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SIZING AND ASSESSING THE SUBPRIME CDO CRISIS

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Collateral Damage:
Sizing and Assessing the Subprime CDO Crisis

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Abstract

This paper conducts an in-depth analysis of structured finance asset-backed securities collateralized debt obligations (SF ABS CDOs), the subset of CDOs that traded on the ABS CDO desks at the major investment banks and were a major contributor to the global financial panic of August 2007. Despite their importance, we have yet to determine the exact size and composition of the SF ABS CDO market or get a good sense of the write-downs these CDOs will generate. In this paper we identify these SF ABS CDOs with data from Intex©, the source data and valuation software for the universe of publicly traded ABS/MBS securities and SF ABS CDOs. We estimate that 727 publicly traded SF ABS CDOs were issued between 1999 and 2007, totaling $641 billion. Once identified, we describe how and why multi-sector structured finance CDOs became subprime CDOs, and show why they were so susceptible to catastrophic losses. We then track the flows of subprime bonds into CDOs to document the enormous cross-referencing of subprime securities into CDOs. We calculate that $201 billion of the underlying collateral of these CDOs was referenced by synthetic credit default swaps (CDSs) and show how some 5,500 BBB-rated subprime bonds were placed or referenced into these CDOs some 37,000 times, transforming $64 billion of BBB subprime bonds into $140 billion of CDO assets. For the valuation exercise, we estimate that total write-downs on SF ABS CDOs will be $420 billion, 65% of original issuance balance, with over 70% of these losses having already been incurred. We then extend the work of Barnett-Hart (2009) to analyze the determinants of expected losses on the deals and AAA bonds and examine the performance of the dealers, collateral managers, and rating agencies. Finally, we discuss the implications of our findings for the "subprime CDO crisis" and discuss the many areas for future work.

I. Introduction

How much will total write-downs be on the universe of CDOs at the center of "the Panic of 2007"?[2] We set out to answer this question not just to clear up speculation about the amount of the write-downs but also to get an understanding of the exact size and composition of the market.[3] Our quest to answer this question and our bottom line figure of $420 billion of write-downs on $641 billion of issuance turned out to be a complicated undertaking, but for reasons much different than expected. The actual pricing of the CDO securities, that many contend is impossible,[4] proved to be among the more straightforward parts of our analysis. What proved to be much more difficult were several of the more basic parts of our research. First among them was defining the universe of publicly traded CDOs that traded on the major ABS CDO desks; these CDOs are considered a major factor in the panic that erupted in financial markets in August 2007 (Covitz, Liang, and Suarez (2009)). Developing a robust classification for the SF ABS CDO market and then identifying the 727 CDOs that comprise this market was complicated not because we could not find any source that attempted to define this market in a systematic way. Once identified, it cleared up much confusion about the size, composition, and institutional features of the SF ABS CDO market as well as making clear how and why this market came to be dominated by subprime securities, increasingly of the synthetic type. Surprisingly, tallying life-to-date write-downs proved more difficult than the valuation exercise for still active securities, which is most important to do since write-downs already incurred make up 71% of our $420 billion estimate. Finally, standardizing data across the many different structures presented a number of challenges that, once resolved, gave us valuable information for our multivariate analysis.

To do our analysis, one needs access to, and expert knowledge of, monthly data files and valuation software from Intex, which we will show is the source data for the universe of publicly issued private-label mortgage-backed securities (MBS)[5] as well as publicly traded SF ABS CDOs.[6] Surprisingly, no academic studies of this market make direct use of Intex,[7] and investment banks that have used Intex (e.g., Goodman, et. al. 2008) have yet to conduct a comprehensive analysis of the type we undertook. Today, these investment banks have no interest in conducting a study of a market that has completely shut down and which has generated extraordinary amounts of write-downs, many at the banks themselves.

This paper is organized as follows. In Section II we first briefly describe the structural features of SF ABS CDOs. Our summary figures for subordination levels on the AAA bonds identify a major disconnect in

[2] This characterization of the financial crisis beginning in 2007 is by Gorton (2008).
[3] One early figure from a credible source had losses of $500 billion on a trillion dollars of issuance. See *CreditFlux Newsletter*, January 8, 2008. Lewis (2010) ended his book without knowing what losses on CDOs were or what the size of the market was.
[4] As Gorton (2008, p. 3) put it, "Looking through to the underlying mortgages and modeling the different levels of structure was not possible." Lewis (2010) repeatedly quotes market participants with the same view, many accusing the CDO dealers of withholding information from investors.
[5] Private-label, or nonagency, MBS refers to those securities not issued by the three agencies, Fannie Mae, Freddie Mac, and the Government National Mortgage Association (GNMA).
[6] This surprisingly little-known company is immortalized in a 2009 article in the *New Yorker* by Osinski (2009), who explains how he wrote the program for the Intex DealMaker™ that became "the bomb that blew up Wall Street."
[7] Barnett-Hart (2009) was able to indirectly use Intex with "Lehman Live," a database of some 735 CDOs compiled by Lehman Brothers. We confirmed Intex is the source data and do a comparison with our database below.

the risk assessments of subprime MBS and CDOs that is essential to understanding the extraordinary losses of the CDOs. We then describe our methodology for defining and sizing the SF ABS CDO market. We estimate that, from start to finish, 727 publicly traded SF ABS CDOs were issued between 1999 and 2007 totaling $641 billion. All told, $201 billion of the underlying collateral of SF ABS CDOs was referenced by synthetic credit default swaps (CDSs). Then we track through the flows of subprime securities into CDOs and show how $64 billion of BBB-rated subprime bonds became $140 billion of CDO collateral. In Section III, we describe how we extracted data from Intex and other sources and produce summary statistics. In Section IV, we describe our process for first compiling write-downs and then our approach for generating expected write-downs to arrive at our $420 billion figure. In Section V, we extend the important work of Barnett-Hart (2009) to analyze the determinants of write-downs on the universe of SF ABS CDO bonds.[8] In Section VI, we conclude by summarizing our findings, assessing the implications of the subprime CDO crisis, and discuss areas for future work.

II. Design and Classification of SF ABS CDOs

We begin our analysis in subsection A by describing the structural features of SF ABS CDOs and show how susceptible they were to catastrophic losses. In subsection B, we describe how we classify the SF ABS CDO subsector and how we use the Intex issuance data to size the market. We also show how and why the market came to be dominated by subprime securities, increasingly synthetic subprime securities. In subsections C and D, we then size two key components of the SF ABS CDO market, the cash and synthetic parts of the market, and the mezzanine and high grade parts. Finally, in subsection E, we track the flows of subprime mortgage bonds from 1998 to 2007 to take an accounting of how many, and how often, these securities were placed into SF ABS CDOs and how much CDO collateral they created.

