account). Specification 2 shows that of the three, overcollateralization has the most importance for explaining adjustments. However, it enters with a negative sign, suggesting that overcollateralizing CDOs is associated with less, not more, AAA ratings, contrary to the effect hypothesized. In later specifications with more controls, the insurance variable enters with a positive sign, indicating that CDOs with insurance receive a 4.9% larger AAA tranche.

In specification 3, we include the fraction of AAA from the CRA model; here, the variable enters with a strong negative coefficient and the adjusted $R^2$ of the model jumps to 0.503. In specification 4, we include the potential determinants of deal ratings, and we find that these increase the adjusted $R^2$ only to 0.569. Since overcollateralization enters with the opposite sign, we estimate specification 5 with the CRA AAA and overcollateralization and find an adjusted $R^2$ of 0.562. Hence, the incremental explanatory power of past deals performed by the manager, insurance, and liquidity can only explain a trivial 0.007 of the cross-sectional variation in the adjustment.

It is possible that adjustments were made by comparing the CRA model with an alternative Gaussian Copula simulation model or a traditional alternative such as the Vasicek (1987) model. We obtain AAA estimates from both (as discussed in the Internet Appendix) and find that neither helps to explain the adjustment. Consistent with the simple summary statistics, adjustments are larger in 2005 (0.020), 2006 (0.029), and especially 2007 (0.059).

Perhaps CRAs give larger adjustments to CDOs with larger excess spreads (one of the most important credit enhancements is excess spread). For a subsample of 669 CDOs with excess spread information, we find that, contrary to expectations, CDOs with higher excess spreads actually have slightly less positive adjustments (specification 8).

We must note that, like most analyses, our specifications cannot rule out an unknown omitted variable that is highly correlated with the amount of AAA from the CRA model. However, to the extent that there are missing variables that are quantitative in nature, they could be captured in the secondary cash flow analysis. As discussed in Section I.B, the BDR is the main output from the cash flow analysis. In specification 9, we find that the relation between $BDR - SDR$ and the adjustment is slightly negative. The adjustment is not explained by a key parameter from the cash flow simulations.

In Figure 3, we examine a simple scatter plot of the fraction of AAA according to the CRA model relative to the adjustment. The graph shows an almost linear relation, where CDOs with a low amount of AAA given by the CRA model receive large AAA adjustments. Conversely, CDOs where the model yields a high amount of AAA exhibit little or no adjustment. Notably, this pattern is similar for synthetic CDOs, which typically do not have cash flow analysis—this suggests that the CRA is likely making adjustments for reasons other than the reliance on cash flow analytics.

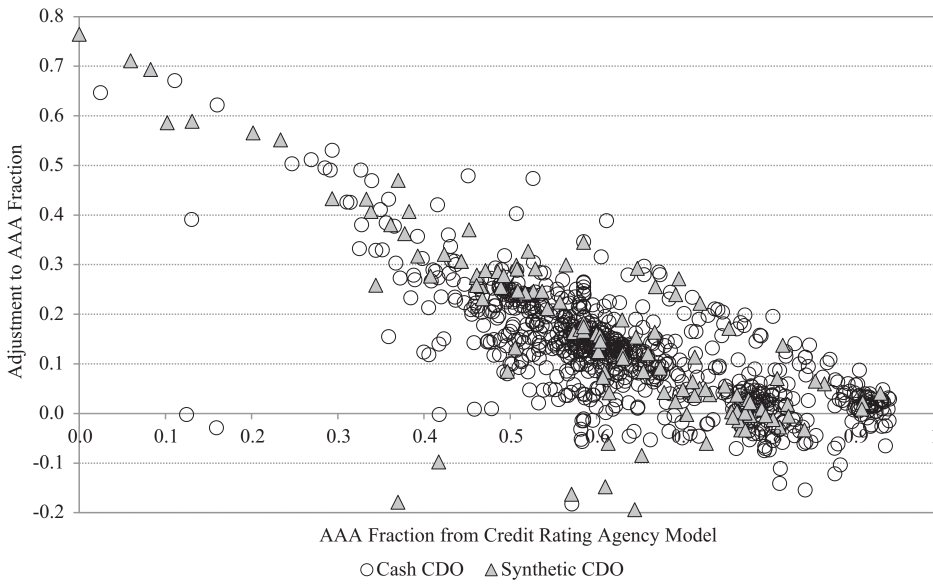



**Figure 3. Credit rating agency model–predicted AAA fraction (*x*-axis) and initial adjustment (*y*-axis).** This figure graphs the AAA fraction from the CRA model (defined as 1–$SDR^{AAA}$) in the first surveillance reports and the adjustment (difference between actual CDO fraction–rated AAA and credit rating agency model AAA fraction). $SDR^{AAA}$ is the scenario default rate for the AAA scenario directly from the rating agency model output. The sample includes 916 CDOs issued between January 1997 and December 2007.

In Figure 4, we further examine this relation by sorting each type of CDO into five groups based on the amount of AAA specified by the CRA model. For CDOs in the quintile in which the model yields the lowest amount of AAA, they receive a 26.8% adjustment on average, and the AAA tranche size is 69.4%. In the top quintile of the CRA model, the model yields an 85.3% AAA and there is a negative 0.4% adjustment. $CDO^2$s in the lowest quintile would have only received 29.2% AAA without the additional 47.0% adjustment enabling total AAA-rated tranches of 76.1% of the CDO. In most of the CDO-type groups, there is an almost monotonic decrease in the amount of AAA issued as the CRA model AAA becomes larger.

This can be consistent with a Bayesian approach.[15] The CRA model average AAA size is 0.634 with a standard deviation of 0.156 (the “data”), and the actual deal average AAA size is 0.755 with a standard deviation of 0.114 (the “posterior”). If we assume truncated normal distributions (between zero and one), then we can back out the prior distribution and find that it has a mean AAA of 0.820 and a standard deviation of 0.121. Since the quality of each deal is determined by the collateral asset pool, it is unclear why it would be optimal for a CRA to allocate a strong weight toward a prior deal structure. Investment

[15] We thank the referee for this insight.

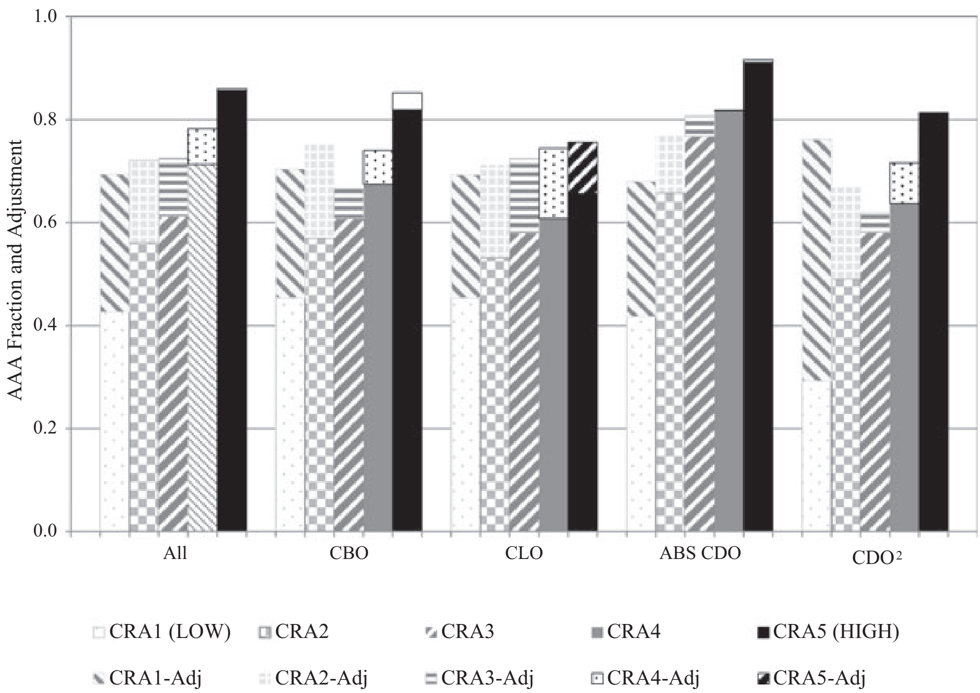



**Figure 4. Credit rating agency model–predicted AAA fraction and initial adjustment by collateral asset type.** This figure graphs the AAA fraction from the CRA model (defined as 1–$SDR^{AAA}$) in the first surveillance reports and the adjustment (difference between actual CDO fraction–rated AAA and CRA model AAA fraction). The bottom bars are from the CRA model's AAA fractions, and the top bars are adjustments. The total length of the bars is the actual AAA fraction. Data are divided into different collateral asset types (CBO, CLO, ABS CDO, $CDO^2$). Within each CDO type, the data are further separated into five groups according to CRA model AAA fraction, from low (group 1) to high (group 5). Empty bars represent negative adjustments. The sample includes 916 CDOs issued between January 1997 and December 2007.