A. Design of SF ABS CDOs

Figure 1 is a stylized visualization of the transformation of mortgage loans to mortgage-backed securities to SF ABS CDOs and, finally, to CDO^{2}s. While this chart is represented elsewhere,[9] what we add are actual figures on the size of the various submarkets from the analysis we describe below, as well as some structural features of the securities. As shown, between 1998 and 2007, a total of $3.3 trillion of mortgage loans were placed into RMBS securities (i.e., prime or Alt-A securities), $2.5 trillion into home equity, or HE, securities (i.e., mostly subprime but also some junior lien and "scratch and dent" loans), for a total of $5.8 trillion of private-label MBS issuance. Mortgage loans are the assets (collateral) for the RMBS and HE securities; liabilities are issued in the form of rated and nonrated securities and sold to investors. Exactly why prime and Alt-A securities are classified as RMBS and traded on the "Resi" desks, while subprime securities are considered ABS and traded on the ABS desks, is described below.

The CDOs use RMBS and HE securities as assets. CDO liabilities are, again, set up in the form of rated and nonrated securities. Generally, bonds with a credit rating of A or above were placed into so-called "high-grade" CDOs; BBB-rated bonds were placed into mezzanine SF ABS CDOs.[10] Based on our analysis, $342 billion of high-grade SF ABS CDOs were issued, and $299 billion of mezzanine SF ABS

[8] We are especially indebted to Anna Katherine Barnett-Hart, who shared her data with us, allowing us to understand her sources and learn from them as we developed our own database.

[9] This depiction was originally done by UBS by Goodman et. al (2008) and reprinted in Gorton (2008), but using only representative numbers for tranche sizes.

[10] This is only a stylized model because in practice it is the weighted average rating that determines the classification, calculations we do below, so bonds with all different ratings can appear in each.

CDOs. The final link in the chain is the CDO^{2}s, whose underlying collateral is primarily CDO bonds. Forty-eight SF ABS CDO^{2}s were issued totaling $31 billion. Our classification for CDO^{2}s was done by using the simple rule that CDOs made up at least 50% of total deal collateral.[11]

While residential mortgage bonds are the primary asset in SF ABS CDOs, all manner of other securities or loans could be included as well. In Table 1 we detail the major categories of collateral for the universe of SF ABS CDOs. A total of 68% of SF ABS CDOs are made up of RMBS or HE securities. Another 10% are made up of other SF ABS CDOs and another 6% commercial mortgage-backed securities (CMBS). All other asset classes of securities and loans make up the remaining 15%. Below, we will show that by 2006 the composition of CDOs shifted to be made up mostly of subprime bonds and other CDOs.

Figure 1 also contains information on structural features of RMBS, HEs, and CDOs, which need to be discussed to fully understand our analysis. Principal and interest (P&I) collections from loans or bonds are distributed to security holders according to the priority of payment, or "waterfall," rules stipulated in the prospectuses of each deal. AAA bonds sit at the top of the waterfall because they are the last to suffer losses in the event that the underlying assets default. Percents in parentheses are averages of the subordination that exist for each of the rated securities. Subordination is a summary measure of how high losses need to be before the bonds suffer losses. First, note that lower rated bonds have less subordination than higher rated bonds across all asset classes. Note also that AAA RMBS bonds have the lowest amount of subordination at 6%, while the AAA CDO^2 bonds have the highest at 26%. Generally speaking, losses on the CDO^{2}s need to reach 26% before the senior AAA bondholders take a loss, while losses would need to reach only 6% for RMBS AAA bonds to suffer losses.

These summary subordination figures, however, point to a critical disconnect between risk assessments given to subprime MBS and that given to SF ABS CDOs that help explain the extraordinarily large write-downs for the CDOs. As shown in Figure 1, the average subordination levels on the junior AAA-rated bonds of the mezzanine SF ABS CDOs and CDO^{2}s have comparable levels of subordination to those provided to the AAA HE mortgage bonds. Note, however, that mezzanine CDOs are composed of collateral made up primarily of BBB-rated subprime securities, not houses. Subprime mortgage losses, on average, needed to reach only 8%, the average subordination level for the A-rated bonds, before the BBB-rated bonds are completely written down. According to Gerardi, et al. (2008), the consensus view on losses in early 2007 was around 3% to 5% for subprime deals. This means that losses would need to reach only 1.5 to 2.5 times their expected levels before the mezzanine CDOs made up of subprime securities became severely impaired or completely worthless.[12] By comparison, note that losses would need to rise by 5 to 8 times above their expected levels before AAA-rated subprime bonds suffered their first dollar loss. We will return to this issue in our concluding comments.

Based on these figures, the exact size of private-label MBS issuance between 1998 and 2007 is $5.59 trillion against total pledged mortgages of $5.80 trillion.[13] As confirmation that we captured the universe

[11] We needed to establish a cutoff because 628 of the 727 CDOs had at least some CDOs as collateral.
[12] This same point is made by Lewis (2010) at several points throughout his book.
[13] The $210 million difference here is due to over-collateralization (OC), which simply means that the total assets pledged to the trust exceed the total liabilities in the trust. This difference provides an additional amount of protection to security holders in the deals.

of publicly traded private-label RMBS and HE securities through Intex, this figure matches almost exactly the figure of $5.66 trillion of private-label MBS issuance from 1998-2007 reported by *Inside Mortgage Finance* (2010), the unofficial keeper of mortgage information on U.S. ABS/MBS. IMF obtains its figures from independent sources and the Federal Reserve, which obtains its figures from a third-party source, Loan Performance (now Core Logic). The minuscule difference is likely due to a small number of privately placed MBS.

Additional features of the structures make their design quite complicated. The various triggers, tests, and events contained in SF ABS CDOs are designed to protect bondholders, particularly the senior-most ones, against unexpectedly high losses associated with the underlying collateral. These features are also negotiated with rating agencies to ensure investment-grade ratings for bonds and, importantly, to help ensure that a larger share of the deal would receive the coveted AAA rating. The complexity and heterogeneity of SF ABS CDO structures make the generation of cash flows quite complicated, so much so that market participants coalesced around Intex and its valuation software to develop pricing analytics and metrics, which we do in Section IV.

B. Classifying the SF ABS CDO Market

As detailed above, Intex contains the universe of ABS/MBS publicly traded securities; we also believe that Intex contains the universe of publicly traded "144A" ABS CDOs issued through these markets.[14] Intex also contains a less complete listing of CDOs from other markets, so our central challenge is to define the subset of CDOs that make up the universe of publicly traded ABS CDOs that traded at the "ABS CDO desks" at the major investment banks and asset-management firms. The reason this is important is that these desks were where structuring, underwriting, and trading took place, and where pricing and fair value information (or "indicative prices") was generated and exchanged. In particular, many believe that stresses on ABS CDO desks in 2007 launched the financial crisis, so we are most interested in identifying securities that traded there.

First, CDOs are classified as "structured finance" in Intex if the CDOs in part include or reference other securities and if the deals can be actively managed. SF CDOs generally have a reinvestment period, usually up to five years, when collateral managers are allowed to purchase new assets or sell defaulted assets from the CDO. The reason mortgage-backed CDOs are allowed to be actively managed is that prepayment risk is high and CDOs can pay down quickly without replacement. In contrast, CMBS or CRE CDOs are mostly "static pools" because commercial mortgages have prepayment penalties or yield-maintenance clauses that effectively eliminate prepayment risk.[15] The static pool feature of CMBS, and the whole loan feature of CRE, is one reason why CMBS/CRE traded on the CMBS/CRE desks separately at the large investment banks.[16] Of course, since CDO structures are whatever the underwriters can sell, there are exceptions to this classification, most notably

[14] Rule 144A of the Securities Act of 1933 allows private companies to sell unregistered securities (the Rule 144 securities) to qualified institutional buyers (QIB) through a broker dealer. The rule also permits QIBs to trade these securities among themselves. To be a QIB, the institution must control a securities portfolio of $100 million or more. Because of their unregistered status, disclosure is often not as complete as in public securities.

[15] Fabozzi (2007) argues that, because of these features, CMBS trade more like corporate bonds.

[16] Lewis (2010, p. 127) offers an amusing, if overstated, characterization: "A CDO composed of nothing but the riskiest, mezzanine layer of subprime mortgages was not called a subprime-backed CDO but a 'structured finance CDO'." The implication here is that the name structured finance CDO was a euphemism to hide the security's true risks, when in actuality it is an artifact of its structuring and trading.

the 68 static ABS CDO pools that emerged with the growth of the synthetic market.[17] For these deals, we left them in the SF CDO category because these static synthetic deals traded on the ABS CDO desks.

A second distinction is made between corporate CDOs and ABS CDOs. It is also the case that there are separate desks where corporate CDOs, collateralized loan obligations (CLOs), and high-yield collateralized bond obligations (CBOs) were underwritten and traded. Therefore, by adding the "ABS" qualifier, we exclude from our classification of SF ABS CDOs the CLO and CBO CDOs, whose underlying collateral is primarily made up of high-yield leveraged loans and corporate bonds.[18]

With this classification scheme in mind, we set our sights on identifying the universe of publicly traded SF ABS CDOs. As shown in Appendix 1, as of mid-2010, the Intex CDO deal library contained 2,280 CDOs issued between 1995 and 2010, totaling $1.4 trillion in issuance. We encountered several challenges. First, Intex enters the "collateral type" information in a free-form text field. As a result, we found 40 classifications of SF CDOs and CDO^2s, many driven by simple text differences. As a first step, we aggregated these into 11 categories of CDOs, summarized in the 11 columns of Appendix 1. Another problem is that the synthetic CDO^2s and synthetic CDOs became a dumping ground for all manner of synthetic CDOs and CDOs that contained other CDOs.

These classification challenges required us to conduct an exhaustive (and exhausting) review of each of the 842 SF CDOs in the first three columns of Appendix 1. Under our stricter criteria, we reclassified 92 CDO^2s, 16 synthetics, and 7 cash CDO deals into the high-yield and leveraged loan categories. This classification ensures that we have a consistent and robust classification for "structured finance ABS CDOs." Most important, we believe that our classification identifies the universe of publicly traded SF ABS CDOs at the center of the financial panic of 2007 that traded on the ABS CDO trading desks. As shown in Table 2, we estimate that the universe of publicly traded SF ABS CDOs totals 727 deals with $641 billion of issuance.[19] Cash SF ABS CDOs are made up entirely of cash securities, synthetics are made up entirely of reference pools of credit default swaps (CDS) referencing other RMBS/ABS bonds, and hybrids are a mix.

Since LehmanLive is the primary source for several important papers on the CDO crisis,[20] we compare the 735 CDOs contained in LehmanLive with our grouping of 727 CDOs (see Table 3). While we did confirm LehmanLive's source data as Intex and found overlap on 593 CDOs, we do find considerable differences with our classification. Many differences came from including CMBS/CRE, REIT CDOs, and CLO CDOs, but LehmanLive also includes a myriad of other CDOs, including European and trust preferred CDOs. Also,

[17] For the synthetics, which make up most of the static deals, investors often opted not to allow replacement, since they were made up entirely of CDS.

[18] See also Fabozzi (2007, p. 327) for a breakout of different types of CDOs. CLO CDOs were frequently placed into the CDO^2 category in Intex, since a defining feature of CLO CDOs is that they include other CLO bonds.

[19] Gorton (2008, p. 38) provides numbers for "Global CDO Issuance" from the Securities Industry and Financial Markets Association (SIFMA). These numbers are instructive because they highlight the information problem of the dollar volume of CDOs in the market when the August 2007 panic erupted. The category "Structured Finance" shows no figures before 2004 and shows $754 billion of issuance from 2005 to 2007 (versus $517 billion by our classification). SIFMA also shows $237 billion of "synthetic CDOs." Hence, while the dollar volume of active SF ABS CDOs in July 2007 was, by our calculations, $564 billion, the Creditflux estimate of $1 trillion mentioned above was quite plausible.

[20] LehmanLive is used as a principal source of information for the Barnett-Hart (2009) study and for reporting by Lehman Brothers on the crisis (see Lehman Brothers 2008). It is also described in Lewis (2010).

Lehman did not include 134 SF ABS CDOs from our classification. We could not find any pattern to explain why these deals were omitted from the LehmanLive database.[21]

A critical point for understanding the subprime CDO crisis is to understand why subprime securities traded on ABS desks at the large investment banks and thus came to dominate SF ABS CDOs. According to Fabozzi (2007, 313), the typical subprime borrower "used a home equity loan to consolidate consumer debt using the current home as collateral rather than to obtain funds to purchase a new home." For this reason, subprime securities traded on ABS desks. Conversely, prime and Alt-A loans traded through the RMBS, or "Resi," desks at the large investment banks. Fabozzi (2007, pp. 296-97) characterizes RMBS as "securities backed by 1- to 4-family single residential mortgages with a first lien," mainly prime "jumbo" loans with loan balances too large to be insured by the agencies. Alt-A loans did not qualify for agency purchase because of the more limited documentation requirements, but they fit more closely into the definition of RMBS; therefore, Wall Street Alt-A "shelves" traded at the RMBS desks. The big Wall Street trading desks determined how Intex delivered their "deal libraries," separately between RMBS and HE, as depicted in Figure 1.

The dominance of subprime in SF ABS CDOs also had another cause: it was preferred by the rating agencies, whose views were driven by the poor performance of multi-sector CDOs during the 2000-2001 recession. This is also extremely important, since ratings are a requirement for CDO issuance, and the rating agencies' views about the collateral mix determined how CDOs were placed in the market. Moody's views on "structured finance CDOs" were described by Hu (2007, p. 46) this way:

> In the aftermath of the 2000-2001 economic recession, the poor performance of HY CBOs, manufactured housing ABS, franchise loan ABS, and aircraft lease ABS led to losses in the underlying pools of many early SF CDOs. As a result, the issuance of SF CDOs declined in 2003. The industry realized that diversification just for diversification's sake was not the most prudent collateral management strategy. Meanwhile, asset managers moved away from poorly performing asset types to strongly performing and traditional asset types such as RMBS, with which they were most familiar.