banks may target a high fraction of AAA to make the deal economic. It is possible that the prior reflects the underwriter's target structure.

In summary, we are unable to explain adjustments with variables that rating agencies report to be important considerations. The most systematic feature we find, both economically and statistically, is that CDOs with low model-predicted amounts of AAA receive large adjustments.

## IV. Adjustments and Downgrades

In this section, we examine the efficacy of the CRA adjustments to increase CDO rating accuracy. Rating changes can be caused by unpredictable market developments or inaccurate initial rating assessments. If adjustments are made for beneficial reasons, then we expect CDOs with larger upward adjustments at the time of the rating to receive fewer (or at least no more) downgrades.

We first focus on downgrades up to December 31, 2008, since the ratings methodology changes in 2009 allowed for an increased role for qualitative considerations. Large negative adjustments are exceptionable and perhaps better reflected as having no adjustment; we therefore truncate negative adjustment values at zero.[16] Because massive downgrading was common on some dates related to detailed collateral characteristics such as certain types of subprime residential mortgage-backed securities (RMBS), we include time dummy variables (shocks) for the five dates with the most massive downgrading as a proxy for these potentially omitted collateral characteristics. We also include the broad collateral type variables in all specifications.

Table IV uses an ordered logit model to predict downgrades. Specification 1 shows that AAA tranches with larger adjustments are more likely to be downgraded. In specifications 3 through 6, we include year dummy variables for the 2004 to 2007 ABS vintages that are thought to have contained increasingly more risky subprime mortgage collateral. Vintage dummy variables are also included for $CDO^2$s since they often contain ABS CDOs. It is indeed the case that CDOs issued in 2006 and particularly 2007 are more likely to be downgraded. Nevertheless, even after collateral-vintage controls, the adjustment remains highly significant. We also include additional features of the CDO such as overcollateralization, insurance, and liquidity in specification 4, but find that these features have little effect on the adjustment and are of less economic importance than the adjustment. Finally, in the last specification we remove the dummy variable for the five downgrading shocks and find that the economic magnitude and statistical significance of the adjustment strengthens.

We stress these results against a host of robustness analyses. Even though rating agencies changed methodologies in 2009, one may argue that results can become more accurate over time, if ratings are forced to gradually recognize CDO quality. We use 2010 downgrading data and find that the economic importance of the adjustment strengthens considerably (see the Internet Appendix). In fact, the odds ratio strengthens to 24.1, which includes all the controls. We also estimate the adjustment coefficient separately on positive and negative adjustments, additionally controlling for excess spread and for a smaller sample with the first surveillance data within 6 months or 1 year of the CDO closing. The results are all similar to Table IV except for some marginal insignificance in the smaller 6-month subsample and some insignificance in the specification without shocks. We estimate our original ordered logit regressions by type and find that AAA adjustments are related to future downgrades in the CBO/CLO sample as well as in ABS CDOs. Ordered probit and plain OLS also yield strong statistical significance.

Because of potential advantages of hazard models, such as the ability to control for the length of period at risk, we follow Shumway (2001) and Bharath

[16] Large negative adjustments occur because there is a planned super-senior AAA tranche that is not offered to investors at closing time, and because there was a top tranche not rated by our rating agency but rated by another leading rating agency. Examples include Lacerta ABS CDO 2006-1 and Coda CDO 2007-1, where negative adjustments become zero after accounting for these issues.

**Table IV**

## AAA Fraction Adjustment and Subsequent Downgrading as of December 31, 2008

This table shows ordered logit regression results. The dependent variable is the number of notches downgraded from initial AAA rating. *AAA Adjustment*, the first independent variable, is defined as the difference between the actual AAA fraction with super-senior tranches and the CRA model–predicted AAA fraction as described in Table II, truncated on the left side at zero. This variable is collected from the first surveillance report data after issuance. *Multiple CRA* is a dummy variable with one for multiple ratings on the CDO, and zero otherwise. *ABS 2004–2007* and $CDO^2$ are interactions between CDO type and closing year. *Shocks* represents the five dates when the most CDOs are downgraded. For example, the first three occur when CDOs backed by various types of RMBS collateral are placed on credit watch or downgraded. Other independent variables are described in Table I. Data are from the first CRA CDO surveillance reports and the CDO rating databases. CDOs are issued over the January 1997 to December 2007 period. Odds ratios are reported with White (1980) heteroskedasticity-adjusted $z$-statistics in parentheses.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| AAA Adjustment | 68.19 | 32.14 | 15.60 | 17.38 | 18.21 | 9.46 |
| | (5.30) | (4.18) | (3.35) | (3.46) | (3.49) | (3.08) |
| ABS CDO | 80.69 | 74.76 | 27.41 | 26.12 | 25.70 | 28.88 |
| | (14.50) | (14.51) | (9.25) | (9.16) | (9.12) | (8.97) |
| $CDO^2$ | 76.19 | 73.32 | 3.45 | 1.91 | 1.85 | 1.80 |
| | (10.08) | (9.72) | (1.01) | (0.78) | (0.74) | (0.75) |
| Synthetic Dummy | | 3.21 | 1.47 | 1.16 | 1.17 | 1.42 |
| | | (4.45) | (1.22) | (0.46) | (0.47) | (1.19) |
| ABS 2004 | | | 1.21 | 1.07 | 1.10 | 1.14 |
| | | | (0.52) | (0.19) | (0.26) | (0.32) |
| ABS 2005 | | | 4.11 | 4.70 | 4.77 | 5.32 |
| | | | (4.58) | (4.95) | (5.02) | (4.92) |
| ABS 2006 | | | 12.16 | 12.51 | 12.44 | 23.43 |
| | | | (6.59) | (6.69) | (6.68) | (8.64) |
| ABS 2007 | | | 29.96 | 35.75 | 36.22 | 62.68 |
| | | | (7.96) | (8.15) | (8.21) | (9.97) |
| $CDO^2$ 2004 | | | 7.35 | 4.28 | 4.29 | 5.70 |
| | | | (1.29) | (1.03) | (1.03) | (1.38) |
| $CDO^2$ 2005 | | | 22.01 | 36.64 | 37.00 | 40.83 |
| | | | (2.21) | (3.27) | (3.27) | (3.48) |
| $CDO^2$ 2006 | | | 41.47 | 77.43 | 77.70 | 108.56 |
| | | | (2.68) | (4.26) | (4.25) | (4.54) |
| $CDO^2$ 2007 | | | 327.73 | 619.05 | 655.52 | 1130.70 |
| | | | (4.08) | (5.92) | (5.93) | (7.01) |
| Overcollateralization | | | | 1.22 | 1.21 | 1.25 |
| | | | | (1.81) | (1.78) | (2.29) |
| Insurance Dummy | | | | 1.22 | 1.25 | 1.55 |
| | | | | (0.51) | (0.55) | (0.99) |
| Liquidity Dummy | | | | 2.00 | 2.01 | 1.78 |
| | | | | (3.19) | (3.18) | (2.71) |
| Multiple CRAs | | | | | 1.57 | 1.30 |
| | | | | | (0.97) | (0.56) |
| Shocks | Y | Y | Y | Y | Y | N |
| $N$ | 916 | 916 | 916 | 916 | 916 | 916 |
| Pseudo $R^2$ | 0.313 | 0.322 | 0.368 | 0.373 | 0.374 | 0.359 |