Of special note by Moody's was the increased use of subprime collateral for CDO issuance, which Hu (2007, p. 47) described as the result of several factors, including wide spreads, the rise of synthetics, and the ability to "produce loan collateral on a massive basis," something on which the CDO dealers willingly obliged the rating agencies. Thus, the rise of subprime CDOs was driven by a combination of the trading of subprime securities on the ABS desks, attractive yields, large issuance volumes, and rating agency concurrence.

As shown in Figure 2, the SF ABS CDOs issued in 1999 and 2000 were truly multi-sector CDOs, but came to be increasingly dominated by subprime. Home equity (i.e., subprime) accounted for 20% of the original issuance balance and all mortgages, 21%; ABS/CMBS/Other made up 63%. Subprime securities were a smaller part of ABS issuance at this time, but they still dominated the mortgage sector. Note that by 2007 the 'Other' category had shrunk to 4%, replaced increasingly by HE securities. Note also that SF ABS CDOs had risen

[21] While Barclays maintains the database since it acquired Lehman, the original staff that created the database is no longer employed at Barclays. So we are not able to get a clear understanding of Lehman's classification scheme. It appears to be a combination of deals that Lehman had investments in and deals it was tracking for other reasons.

from 1% of collateral in 2000 to 14% by 2007.[22] By 2006, SF ABS CDOs were effectively subprime CDOs, dominated by subprime and other SF ABS CDOs. Subprime securities became the primary collateral for SF ABS CDOs as the subprime market boomed and the rating agencies soured on multi-sector CDO structures. Almost two-thirds of total issuance occurred in the period 2006 to 2007.

C. Determining the Dollar Volume of Cash and Synthetic CDOs

Based on our ability to compute the share of synthetic collateral in each deal, we are able to compute a precise dollar amount and share of synthetic collateral in SF ABS CDOs. As shown in Table 4, $201 billion of SF ABS CDO collateral issued was in the form of synthetic credit default swaps, 31% of the total. Also shown in Table 4, 93% of the synthetic CDO collateral was issued after the first half of 2005. This is important because it was in July 2005 that the International Swap and Derivative Association (ISDA) Master Agreement for MBS was finalized, which standardized over-the-counter CDS transactions for MBS. Another important development was the introduction of the ABX indexes starting in January 2006, which were often referenced in these CDOs.[23] These two developments sharply increased the share of CDS in the SF ABS CDOs, also shown in Figure 2. As late as 2004, synthetic securities accounted for a very small 5% of collateral in the typical deal. By 2005, it had shot up to 16%, then to 43% in 2006. By 2007, over half of the typical SF ABS CDO deals were synthetic.[24]

D. Risk Classifications for SF ABS CDOs

We begin our risk analysis of the SF ABS CDO market by subdividing the SF ABS CDO market between mezzanine CDOs and high-grade SF ABS CDOs. This classification involved using a weighting scale derived from initial rating agency ratings (see Appendix 2). As is done in industry classifications and other studies of the CDO market, we define a deal with a Moody's weighted average rating factor (WARF) of 180 or lower to be high grade; WARFs greater than 180 are classified as mezzanine. For deals for which WARFs are not available, we used the Fitch score. A Fitch score of 7 or lower is defined as high grade; a Fitch score greater than 7 is defined as mezzanine.[25] For deals with no Moody's WARF or Fitch score available in Intex, we examined the underlying collateral of the CDOs for their original ratings to determine risk classifications.

Our final tallies are reported in Table 5. Of the total $641 billion of SF ABS CDO issuance, $342 billion is high grade, and $299 billion is mezzanine. Of the 727 deals, 255 are high grade, and 472, mezzanine. Note that while mezzanine issuance balances are 47% of total SF ABS CDO issuance balances, mezzanine deals constitute 65% of all SF ABS CDO securities. This is undoubtedly a function of the very small size of BBB-rated bonds in a given RMBS relative to A-rated bonds and the lower leverage needed for mezzanine SF ABS CDOs to make economics of the deal work versus their high-grade counterparts. Table 5 also reports high grade and mezzanine securities by vintage. The vintage breakouts are especially meaningful for our loss estimates, since later vintages will be especially hard hit by the credit crisis.

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[22] These figures are based on simple averages by deal, so they are more representative of the average deal, which gives more weight to the smaller balance mezzanine CDOs that have heavier concentrations of subprime and synthetic securities. Weighted averages for 2007 would show mortgage concentrations in 2007 at 88% (versus 93% for simple averages) with synthetic shares at 43% (versus 51%).

[23] There are four ABX.HE indices, ABX.HE.06.1, 06.2, 07.1 and 07.2, each composed of 20 representative subprime securities issued over the previous six months. They were a key trading tool for banks and asset managers to hedge or take a position in the subprime market. See Gorton (2008).

[24] Figure 2 shows unweighted averages, depicting typical deals, while Table 4 reports total balances, showing weighted averages. The higher share in Figure 2 reflects the dominance of synthetics in the smaller mezzanine CDOs.

[25] S&P, the other major rating agency, had no comparable numerical weighting scale.

E. Assessing the Linkages of Subprime Mortgage Bonds to SF ABS CDOs

Now that we have identified the population of residential mortgage bonds and SF ABS CDOs, we can provide insights into the meaning of the "subprime CDO crisis" by tracking the HE securities that were either placed or referenced in SF ABS CDOs. Subprime bonds can be directly placed into CDOs, in whole or in part, or they can be "referenced" in the form of CDSs of any size, against the bonds. Either way, their CUSIPs[26] are listed as collateral in the CDOs in Intex and therefore can be linked back to the subprime deals.

Starting with the original bond ratings, we show that lower-rated HE bonds, particularly BBB-rated bonds, were the most commonly used collateral for SF ABS CDOs. As shown in Table 6, only 11% of HE bonds originally rated AAA issued between 1998 and 2007 were placed into CDOs, while 71% of AA-rated bonds, 78% of A-rated bonds, and 79% of BBB-rated bonds were placed or referenced in SF ABS CDOs, respectively. More important, the number of occurrences of lower-rated bonds being placed or referenced in SF ABS CDOs was far greater. More than twice as many AA- and A-rated bonds were placed or referenced in SF ABS CDOs as were issued (206% and 250%). For BBB-rated bonds issued, the 5,496 subprime bonds were placed or referenced in the 727 CDOs a total of 36,901 times!

When we examine dollar balances, a different picture emerges. When bonds are referenced, the dollar balances of the referenced notes need not match the dollar balances of the cash bonds. Because of the large notional values of the A-rated bonds, dollars referenced were smaller than the actual dollar balances of the cash bonds. As shown in Table 6, AAA-rated HE bonds by balance were only 1% of the dollar amount of AAA HE bonds issued and 16% of those placed or referenced in CDOs. Balance shares increase as the ratings go down. Note that the BBB-rated bonds had larger balances placed or referenced in CDOs than were issued (182%).[27] In short, the demand for BBB-rated subprime bonds was such that $64 billion of BBB-rated subprime bonds was transformed into $140 billion of subprime CDO collateral, more than doubling their initial cash value. Thus, it was the lower-rated subprime bonds, which were more difficult to place but which offered much higher yields that provided the primary collateral for the later vintages of SF ABS CDOs.[28] Without full knowledge of how subprime securities were being placed into these CDOs, the enormous amount of cross referencing of these securities across many CDOs further correlated risks in ways that would be very difficult to capture in a single model done on an individual deal.

[26] The acronym CUSIP historically refers to the Committee on Uniform Security Identification Procedures. The 9-character alphanumeric code identifies any North American security for the purposes of facilitating clearing and settlement of trades.

[27] For example, Abacus 2007-AC1, a pure synthetic mezzanine CDO that was part of the SEC enforcement action against Goldman Sachs, was composed of 90 CDS totaling $2 billion. Each reference note was exactly one-ninetieth of $2 billion, or $22,222,222. The original cash value of the underlying BBB bonds was $1.238 billion. In HG SF ABS CDOs, because of the large dollar balances of the cash bonds, referencing was generally less than the cash amounts of the bonds.

[28] The one exception is the small number of below-investment-grade B-rated bonds, which had smaller shares. Apparently, an investment grade rating was important for placement of HE bonds in SF ABS CDOs.

III. Data and Summary Statistics

A. Data

Intex warehouses an enormous amount of current and historical deal and collateral information for each ABS/MBS security, including data and program code for cash flow structures necessary to conduct a full valuation of each ABS/MBS security. Our SF ABS CDO database includes variables relating to deal liabilities, deal collateral, major participants in the deal, and, importantly, all aspects of the deal structure. Intex provides information on the CDO deal or tranche level static variables, including CUSIPs, original ratings, issuers, deal and tranche balances, coupons, gross margin spreads, underwriters, collateral managers, collateral type, trigger information, and other variables. All data are housed in monthly files, including performance information.

As part of our efforts to use rating agency ratings in our analysis, we convert letter-grade ratings to numerical scores with a process detailed in Appendix 3. In cases where we wish to combine ratings, we developed a composite rating scale. We apply the lower of the two ratings if two NRSROs rate a given bond or the lowest of three if the bond is rated by all three rating agencies (i.e., Moody's S&P, and Fitch). For bonds that have paid down or been written down, current ratings would generate a WR (withdrawn rating). In these cases, we reviewed all of these SF ABS CDO deals individually and supplemented tranche info with current ratings immediately before liquidation. Composite ratings are also translated into rating scores based on the rating scale table in Appendix 3.

The collateral-related Intex information for SF ABS CDOs is not as readily accessible for all SF ABS CDO deals as are the deal-level variables. To obtain the original collateral assets for the 727 SF ABS CDOs, we applied the Intex API (application programming interface) to directly access its CMO descriptor indicator (CDI) and CMO descriptor update (CDU) files. CDI is a static file used for both the initial descriptive and cash flow information of the structured finance transaction, while CDU files contain, depending on the reporting period, the quarterly or semi-annual available bond and collateral information such as payments, balances, triggers, etc. Historical CDU files provide snapshot information at the specified month. Given that CDOs are not consistently reported as of the deal closing date in Intex, our API needed to look through the CDI as well as the monthly CDU files to access the first available collateral asset information for each individual deal. We obtained all CDI and CDU files for all CDOs.

Since SF ABS CDOs are 144A deals, collateral asset information from Intex is not as consistent and uniform as for other public security deals. Of the 727 SF ABS CDOs, 10 transactions have no CUSIP-level collateral information. We will use a dummy variable for deals with and without collateral asset details to test for risks in these deals. Second, categorizing the CDO collateral into the seven major asset classes (home equity loan, Alt-A RMBS, prime RMBS, CDO, CMBS, ABS, and other) proved to be complicated by inconsistent reporting and missing information from trustees. We therefore supplemented Intex data with data from other sources, such as Bloomberg, and we were able to obtain some deal prospectuses from industry sources. Three Intex data elements, collateral type, deal type and asset sub type, are referenced for classifying specific collateral assets. Where necessary, issuer names are populated based on industry experience. CDO trustees also report asset information in an inconsistent manner for synthetic CDS. Many deals list the synthetic position line item twice, one with the real CUSIP and the second with a dummy CUSIP, with actual contributing balances both referencing the same asset.

Consolidating the data line items for synthetic positions presented a cumbersome, but ultimately successful, process for finalizing the data set and in reporting on synthetic balances. Finally, data flags for synthetic credit default swaps and fixed rate bonds are not populated for all of the collateral assets in the Intex data pull. We specifically reviewed the missing data flags for synthetic positions on individual deals. We populated the coupon formula for bonds with missing fixed flags to determine their coupon type.

SF ABS CDO tranche level principal write-downs will serve as the dependent variable in our regression. We will employ Intex, Bloomberg, and some industry sources for historical data on principal payments and loss allocations. For transactions still outstanding, we apply a bottom-up approach, evaluating each underlying collateral asset and estimating expected write-downs in the pool. We then aggregate write-downs and use the Intex cash-flow engine to allocate expected principal pay-downs and write-downs to each of the CDO tranches through the priority of payment (or "waterfall").

B. Summary Statistics

In Tables 7 and 8 we compute summary statistics for the 727 SF ABS CDO deals. We break out our results by high grade (Table 7) and mezzanine (Table 8), which represent the basic deal-level collateral statistics. High-grade SF ABS CDOs have 255 deals in the database versus 472 deals among the mezzanine SF ABS CDOs. The average CDO issue year of 2005.53 for high grades and 2004.78 for mezzanines reflects the concentration of SF ABS CDOs in the later years. High grades have an average of 10.06% of the collateral in the form of synthetic CDSs, significantly lower than the mezzanine SF ABS CDO average of 38.18%. This is expected given that A-rated tranches of cash ABS and RMBS are more abundant in terms of both number of bonds and dollar amount issued relative to their BBB-rated cash counterparts.

As for collateral assets, HEs dominate the collateral for both high grade and mezzanine, on average, accounting for 48.97% and 59.31% of the underlying assets, respectively, with higher shares in the mezzanine. CMBS bonds make up 4.15% of assets for high grade and 5.26% for mezzanine. For both, there are transactions that are collateralized 100% by CDOs.