**Table V**

**Hazard Model of AAA Downgrading as of June 30, 2010**

This table shows estimation results for the downgrading hazard model. The dependent variable is time to a downgrade of CC or below for initially AAA-rated CDOs. *AAA Adjustment*, the first independent variable, is defined as the difference between the actual AAA fraction with super-senior tranches and the CRA model-predicted AAA fraction as described in Table II, truncated on the left side at zero. *Multiple CRA* is a dummy variable with one for multiple ratings on the CDO, and zero otherwise. Other independent variables are described in Table IV. Data are from the first CRA CDO surveillance reports and the CDO rating databases. CDOs are issued over January 1997 to December 2007 period. Hazard ratios are reported with White (1980) heterosketasticity-adjusted $t$-statistics in parentheses.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| AAA Adjustment | 6.13 | 2.93 | 2.62 | 2.83 | 2.82 | 3.86 |
| | (4.29) | (2.43) | (2.38) | (2.45) | (2.44) | (3.22) |
| ABS CDO | 5.33 | 5.48 | 1.22 | 1.23 | 1.22 | 3.07 |
| | (5.98) | (6.54) | (0.58) | (0.55) | (0.53) | (3.27) |
| $CDO^2$ | 8.32 | 9.29 | 0.63 | 0.50 | 0.49 | 0.82 |
| | (6.63) | (7.33) | (–0.46) | (–0.67) | (–0.68) | (–0.19) |
| Synthetic Dummy | | 3.00 | 1.22 | 1.11 | 1.11 | 1.20 |
| | | (6.58) | (1.05) | (0.57) | (0.56) | (0.94) |
| ABS 2004 | | | 4.03 | 3.83 | 3.85 | 4.28 |
| | | | (4.65) | (4.42) | (4.43) | (4.38) |
| ABS 2005 | | | 12.52 | 13.49 | 13.52 | 15.12 |
| | | | (8.71) | (8.75) | (8.77) | (8.50) |
| ABS 2006 | | | 45.68 | 46.54 | 46.52 | 68.93 |
| | | | (11.56) | (11.49) | (11.49) | (12.38) |
| ABS 2007 | | | 211.89 | 230.82 | 233.11 | 322.94 |
| | | | (13.59) | (13.89) | (13.91) | (14.52) |
| $CDO^2$ 2004 | | | 8.54 | 6.48 | 6.50 | 9.71 |
| | | | (2.01) | (1.75) | (1.76) | (2.12) |
| $CDO^2$ 2005 | | | 42.99 | 52.01 | 51.94 | 79.20 |
| | | | (3.77) | (3.78) | (3.78) | (4.23) |
| $CDO^2$ 2006 | | | 84.48 | 118.99 | 118.72 | 158.44 |
| | | | (4.24) | (4.42) | (4.42) | (4.63) |
| $CDO^2$ 2007 | | | 427.31 | 578.98 | 581.08 | 744.70 |
| | | | (5.76) | (5.76) | (5.76) | (5.90) |
| Overcollateralization | | | | 1.13 | 1.13 | 1.16 |
| | | | | (2.12) | (2.11) | (2.66) |
| Insurance Dummy | | | | 1.06 | 1.06 | 1.32 |
| | | | | (0.15) | (0.16) | (0.76) |
| Liquidity Dummy | | | | 1.42 | 1.41 | 1.36 |
| | | | | (2.60) | (2.56) | (2.28) |
| Multiple CRAs | | | | | 1.16 | 1.22 |
| | | | | | (0.44) | (0.51) |
| Shocks | Y | Y | Y | Y | Y | N |
| $N$ | 916 | 916 | 916 | 916 | 916 | 916 |

and Shumway (2008) and use a proportional hazard model to examine the relation between adjustments and the likelihood of an AAA security downgrade to CC or below. In Table V, we find that, even after controlling for CDO type and vintage/type effects (in specification 3) and other controls (in specifications

4 through 6), CDOs that received larger adjustments bear more risk of being downgraded to CC or below. One problem with the hazard model is that it implicitly assumes a constant hazard rate, whereas the hazard rate for a live CDO right before the financial crisis differs from one that is paid-in-full prior to the crisis. Including dummy variables for each quarter from 2007 to 2010 allows the baseline hazard rate to vary over time and yet the results are similar (see the Internet Appendix).

What would have been the effect on default if the CRA did not make the adjustment? We are able to collect asset default data as of March 2009 for a subset of 791 CDOs. We find that 234 CDOs had collateral impairment ratios (the fraction of defaulted assets in the collateral pool) higher than the AAA subordination, indicating that these AAA tranches would likely default. Had the CRA structured the CDOs at the model subordination ratio, 52 (or 22.2%) of those 234 CDOs would not have had impairment ratios exceeding model subordination. Since losses often accrue with a lag, our analysis here is limited by the fact that we are unable to collect default asset data after March 2009.

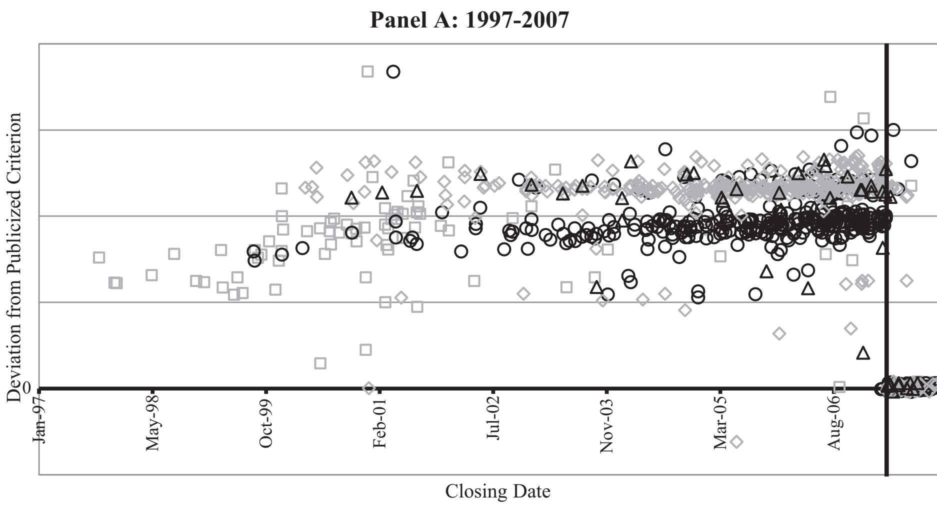
## V. Criterion Deviation

Our analysis thus far does not analyze the validity of CRA assumptions, which are the inputs of its model. In this section, we focus on the most straightforward model input: the default probability criterion, or CDOs' presumed credit risk.

### *A. Rating Default Probability Criterion*

Recall from Section I.B that the default probability criterion is the maximum default probability allowed under a particular rating and maturity as shown in the Internet Appendix. In our database, we have the actual default probability criterion reported for each CDO at each rating level. To examine the default probability criterion, we construct a "criterion deviation," defined as the actual criterion minus the publicized criterion (as shown in the Internet Appendix) with the same maturity. A zero deviation is rating at the edge, and a positive deviation represents a default threshold that is not as strict as the publicized criterion. If the CRA meets its publicized standards, it should never be the case that the actual default criterion is higher than that publicized.