Original deal size for high-grade SF ABS CDOs is, on average, more than twice the size of the mezzanines ($1.3 billion versus $607 million). The biggest reason for this is that A-rated securities are much larger than BBB-rated ones. Another reason for the larger size of high grades is that they require higher transaction leverage or higher percentages in senior tranches, so as to reduce the weighted average coupon of the liabilities to make the economics of the deal work. As a result, for a given level of CDO equity, high grades will result in much larger deal sizes than mezzanines.

The number of original assets is in the range of 20 to 394 for high-grade SF ABS CDOs and 1 to 390 for mezzanine. The single asset transaction indicates that the deal is a re-securitization of another security.

IV. Valuation Exercise for SF ABS CDOs

The next step in our analysis is to compute principal write-downs, both actual and expected, for the $641 billion of securities in the 727 SF ABS CDOs. In this section we detail our estimation process and

summarize our findings. In subsection A, we calculate principal write-downs on all liquidated deals as of March 2011. In subsection B, we describe our methodology for estimating expected write-downs for the non-liquidated deals and report the results. In subsection C, we sum up.

A. Losses on Liquidated SF ABS CDOs

We begin our valuation exercise by cumulating what we should already know: the principal dollar write-down of deals liquidated as of March 2011. The process for determining the principal write-down involves retrieving, for each reporting period, the principal received for each tranche. Principal write-downs for tranche *i* is defined as the original balance of tranche *i* less aggregated principal received by tranche *i* up to termination time T:

(1) $$WD_{i,T} = Balance_{i,O} - \sum_{n=1}^{T} PR_{i,n}$$

where
$WD_{i,T}$ = principal writedown of tranche i at termination T,
$Balance_{i,O}$ = balance of tranche i at origination, and
$PR_{i,n}$ = principal received by tranche i at time n.

To obtain principal write-downs for deal j composed of tranches 1 to m, we simply sum the principal write-downs across all tranches:

(2) $$WD_{j,T} = \sum_{i=1}^{m} WD_{i,T}$$

where
$WD_{j,T}$ = principal writedown of deal j at termination T on m tranches.

The challenge of obtaining principal received stems from the lack of reporting of the final liquidation waterfall report by trustees. While trustees always report when a deal is active, reports are not always available for final liquidation waterfall reports. Therefore, we use Bloomberg and industry sources to obtain the information needed to do our accounting for the all-important final reporting period of liquidation proceeds.[29] We also used these sources to cross check against each other for reasonableness to ensure we are aggregating write-downs correctly. We believe that our final tallies are the most accurate accounting possible without having all final trustee liquidation reports.

As shown in Table 9, for the 727 SF CDO deals in the database, 213 transactions totaling $208 billion have either been paid down or liquidated as of March 2011. Total deal write-downs on liquidated SF ABS CDOs total $161 billion, or 78% of the original $208 billion of deal balances. As expected, deal write-downs increase by vintage. Write-down percentages for early vintages, 2000 to 2002, range from 5% to 9%, confirming the fact that earlier vintages of SF ABS CDOs benefited from the booming housing market and better diversification in the pools. Write-downs reached 18% in 2003 and escalated sharply thereafter, with 2006 and 2007 vintages reaching 82% and 88%, respectively.

[29] We would like to thank Justin Pauley from RBS Global Banking & Markets for sending us RBS Global's Structured Finance CDO Status Reports (RBS (2011)) as well as a spreadsheet of pay-down information on a subset of the CDOs.

B. Methodology for Estimating Write-Downs on Non-liquidated SF ABS CDOs

For the 514 non-liquidated deals, estimating write-downs is a bottom-up approach from the underlying collateral, involving four separate steps. The first step parallels what we did in the last subsection: take an accounting of principal received (up to time t) for each tranche and each deal (as in equations (1) and (2)). As of March 2011, $222.3 billion of active collateral balances were still reported out of an original issuance balance of $432.6 billion. Of this, $75.9 billion of principal has been received. Netting this out of $432.6 billion and subtracting the active balances leaves principal write-downs of $134.4 billion.[30] As we do with liquidated deals, we use Bloomberg and industry sources to cross-check our figures.

Step two is to estimate or, in some cases, obtain a fair value for the $222.3 billion of still active collateral. For our valuation exercise, we apply the approach used in Goodman, et al. (2008) and assume these fair values are *expected liquidation proceeds* for the remaining collateral assets. Thus,

(3) $$E(LP_{j,t}) = \sum_{k=1}^{s} FV_{k,t} * CBal_{k,t}$$

where
$E(LP_{j,t})$ = expected liquidation proceeds of deal j at time t,
$FV_{k,t}$ = fair value of collateral asset k at time t, and
$CBal_{k,t}$ = contributing balance of collateral asset k at time t.

Because of the large numbers of different types of assets and the ways we obtain fair values, we summarize our methods for obtaining fair values in Table 10. Of the 514 active SF ABS CDOs, 23,197 unique securities are still active or being reported (16,668 having been paid off or written down as compared with counts in Table 1). Per Table 10, 67% of these are residential mortgage bonds, including home equity, Alt-A RMBS, and prime RMBS. For these, we use proprietary prepayment, default, and loss models, fully integrated with the Intex cash-flow engine, purchased from a third-party vendor that is a market leader in the industry. We use its internal research to obtain appropriate "tunings" for prepayment speeds, severities, and default transitions. For discount rates, we estimate credit option-adjusted spreads (CrOASs) and add them to their index values, using a combination of market prices on the aforementioned ABX index for HE securities and the PrimeX index for prime RMBS securities.[31] For Alt-A bonds, we interpolate between the two, assuming that Alt-A bond risk lies between subprime and prime RMBS.[32] Thus, we obtain market-based fair values for these underlying HE and RMBS securities.

As shown in Table 10, even though mortgage assets dominate the transactions by balance, there are large numbers of other securities that need to be valued. For these, we use a combination of fair value prices from a number of pricing vendors and rating agency and vendor models. In cases where none is available, we use a simple ratings table to estimate fair values on the tiny amount of remaining collateral. Pricing information was obtained primarily from three sources: the Interactive Data Corporation (IDC), Gifford &

[30] The calculation is $432.6B - $222.3B - $75.9B = $134.4B. Note that write-downs are not necessarily immediately recorded to the tranches (the liabilities) when the collateral (the assets) is written down. Thus, the tranches have "implied write-downs," with losses needing to be allocated through the waterfall in the Intex software.
[31] Similar in design to the ABX, PrimeX is an index developed from a basket of prime RMBS securities and is publicly traded, thus providing us with market prices to derive OAS and discount rates. For details, see Amherst Mortgage Insight, Amherst Securities LP (April 27, 2010).
[32] Our exact calculations are available from the authors upon request.