Panel A of Figure 5 plots the time series of the criterion deviation for the AAA rating with CDO closing dates from January 1997 to December 2007. Although we map those deviations to rating magnitudes below, we do not report the values to keep the identity of the CRA anonymous. Only three CDOs appear to meet the criteria prior to 2007 and the rest of the deviations are positive, meaning that the riskiness of the AAA tranche is higher than the publicized criterion. Beginning in roughly April 2007, the deviations largely disappear.



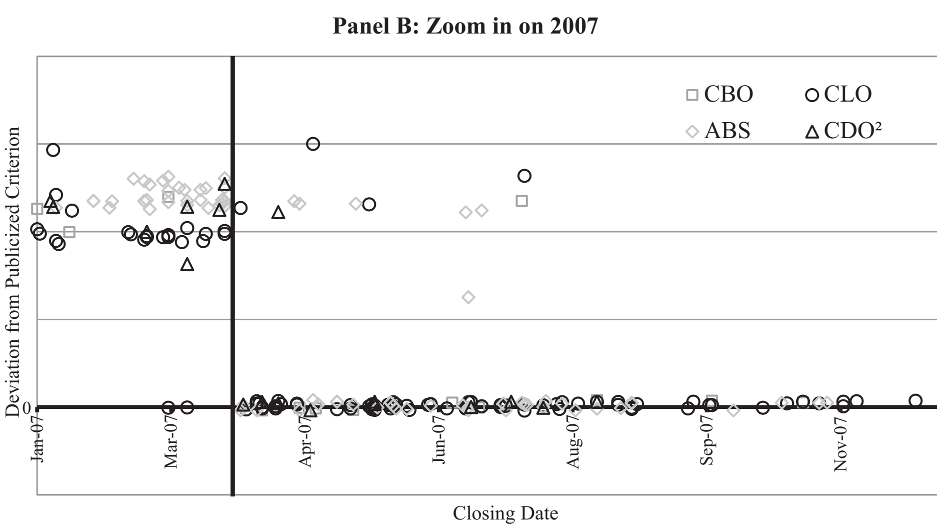




**Figure 5. Difference between actual and publicized default rate criterion for CDO AAA credit rating in first reports.** This figure graphs the deviation in actual default rate criterion from the publicized default rate criterion for CDO AAA credit ratings over time. The deviation is defined as the difference between the actual criterion in the first CRA surveillance reports and the publicized criterion with the same maturity (actual−publicized). The magnitude of the deviation ($y$-axis) is not shown to keep the anonymity of the data source. The black horizontal line refers to zero deviation, and the black vertical line refers to April 1, 2007.

Panel B of Figure 5 zooms in on 2007 and shows that there are relatively few deviations after April 1, 2007.[17]

[17] Differences in the length of time between when the deal was preliminarily rated and when the first surveillance report data appear can vary considerably and could potentially explain why a few CDOs issued after April 2007 continue to look similar to CDO reports prior to April.

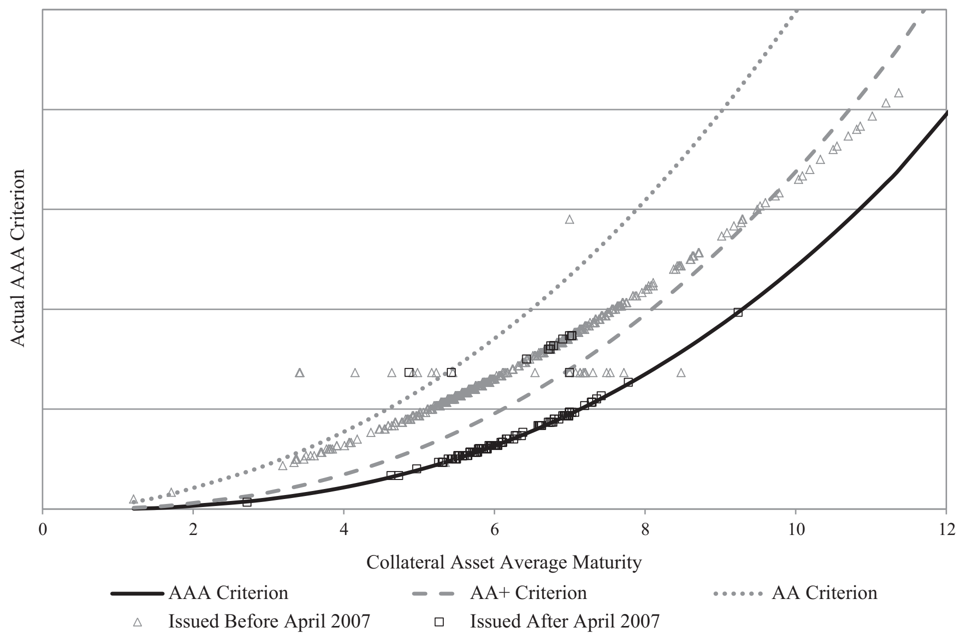



**Figure 6. Actual and publicized default rate criterion for CDO AAA credit rating in first reports.** This figure graphs the actual default rate criterion for the CDO AAA credit rating ($y$-axis) against collateral asset average maturity ($x$-axis) using data from the first CRA surveillance reports, along with the credit rating agency's publicized default rate criteria for AAA, AA+, and AA in rating software and manuals. The magnitude of the default rate criterion ($y$-axis) is not shown to keep the anonymity of the data source. The sample includes 916 CDOs issued between January 1997 and December 2007. CDOs issued before and after April 1, 2007 are plotted separately.

It is important to note that the criterion deviation in Figure 5 is an approximation, since it is not adjusted by differences in maturity. In Figure 6, we plot all actual AAA default probability criteria against maturity and see that the publicized criteria are smoothly distributed on a convex curve as expected. CDOs issued prior to April 2007 are shown as a light gray triangle. Before April 1, 2007, most of the actual default criteria lie on another distinctive curve, seemingly related to the shape of the publicized criteria but to the left, meaning that the default criteria are higher than the publicized criteria. CDOs with initial surveillance reports after April 1, 2007 are in dark squares and mostly overlap with publicized criteria. We also plot dashed and dotted lines for the publicized criteria of the AA+ rating and the AA rating. Most CDOs with AAA ratings only meet the AA rating criterion (between AA and AA+ publicized criterion lines).

We notice one additional, less prominent but clear, irregularity: 27 CDOs seem to form a straight line, independent of the maturity. Upon further investigation we notice that, for those CDOs, not only are their default probability criteria constant and identical, but their SDRs are exactly identical for each of the 19 rating scales from AAA to CCC–. This is only possible if the CDOs have the exact same portfolio loss distribution, which would seem improbable given that the CDO features differ considerably as discussed in the Internet Appendix.

Thus far, we have focused on a comparison of actual AAA default probabilities relative to publicized AAA default standards. We now compare the standards across all rating levels. To fully characterize this "criterion deviation" finding, we re-assign credit ratings for each tranche corresponding to the actual default criterion used for CDOs in our sample. The results for all CDOs are summarized in Table VI before and after April 1, 2007 in Panels A and B, respectively. For CDOs issued before April 1, 2007, Panel A shows that 1.3% of AAAs comply with the publicized AAA criterion, 4.8% comply with the publicized AA+ criterion, and 92.5% comply with the publicized AA criterion. The results are similar for AA+ to A–. A dramatic change occurs when 96.5% of the BBB actual default probabilities match publicized default probabilities for CDOs issued before April 1, 2007. Panel B shows that, for CDOs issued after April 1, 2007, the compliance rates (actual default probability meeting publicized default probability criterion) are above 90% for all ratings.