Feng Associates (for high yield CDOs mostly), and Bloomberg's Bval Service. For 710 of the securities, we obtained no information at all except for ratings and, in some cases, an asset class. For these securities, we use a combination of current rating and asset class risk categories to assign our fair values. As summarized at the bottom of Table 10, we assign zero values to single C-rated securities or below, 10 cents for CC-rated securities, increasing 10 points for each letter grade, up to 70 cents for AAA-rated securities. We apply further haircuts in the range of 5 to 10 points for more risky assets, such as franchise loan ABS. Fortunately, we needed to do this only on 710 of the securities, less than 3% of total assets.

Step three is to run price/yield analytics on the CDO collateral through the Intex cash-flow engine for each deal. For the active collateral, each asset contributes its liquidation proceeds to the deal, with the aggregate recovery amounts allocated in the Intex software to the various tranches of the CDOs according to the priority of principal and interest payments (i.e., the "waterfall"). The waterfall also adjusts for all structural features that can divert cash flows to more senior tranches. We use the "liquidation mode," which results in expected prices for the CDO tranches without the need to address the discount rate issues associated with evaluating significantly illiquid and deeply distressed securities, since theoretically the liquidation occurs immediately and the resulting cash flows are allocated at time t. Thus,

(4) $$E(P_{i,t}) = \left\{E(LP_{j,t}) \middle| Waterfall_j\right\}/Balance_{i,t}$$

where
$E(P_{i,t})$ = expected price of tranche i at time t,
$Waterfall_j$ = priority of principal and interest payments from deal j, and
$Balance_{i,t}$ = balance of tranche i at time t.

For the valuation of the SF ABS CDOs that contain other SF ABS CDO bonds, we set up a two-stage process by first valuing the CDO bonds that have no SF ABS CDOs as collateral and then incorporating the pricing results from the first stage with fair values for all other assets to estimate prices for those CDOs that are partially or fully collateralized by SF ABS CDOs. For the small number of cases where the CDOs are private placements, we use external prices or, as a last resort, our ratings matrix described above.

Table 11 summarizes distributions of prices (as of March 2011) for the active CDO tranches by their original ratings, giving us our first look at the enormous amount of write-downs that we estimate will occur on these securities. For the senior AAA bonds, average and median prices are around 35 and 32 cents, respectively. For the 808 junior AAA bonds, prices average 16 cents, but the median price is 0.2 cent, meaning that half the bonds are expected to be almost fully written off. Average prices of more junior bonds drop substantially after that, averaging 6 cents for AA bonds, but with more than three-quarters valued at less than 1 cent. Almost all bonds originally rated below AA are worthless.

Our fourth and final step is to calculate tranche level expected principal write-down amounts for all active SF ABS CDOs by subtracting the historical principal received and the expected recovery values from the original balances of the tranches. Thus,

(5) $$E\left(WD_{i,t}\right) = Balance_{i,O} - \sum_{n=1}^{t-1} PR_{i,n} - E(P_{i,t}) * Balance_{i,t}$$

where

$E(WD_{i,t})$ = expected principal writedown of tranche i at time t.

As in equation (2), to obtain expected principal write-downs for deal j, we simply sum principal write-downs across all tranches:

(6) $$E(WD_{j,t}) = \sum_{i=1}^{m} E(WD_{i,t})$$

where

$E(WD_{j,t})$ = principal writedown of deal j at time t on m tranches.

Write-downs percentages for both the tranche and the deal level are also calculated by dividing the dollar write-down amounts by the respective tranche or deal original balances. As shown in Table 12, the 514 active SF ABS CDOs as of March 2011 with original deal balance of $432.6 billion are expected to write down $257.8 billion, 60% of the original deal balance. Starting from the 2001 vintage, the estimated write-down percentages increase monotonically over the years, from 34% in 2003 to 80% by 2007, a familiar pattern from earlier tables.

C. Summing Up

As summarized in Table 13, we estimate that, all told, total principal write-downs on SF ABS CDO will reach $420 billion, 65% of the $641 billion of total issuance. Note that, as of March 2011, 71% of the write-downs have already occurred, with the remaining 29% of write-downs expected from the $222 billion of active collateral. Thus, while one can quibble with our valuation methodology, most write-downs from the SF ABS CDO market have already occurred; so our final write-down estimate will likely not be too far off the mark. These write-down estimates are astounding by any measure, more so when considering the sheer size of the SF ABS CDO market. When Goodman et al. (2008, p. 269) conducted a comparable bottom-up estimation of losses on 420 subprime-backed CDOs, they described their loss estimates as "indicative of the greatest ratings and risk management failure ever." Their loss rates, computed in early 2008, are substantially *lower* than ours.[33]

Write-downs show a sharply escalating pattern by vintage (Table 14). Between 1999 and 2003, write-downs range from 20 to 29%, comparatively low by these standards, but still substantial, showing that no vintage of SF ABS CDOs was immune from the very large write-downs experienced in the SF ABS CDO market. Write-downs in the earlier vintages reflect large losses suffered by the multi-sector CDOs during the recession of the early 2000s. Write-downs rise to 44% for the 2004 vintage and then rise monotonically to 84% by 2007. Write-downs in the 2005-07 vintages are especially heavy; these vintages constitute 80% of issuance (see Table 2) and generate 90% of write-downs.

These expected write-down percentages, given subordination levels reported in Figure 1, mean that most bonds rated below AAA have been or are likely to be completely written off, with substantial write-downs for AAA bonds. This is confirmed in Table 15, which summarizes write-downs at the tranche level by original ratings. Write-down distributions reported show that no tranche is unaffected, with write-downs on the originally senior AAA tranches showing average write-downs of 55%. The junior AAA

[33]For example, their expected loss rates on the senior AAA mezzanine bonds in 2006-07 averaged 43%, while our figures average over 70%.

class shows an average write-down of 80%, 100% for the median bond. The write-downs experienced by the AAA bonds are the most damaging, since these bonds had the lowest capital charges and formed some of the collateral used to secure debt in other markets, most notably in the asset-backed commercial paper (ABCP) market (see Covitz, Liang, and Suarez (2009)). All bonds rated below AAA have average write-downs above 90%, with close to three-quarters or more facing complete write-downs.

Write-downs by vintage show a sharply escalating pattern starting in 2004, with write-downs rising even more sharply in 2006-07. All AAA classes had relatively low write-downs from 1999 to 2001, but the lower-rated tranches experienced very heavy write-downs.[34] For the 2006-07 vintages, most all bonds rated below AAA are expected to be completely written down, with junior AAA bonds expected to experience write-downs of 93% to 94%. Senior AAA bonds show write-downs in excess of two-thirds to three-quarters of the original balance.