To gauge the economic importance of the default criterion deviation in a comparable scale, we ask how much more AAA the lower criterion allows. We find that using the publicized AAA default standard amounts to an increase in SDR (and hence less allowable AAA) of 2.7% according to our simulation model. Notice first that, while 2.7% seems small, this reduction in SDR could be critical in practice when the only condition for granting a rating is that the BDR must be greater than the SDR. Furthermore, the magnitude of the deviation might be important for a CDO that was structured with a BDR within striking distance of the SDR, the so-called "rating at the edge" practice. The lower tranches are also notoriously hard to place. Thus, examining 2.7% as a fraction of the total CDO is in some sense misleading. For our sample, on average 90.7% of the issuance is above BBB and 9.3% is rated BBB or below or unrated. Shifting 2.7% of the CDO from below BBB to investment grade means that, instead of having 12.1% of the CDO to place, there is only 9.3% of noninvestment grade debt—that is 22% less hard-to-place debt.[18]

### B. Potential Explanations

One possibility for the criterion shift in April 1, 2007 is that the criterion used by the rating agency was indeed different, but we only observe the most recent publicized criterion. We first track the CRA's default probability criterion updates. The CRA's documentation, including public news releases, research reports, and presentation slides at conferences and training sessions, confirms the consistency of the record of the publicized CDO rating criterion as shown in the Internet Appendix over time. Alternatively, the rating agency might have

[18] This might mean one fewer buyer. We thank an anonymous industry expert for bringing this issue to our attention.

**Table VI**

## Actual-Publicized CDO Rating Criterion Mapping Matrix

This table reports the frequency distribution of rating default rate criterion deviations. In the row "AAA," we compare the AAA rating default rate criterion actually reported in rating agency surveillance reports to the publicized default rate criterion with the same maturity in publicly distributed CDO rating software and manuals. If the actual criterion qualifies the publicized criterion, then we assign "0" notches deviated. If the actual criterion does not qualify for AAA rating according to publicized criterion, but qualifies for the "AA+" ("AA", "AA–," "A+" and below) criterion, then we assign "–1" ("–2," "–3," "–4 or less") notches deviated. We calculate the percentage for each category of notch deviations, so all numbers in each row add up to one. This procedure is done for all ratings from "AAA" to "CCC–." A default probability can qualify for a certain rating if the actual default probability is less than 1.05 times the publicized default probability of such a rating. The default probabilities are rounded to four decimal points. CDOs are issued over the periods from January 1997 to March 2007 (Panel A) and from April 2007 to December 2007 (Panel B).

| Panel A: CDOs Issued before April 1, 2007 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of Notches Deviated | | | | | | | |
| | 3 or more | 2 | 1 | 0 | −1 | −2 | −3 | −4 or less |
| AAA | – | – | – | 0.013 | 0.048 | 0.925 | 0.009 | 0.005 |
| AA+ | – | – | 0.005 | 0.017 | 0.951 | 0.015 | 0.008 | 0.004 |
| AA | – | 0.001 | 0.001 | 0.022 | 0.018 | 0.135 | 0.717 | 0.106 |
| AA− | 0.000 | 0.001 | 0.017 | 0.010 | 0.041 | 0.447 | 0.461 | 0.023 |
| A+ | 0.001 | 0.001 | 0.008 | 0.015 | 0.066 | 0.860 | 0.046 | 0.003 |
| A | 0.001 | 0.003 | 0.012 | 0.021 | 0.735 | 0.225 | 0.004 | 0.000 |
| A− | 0.001 | 0.004 | 0.014 | 0.049 | 0.923 | 0.006 | 0.003 | 0.000 |
| BBB+ | 0.004 | 0.009 | 0.008 | 0.408 | 0.568 | 0.004 | 0.000 | 0.000 |
| BBB | 0.004 | 0.009 | 0.009 | 0.965 | 0.013 | 0.000 | 0.000 | 0.000 |
| BBB− | 0.012 | 0.001 | 0.008 | 0.976 | 0.004 | 0.000 | 0.000 | 0.000 |
| BB+ | 0.012 | 0.001 | 0.015 | 0.959 | 0.010 | 0.003 | 0.000 | 0.000 |
| BB | 0.012 | 0.003 | 0.006 | 0.964 | 0.013 | 0.003 | 0.000 | 0.000 |
| BB− | 0.013 | 0.001 | 0.073 | 0.909 | 0.004 | 0.000 | 0.000 | 0.000 |
| B+ | 0.013 | 0.006 | 0.906 | 0.071 | 0.004 | 0.000 | 0.000 | 0.000 |
| B | 0.014 | 0.012 | 0.499 | 0.467 | 0.008 | 0.000 | 0.000 | 0.000 |
| B− | 0.019 | 0.031 | 0.866 | 0.080 | 0.004 | 0.000 | 0.000 | – |
| CCC+ | 0.022 | 0.059 | 0.875 | 0.044 | 0.000 | 0.000 | – | – |
| CCC | 0.022 | 0.492 | 0.483 | 0.004 | 0.000 | – | – | – |
| CCC− | 0.013 | 0.637 | 0.346 | 0.004 | – | – | – | – |

*(continued)*

**Table VI**—*Continued*

Panel B: CDOs Issued after April 1, 2007

| | Number of Notches Changed | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 or more | 2 | 1 | 0 | −1 | −2 | −3 | −4 or less |
| AAA | – | – | – | 0.913 | 0.008 | 0.072 | 0.007 | 0.000 |
| AA+ | – | – | 0.000 | 0.913 | 0.072 | 0.007 | 0.007 | 0.000 |
| AA | – | 0.000 | 0.000 | 0.913 | 0.000 | 0.007 | 0.065 | 0.014 |
| AA− | 0.000 | 0.000 | 0.000 | 0.913 | 0.007 | 0.058 | 0.014 | 0.007 |
| A+ | 0.000 | 0.000 | 0.000 | 0.913 | 0.007 | 0.065 | 0.014 | 0.000 |
| A | 0.000 | 0.000 | 0.000 | 0.913 | 0.072 | 0.014 | 0.000 | 0.000 |
| A− | 0.000 | 0.000 | 0.000 | 0.920 | 0.072 | 0.007 | 0.000 | 0.000 |
| BBB+ | 0.000 | 0.000 | 0.000 | 0.957 | 0.043 | 0.000 | 0.000 | 0.000 |
| BBB | 0.000 | 0.000 | 0.000 | 0.986 | 0.014 | 0.000 | 0.000 | 0.000 |
| BBB− | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| BB+ | 0.000 | 0.000 | 0.000 | 0.986 | 0.014 | 0.000 | 0.000 | 0.000 |
| BB | 0.000 | 0.000 | 0.000 | 0.986 | 0.014 | 0.000 | 0.000 | 0.000 |
| BB− | 0.000 | 0.000 | 0.007 | 0.993 | 0.000 | 0.000 | 0.000 | 0.000 |
| B+ | 0.000 | 0.000 | 0.072 | 0.928 | 0.000 | 0.000 | 0.000 | 0.000 |
| B | 0.000 | 0.000 | 0.072 | 0.928 | 0.000 | 0.000 | 0.000 | 0.000 |
| B− | 0.000 | 0.000 | 0.072 | 0.928 | 0.000 | 0.000 | 0.000 | – |
| CCC+ | 0.000 | 0.000 | 0.087 | 0.913 | 0.000 | 0.000 | – | – |
| CCC | 0.000 | 0.065 | 0.022 | 0.913 | 0.000 | – | – | – |
| CCC− | 0.000 | 0.072 | 0.014 | 0.913 | – | – | – | – |

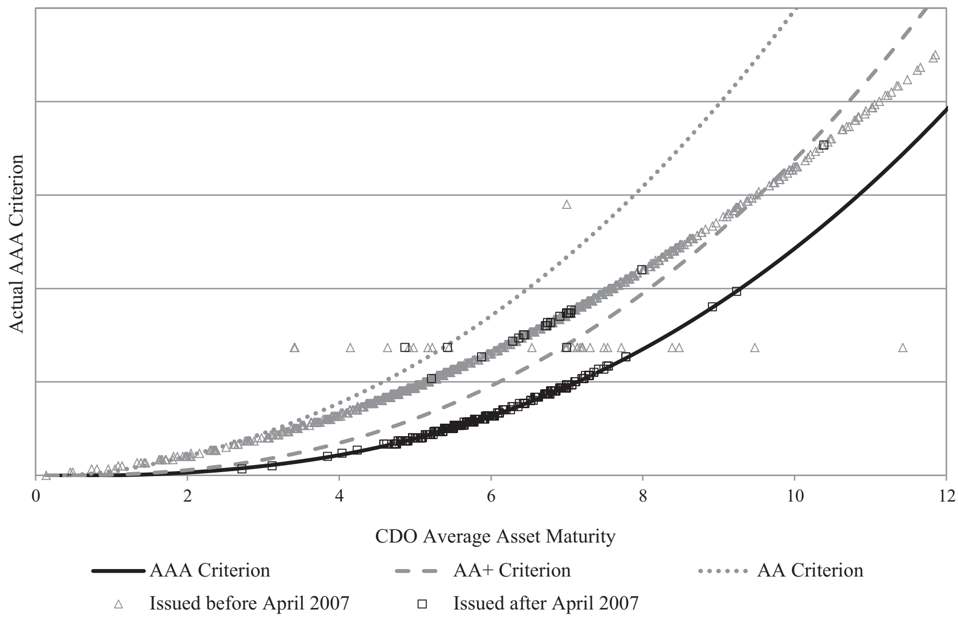



**Figure 7. Actual and publicized default rate criterion for CDO AAA credit rating in all reports after April 1, 2007.** This figure graphs the actual default rate criterion for the CDO AAA credit rating ($y$-axis) against collateral asset average maturity ($x$-axis) using data from all CRA surveillance reports from April 1, 2007 to September 30, 2008, along with the CRA's publicized default rate criteria for AAA, AA+, and AA in rating software and manuals. The magnitude of the default rate criterion ($y$-axis) is not shown to keep the anonymity of the data source. The sample includes 916 CDOs issued between January 1997 and December 2007. CDOs issued before and after April 1, 2007 are plotted separately.

used a default probability criterion before 2007 but an expected loss criterion after 2007, which would appear consistent with Figure 6.[19] However, we verify from several CRA documents that the CRA used the exact same default criterion during and even more than a year after the end of our December 2007 sample period.

As our analysis so far is based on the first surveillance report after the CDO issuance, we now examine the criteria used by the CRA after April 1, 2007 in continuing surveillance reports. In Figure 7, we label the CDOs by whether their date of issuance is before April 1, 2007 (triangles) or after April 1, 2007 (squares). During the 18 months from April 2007 to September 2008 (when these data stop), there are two main default probability criteria actually used by the CRA for AAA ratings. CDOs issued after April 1, 2007 (the squares) follow the publicized lower default probability criterion strictly. But all of the CDOs issued prior to April 2007 continue to use the same default probability criterion demonstrated at the time of issue (in Figure 6). It is not clear how a

[19] We thank the referee for this point.

CRA model can use two different CDO standards simultaneously. If the rating agency switched to the use of expected loss rates, then it would seem that this switch should apply to all of the continuing surveillance reports and not just those for CDOs issued after April 2007.

Importantly, there is no disclosure of changing CDO modeling methods or varying standards in any of the CRA websites regarding CDOs around April 2007 that we can locate in our extensive searches. We find that the same default probability tables are used prior to and after April 2007. However, there was some documented tightening of standards for MBS securities and a decline in ABX.HE (an index of CDOs backed by home equity loans) beginning in January 2007. A most notable quote on March 3, 2007 (Mitchell (2009)) states that, "the legs that power the CDO machine for the last three years have fallen off." On April 17, 2007, the managing director of S&P RMBS testified before a Senate banking subcommittee. More details on surrounding credit market conditions are provided in the Internet Appendix.

## VI. Replicating CRA Modeling and Measuring Economic Value

### *A. Simulation Approach to CDO Valuation*

How closely can we replicate the CRA model? There are several reasons why answering this question is useful. First, it helps us discover if the CDO modeling process is standard and if there are large structural shifts. Second, it allows us to semivalidate whether our interpretation of the CDO modeling process as documented by the CRA is consistent with the CRA's model outcome. Third, the replication is useful for examining valuation differences.

We use the Gaussian Copula Monte Carlo simulation model as it is the most widely used by professionals. Most of the average inputs are available in the CRA database. We estimate our simulation with average CDO characteristics (collateral rating and asset correlation) used by the CRA, rather than specific underlying collateral details. However, CRAs often (at least preliminarily) rate before detailed information is available.

We calculate the AAA fraction ($1-\mathrm{SDR}^{\mathrm{AAA}}$) from our Monte Carlo simulation as compared to the output from the CRA and find that, cross-sectionally, the two models have a correlation of 0.82. The high correlations, despite the simplicity of our model, suggest that the CRA approach must be fairly standard. To shed light on the difference between our simple simulation model and the CRA model, we regress the AAA fraction difference (CRA model over our model) on CDO structural characteristics in Table VII. In specification 1, we consider CDO features directly related to our simulation approach. The 0.452 adjusted $R^2$ from the CDO structural variables indicates that the models are indeed systematically different. Specifications 2 and 3 show that the differences between the model and the CRA fraction are not largely related to manager experience or credit enhancement features (overcollateralization, liquidity, and insurance). This indicates that these features are not critical considerations in the CRA model.

**Table VII**

## Rating Agency and Our Simulation AAA Fraction Difference Regressions

This table reports coefficient estimates from OLS regressions. The dependent variables are the difference between the CDO AAA fraction from the CRA model and from a Monte Carlo model (CRA AAA – Monte Carlo AAA). The Monte Carlo simulation inputs are average collateral default rates, maturity, correlations, and number of assets reported by the CRA. The simulation approach is described in the Internet Appendix. The independent variables are described in Table I. *CLO*, *ABS CDO*, and *CDO*$^2$ are collateral asset type dummy variables. Closing year dummies for 2002 to 2007 are included with closing year 2001 and before as the comparison group. CDOs are issued over the January 1997 to December 2007 period. White (1980) heteroskedasticity-adjusted $t$-statistics are in parentheses.

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Intercept | 0.160 | 0.016 | 0.036 | −0.006 | 0.137 | 0.471 | 0.562 | 0.201 |
| | (1.68) | (3.17) | (5.83) | (−0.63) | (1.37) | (4.24) | (6.07) | (1.94) |
| Col. Def. Prob. | −2.116 | | | | −2.118 | | −1.400 | −2.168 |
| | (−13.05) | | | | (−12.99) | | (−11.09) | (−13.25) |
| Avg. Col. Rating | 0.008 | | | | 0.008 | −0.002 | | 0.009 |
| | (7.28) | | | | (6.93) | (−2.00) | | (7.11) |
| Avg. Col. Maturity | −0.007 | | | | −0.007 | −0.003 | −0.006 | −0.006 |
| | (−4.16) | | | | (−4.16) | (−1.80) | (−3.52) | (−3.68) |
| Correlation | −0.003 | | | | −0.005 | −0.026 | −0.019 | −0.036 |
| | (−0.18) | | | | (−0.27) | (−1.18) | (−0.93) | (−1.77) |
| Log(CDO Size) | −0.011 | | | | −0.011 | −0.027 | −0.029 | −0.015 |
| | (−2.44) | | | | (−2.35) | (−4.94) | (−6.11) | (−3.00) |
| Number of Assets | 0.000 | | | | 0.000 | 0.000 | 0.000 | −0.000 |
| | (1.21) | | | | (0.11) | (0.63) | (0.44) | (−0.05) |
| Number of Obligors | 0.001 | | | | 0.001 | 0.001 | 0.001 | 0.001 |
| | (10.07) | | | | (10.32) | (9.76) | (10.10) | (10.79) |
| Log(Mgr Deal #) | | 0.009 | | | −0.003 | −0.004 | −0.004 | −0.004 |
| | | (3.13) | | | (−1.42) | (−1.69) | (−1.52) | (−1.65) |
| Overcollateralization | | | −0.002 | | 0.003 | 0.005 | 0.003 | 0.004 |
| | | | (−0.30) | | (0.81) | (1.19) | (0.81) | (1.11) |
| Insurance Dummy | | | −0.033 | | 0.003 | −0.011 | 0.002 | 0.004 |
| | | | (−2.69) | | (0.27) | (−1.05) | (0.21) | (0.45) |
| Liquidity Dummy | | | −0.016 | | 0.002 | 0.006 | 0.004 | 0.005 |
| | | | (−2.31) | | (0.40) | (0.97) | (0.70) | (0.90) |
| CLO | | | | 0.062 | 0.030 | 0.030 | 0.044 | 0.028 |
| | | | | (6.32) | (3.25) | (2.51) | (4.00) | (2.54) |
| ABS CDO | | | | 0.028 | 0.031 | 0.038 | 0.020 | 0.038 |
| | | | | (2.85) | (2.86) | (2.95) | (1.65) | (3.20) |
| CDO$^2$ | | | | −0.027 | 0.014 | 0.019 | 0.005 | 0.016 |
| | | | | (−1.88) | (0.99) | (1.15) | (0.32) | (1.08) |
| Synthetic Dummy | | | | −0.016 | −0.007 | 0.001 | 0.002 | −0.010 |
| | | | | (−1.85) | (−0.90) | (0.10) | (0.27) | (−1.23) |
| Closing Year 2002 | | | | | | 0.003 | −0.013 | −0.009 |
| | | | | | | (0.17) | (−0.91) | (−0.68) |

(*continued*)

**Table VII**—*Continued*

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Closing Year 2003 | | | | | | 0.020 | 0.006 | 0.014 |
| | | | | | | (1.47) | (0.43) | (1.14) |
| Closing Year 2004 | | | | | | 0.002 | −0.007 | 0.005 |
| | | | | | | (0.14) | (−0.62) | (0.46) |
| Closing Year 2005 | | | | | | 0.009 | −0.001 | 0.010 |
| | | | | | | (0.73) | (−0.05) | (0.90) |
| Closing Year 2006 | | | | | | −0.004 | −0.010 | 0.002 |
| | | | | | | (−0.36) | (−0.91) | (0.19) |
| Closing Year 2007 | | | | | | 0.019 | 0.017 | 0.029 |
| | | | | | | (1.44) | (1.37) | (2.46) |
| $N$ | 902 | 902 | 902 | 902 | 902 | 902 | 902 | 902 |
| Adjusted $R^2$ | 0.452 | 0.010 | 0.011 | 0.099 | 0.460 | 0.364 | 0.439 | 0.469 |

Specifications 4 to 8 show that CDO type is somewhat important. Year dummies in specifications 6 to 8 are insignificant in most years but increase slightly in 2007. This indicates that the CRA model likely did not change much over the period with the possible exception of 2007.

In sum, the differences between our simulation and the CRA model could be due to our use of only average collateral characteristics and the simplicity of our modeling approach. Given these limitations, we are surprised that the simple Gaussian Copula Monte Carlo approach replicates the CRA model closely—the cross-sectional correlation between our simulation AAA size and the CRA model is 0.82, whereas the CRA model and the observed AAA size have a correlation of 0.49 with the CRA model. Our results indicate that the CRA modeling approach is fairly conventional, but this analysis cannot rule out model error nor examine the validity of the assumptions.

### *B. Economic Magnitudes of the CRA Adjustments and the Criterion Deviation*

To gain a sense of the economic importance of the AAA CRA adjustment and the criterion deviation, we perform several suggestive valuation calculations. For most of our analysis, we focus only on the AAA class, which entails most of the valuation of the deal. We use two methods. The first method revalues the AAA tranches by asking what the adjusted AAA tranche would have been worth had the CRA assigned ratings strictly according to its credit risk model. If the CRA cut the AAA tranche above the level justified by the model (1–SDR), we re-rate only this additional portion of the tranche. Our second method takes the issued sizes of the AAA tranches as fixed (as they were sold) but assign ratings to them using our simple simulation model. If the CDO has multiple AAA tranches, we distinguish the senior (and super senior) AAA tranche from the junior AAA tranche so that cutting the CDO at the stated default levels (without an adjustment) may only affect the rating of the lowest AAA tranche. For each method, we calculate the effect of the adjustment with and without the criterion deviation.

To illustrate the first method, assume for a hypothetical deal that the actual AAA size is 80% but the model implied AAA size is only 70% (because of an $SDR^{AAA}$ of 30%). We then rerate the additional 10% by mapping the rating corresponding to the 20% SDR cutoff in the CRA model outputs, which contain the complete list of SDRs for all rating scales. If the SDR for a BBB rating is 20%, then the additional 10% (80% to 70%) is assigned a BBB rating. Subsequently, we revalue the additional 10% of capital by the spread difference between what it was rated at AAA and BBB.

For the first method, we find that if CRAs had cut the AAA rating at the model-implied level without the 12.1% adjustment, an average of \$87.7 million per CDO would need to be rerated. This \$87.7 million would demand a 2.2% higher than the AAA spread according to concurrent market information. We calculate the value difference of this \$87.7 million according to the simple duration approximation:[20]

$$\begin{aligned} \textit{Value Dif} &= \textit{Col. Maturity} \times (\textit{AAA Spread} - \textit{Altern. Rating Spread}) \\ &\quad \times (\$ \textit{ of Affected AAA Fraction}). \end{aligned} \tag{1}$$

Because the average maturity is 6.45, we find a total valuation difference of \$14.7 million dollars per CDO as displayed in Table VIII. When we use the publicized AAA default criterion, this approach also lumps together the much smaller criterion deviation effect. Hence, we also value the deal using AAA default criteria used in practice and end up with a valuation of \$12.33 million that is solely attributable to AAA adjustments (implying that the criterion deviation inflates values by \$2.4 million per CDO).

For our second estimates, we use our Monte Carlo model; recall that it yielded close estimates.[21] We rerate each AAA tranche according to the given deal structure. For example, if the actual amount of AAA capital is 80%, then the subordination level is 20%. We use the Monte Carlo simulation to find the corresponding rating with SDR of 20%, say, BBB. But if the AAA tranche consists of an A-1 tranche of 55% and an A-2 tranche of 25%, only the A-2 tranche is rerated and revalued at BBB. Using this method, we find that bottom AAA tranches are cut to ratings that we estimate as being equivalent to BBB. Table VIII shows that the valuation difference according to the Monte Carlo simulation amounts to \$42.20 million per CDO. For our sample of 916 CDOs, this amounts to \$38.7 billion. When the criterion deviations are ignored, the difference shrinks to \$35.02 million per CDO, indicating that most of the economic magnitude is driven by adjustments. As with the first method, the valuation differentials are largest among the ABS CDOs.

The above method assumes strict sequential priority structure across tranches. According to Mason (2010), since 2005 an increasing proportion of CDOs have adopted pro-rata principal payment schedules. Pro-rata payments

[20] Due to the lack of coupon information, we further approximate modified duration ("effective maturity") with maturity. Note that we are using collateral asset maturity rather than CDO notes legal maturity.

[21] On average, the CRA model gives 2.3% more AAA than our Monte Carlo simulation.

**Table VIII**

**Valuation Effect of Subjectivity**

This table reports the valuation consequence of adjustment and criterion deviation. The *Value Difference* per CDO is calculated as follows: *Value Difference* = *Collateral Average Maturity* × *Size Affected* × *Spread Difference*, where *Collateral Average Maturity* is the average maturity of collateral assets, *Size Affected* is the dollar value affected by subjectivity, and *Spread Difference* is the difference between the AAA spread of the affected part and a benchmark spread. The benchmark spread is calculated using three methods. The first method in Panel A takes CRA outputs across the entire rating spectrum and assigns ratings to the actual CDO structure. If the top tranche size is 75.5% and the rating agency model indicates 75.0% can obtain A rating, then this tranche is rated as BBB+. The second method in Panel B and its variant in Panel C use our Monte Carlo simulation to rate the tranches. Panel B evaluates each tranche separately. Panel C bundles all AAA tranches together. Two effects drive the difference between Panels B and C. First, on average, the junior AAA tranche has wider spread (46 bps) than the senior AAA tranche (35 bps). Second, junior AAA tranche size is on average smaller than the senior AAA tranche size. All methods are applied with and without the criterion deviation. Data are from the first CRA CDO surveillance reports and the CDO rating databases. Data are grouped by collateral asset type (*CBO* for collateralized bond obligations, *CLO* for collateralized loan obligations, *ABS CDO* for CDOs of asset-backed securities, and *CDO²* for CDOs of CDOs). The sample includes 916 CDOs issued over the January 1997 to December 2007 period.

| | All | CBO | CLO | ABS CDO | CDO² |
|---|---|---|---|---|---|
| Number of CDOs | 916 | 96 | 393 | 373 | 54 |
| Collateral Average Maturity (years) | 6.45 | 5.30 | 5.74 | 7.23 | 8.31 |
| Panel A: Method #1 (Adjusted Portion with Model Implied Rating) | | | | | |
| Size Affected ($ millions) | 87.67 | 56.51 | 83.90 | 98.37 | 96.52 |
| Model Rating | BBB+ | BBB | BBB− | A− | A |
| Spread Difference Total (%) | 2.24 | 2.27 | 2.52 | 2.04 | 1.50 |
| Value Difference Total ($ millions) | 14.73 | 7.38 | 13.12 | 17.72 | 15.25 |
| Value Difference w/o Deviation ($ millions) | 12.33 | 6.12 | 11.96 | 14.08 | 11.17 |
| Panel B: Method #2 (Multiple Tranches Impacted Differently) | | | | | |
| Size Affected ($ millions) | 289.57 | 223.23 | 273.64 | 328.59 | 253.98 |
| Model Rating | BBB | BBB | BBB | BBB | BBB+ |
| Spread Difference Total (%) | 2.40 | 2.51 | 2.49 | 2.41 | 1.57 |
| Value Difference Total ($ millions) | 42.20 | 29.46 | 39.35 | 48.74 | 32.77 |
| Value Difference w/o Deviation ($ millions) | 35.02 | 24.50 | 35.53 | 38.14 | 22.77 |
| Panel C: Variant of Method #2 (Bundling AAA Together) | | | | | |
| Size Affected ($ millions) | 529.62 | 342.51 | 366.54 | 761.05 | 450.60 |
| Model Rating | BBB | BBB | BBB | BBB | BBB+ |
| Spread Difference Total (%) | 2.56 | 2.54 | 2.53 | 2.66 | 2.14 |
| Value Difference Total ($ millions) | 94.13 | 54.75 | 52.94 | 146.83 | 74.68 |
| Value Difference w/o Deviation ($ millions) | 78.91 | 47.92 | 47.49 | 120.40 | 57.47 |

essentially give the same security to all AAA-rated tranches in the same class in terms of principal payments. We do not have data on what fraction of CDOs have a pro-rata payment schedule.[22] If we group all rating classes

[22] Another rationale for grouping AAA tranches as a whole is that credit enhancement from overcollaterization and interest coverage tests are generally only implemented at the class level

together, then Panel C in Table VIII shows that the valuation effect more than doubles.

Since valuations differ considerably, even between the first two methods, we briefly discuss their differences. The first method asks how much value the adjustment and criterion deviation added to the transaction from the perspective of the investment bank structuring the deal. The second method is similar to asking what the valuation impact would have been to investors who bought the AAA tranches (as they were sold) if they were in fact rated BBB. Interestingly, from the perspective of the investment bank, even the first method's estimate of \$14.7 million is quite important. If the underwriting fees are 1.25% to 1.5% of the asset size, then the fees would be \$7.9 to \$9.5 million per CDO for our sample (with average deal size of \$634 million). This rating inflation allows the structure to receive interest payments greater than their payouts, which is crucial for the economics of CDOs (Coval et al. (2009b)).

Overall, these suggestive estimates, while substantial, are likely understatements. For example, moving massive amounts of capital to BBB would surely increase BBB spread differentials as the demand was primarily for AAA. Additionally, we do not consider the important effects of systematic default risk and parameter uncertainty as described in Coval et al. (2009a,b). Like Coval et al. (2009a), we provide another metric that indicates AAA tranches were massively overpriced. Our analysis can also shed light on the CDO market going forward. After controlling for other factors such as collateral characteristics, CDOs' AAA fractions would need to be much smaller, and deals will be considerably less profitable. Indeed, CDO issuance has shrunk from \$520.6 billion in 2006 and \$481.6 billion in 2007 to \$4.3 billion in 2009 and \$8.0 billion in 2010 according to SIFMA.

## VII. Summary and Concluding Remarks

This paper examines subjectivity in CDO credit ratings by focusing on what happens beyond a CRA's direct quantitative model. Using data on 916 CDOs issued from 1997 to 2007, we find that the actual size of the AAA tranche exhibits a correlation of only 0.49 with the size from the CRA credit risk model, indicating that this modeling process is roughly 25% of the picture. "Adjustments" to the CRA credit risk model are positive, amounting to an additional 12.1% AAA for the average CDO. Adjustments are not explained by likely candidates such as manager experience or credit enhancements. CDOs with lower proportions of AAA implied by the CRA model received higher adjustments. Adjustments are positive predictors of future downgrades—they were not helpful in practice.

Additionally, in examining default risk criteria, we document an empirical irregularity distinct from the adjustment. The AAA default risk criterion prior to April 2007 is typically a full rating lower than the stated default risk rating criterion. Thereafter, the CRA switched to the stated criteria for most of the newly issued CDOs. Nevertheless, even after April 2007, CDOs issued prior to

(instead of the tranche level). Hence, a senior AAA and a junior AAA can effectively have similar protection. More details are in the Internet Appendix.

April 2007 kept the old criterion, such that there were two default probability criteria in place simultaneously. Even using the most conservative calculations, the valuation impacts of adjustments and the criterion deviation were much greater than structuring and rating fees and hence would explain the push for underwriters to securitize $1.7 trillion of CDOs between 2000 and 2007 (SIMFA).

Our results have important direct implications for investors and regulators in determining the proper role of CRAs.[23] First, there has been a recent movement to blame modeling, and the top rating agencies have made their rating process more qualitative.[24] Our findings suggest that this step is in the wrong direction. Second, even after the crisis, rating agencies are careful not to disclose all the details on how they rated past or current deals. Data on key inputs, outputs, and the rating modeling process should be made more, not less, transparent. The modeling box could then be opened and debated. Third, upward adjustments should not be allowed. If a model is flawed or incomplete, it should be formally corrected.

While we help answer part of the rating accuracy question, it is important to note that our study is not meant to be interpreted as a comprehensive analysis of what caused CDOs to fail so quickly. In addition to the factors in this paper, it is quite likely that other effects were jointly at work and we hope to see more research on structured finance credit ratings. Our findings also suggest that perhaps researchers should more carefully examine the claims of Akerlof and Romer (1993) (emphasized recently by Akerlof and Shiller (2009)) regarding linkages between financial sophistry and financial crises. The causes for the failure of the shadow banking system may be deeper than an exogenous banking sunspot.

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[23] Partnoy (2009b) and Coffee (2010) discuss proposals for credit rating agency reform.

[24] Modeling method reforms by S&P (2009) and Moody's (2009) both emphasize a greater role for qualitative elements.

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