V. Determinants of SF ABS CDO Losses

Now that we have estimated write-down percentages on SF ABS CDO deals and tranches, our final analysis involves examining the determinants of these write-downs. In the seminal paper by Barnett-Hart (2009, p. 34), which uses LehmanLive and a smaller proprietary sample, she laments that she did not have "a direct measure of CDO loss available." Since we have estimated write-downs, we are able to extend her work in important ways, starting with a dependent variable that gives a direct estimate of write-downs, at both deal and tranche levels. We have several other advantages as well. Our classification scheme for SF ABS CDOs includes the population of securities at the ABS CDO trading desks, a much more complete data set than could be obtained from LehmanLive or any other source. Our access to the Intex valuation software and CDU files allows us to develop our own metrics with source data. This proved especially helpful when complexities in the deal structures, which were many, gave us opportunities to customize and standardize variables. As we show, the Intex software also includes many additional variables on the deal structures that can affect performance. Finally, we have an additional two years of performance, allowing us much more information on performance.

In subsection A, we conduct multivariate analysis on deal performance. In subsection B we examine dealer and collateral manager fixed effects. Finally, in subsection C we conduct analysis at the tranche level, but only on the AAA-rated bonds, since lower-rated bonds are mostly fully written down.

A. The Effects of Deal Characteristics on Deal Performance

Our modeling approach is to conduct an analysis of the variance of write-down percentages on SF ABS CDO deals using ordinary least squares (OLS). Our first set of regressions tests our model to determine which set of deal characteristics explains write-down percentages on SF ABS CDOs. Write-down percentages, a combination of actual and expected write-downs, are regressed on key characteristics of the CDOs. Our basic specification is as follows:

$$(7) \qquad Writedown\ Percentage = f(Structure, Asset, Risk, Vintage\ \&\ Controls).$$

[34] The slightly lower loss rates on BBB-rated bonds relative to A- or AA-rated bonds are an artifact of the early vintages, which often had a bond structure of AAA combined with BBB, with the AAA tranches likely "wrapped" by insurance monolines.

Deal characteristics are broken down into four very broad categories that generate testable hypotheses. Structure refers to the structural characteristics of the deals that can affect performance; our hypothesis here is that more complex structures result in worse performance (Coval, et al. (2009)). Larger deal sizes, a larger number of assets, and a larger number of tranches can all add to increased complexity and increase write-downs. In contrast, static deals, which don't allow replacement of assets when existing assets pay down or default, will decrease complexity and potentially reduce write-downs. Finally, not having deal triggers to protect bondholders in the event of unexpectedly high write-downs is a direct benefit to equity and lower-rated tranches, increasing risk and write-downs.

Variations in risk are also affected by the types of assets in the deals, discussed in Section II.C. Many studies have found that higher shares of nontraditional lending, packaged into home equity and Alt-A securities, should result in much poorer performance (Mayer, Pence, and Sherlund (2008); Mian and Sufi (2008); Demyanyk and Van Hemert (2009); and others). Likewise, higher concentrations of CDOs will result in worse performance, since CDOs are made up predominantly of nontraditional mortgage collateral, particularly in later vintages. Other asset classes that performed better during the crisis should positively affect performance; these include prime mortgage securities, CMBS, and ABS. Of course, this is hard to ascertain ex ante, since performance of the underlying securities depends on the risk of the assets chosen and structural features of the underlying securities themselves. If the strategy was to pick higher margin (i.e., riskier) securities, these nonmortgage asset classes might not decrease risk at all.

Risk characteristics measure the effects of the overall structure itself on deal performance. Thus, ceteris paribus, mezzanine SF ABS CDOs, since they are made up of BBB-rated securities, should perform worse than their high grade counterparts. Likewise, pure synthetic and hybrid SF ABS CDOs should perform worse than pure cash CDOs, given the ability to quickly manufacture CDOs with synthetic collateral. The 48 CDO^2s should perform worse still, since they are made up primarily of subordinated bonds of SF ABS CDOs, particularly in later years, as shown in Figure 2. The weighted average rating factor (WARF) determines the classifications for mezzanine and high-grade CDOs; thus, higher WARFs should lead to higher write-downs.

Finally, vintage effects and controls will also affect performance. There is ample research to document the decline in underwriting standards that fueled the housing boom and the extraordinary expansion of lending. In addition, house prices peaked in 2005 and started declining in 2006. These combinations of effects suggest that more recent vintages will perform much worse than earlier vintages (Goodman, et al. (2008)). Liquidated deals should also perform worse, since, as mentioned above, the worst-performing deals are often liquidated first. Ten of the deals provided no asset information whatsoever, which could be a sign of higher risk.

Overall, the regression results reported in Table 16 show that all the major risk dimensions discussed above have a significant effect on CDO write-down percentages, explaining 57 to 59% of variation in write-downs. We show three specifications of the model. The first regression includes all characteristics and controls, our full model. Since asset and deal risk characteristics are so collinear, our second and third regressions treat each category separately along with the other effects.

As shown in Table 16, for the full model (1), all major groupings contributed significantly to explaining variation in write-down percentages. For the deal characteristics, results show that having more assets in the deal significantly increases write-down percentages, consistent with the hypothesis that more assets result in more complex deal structures, thereby increasing write-down percentages.

For the asset characteristics, several groupings contributed significantly to risk, with no major grouping decreasing risk. The share of synthetic collateral has a coefficient of 0.15. The way to interpret this coefficient is that a $1 increase in synthetic collateral increases write-downs by 15 cents. Home equity securities increase write-down percentages by 16%, Alt-A RMBS increase write-down percentages by 20% and CDO collateral increases writedown percentages by 32%. The other asset categories have positive coefficients but were not significant. Still, it is important that none of these categories decreased write-downs, suggesting that riskier securities were placed into CDOs across the board. (We will further confirm this below.) Interestingly, the coefficient on Alt-A collateral was larger than that on home equity, which we interpret as consistent with higher *unexpected* write-downs in Alt-A securities, as evidenced by much lower subordination levels in Alt-A bonds relative to subprime (see Figure 1). This may also explain why prime RMBS did not decrease the risk of the SF ABS CDOs, since prime RMBS bonds had even lower subordination than Alt-A RMBS or home equity. Not surprisingly, CDO collateral had the largest coefficient of all (32%), since these subordinated bonds, dominated by SF ABS CDOs, are expected to be fully written off (Table 15).

The last two categories in Model (1) of Table 16, deal characteristics and controls, are all mostly dummy variables; so they have a different interpretation. For these coefficients, they represent the variation in risk *relative to* an omitted category. For the deal risk characteristics, only the flag on pure synthetic collateral was weakly significant, and negative, relative to cash CDOs. These variables are mostly collinear with the asset characteristics, which may be why they are not particularly important in Model (1).

For the controls category, the issue year dummy variables are positive and significant starting in 2004 (relative to the 1999-2000 cohorts) and increase in significance in a monotonic way up to the shutdown of the SF ABS CDO market in 2007. Relative to issue years 1999 and 2000, issue years 2001-2003 were negative and insignificant; no doubt these vintages benefited from the greater diversification of the pools (from Figure 2) as well as favorable market conditions in housing. Starting with 2004, collateral was 13% riskier than in the 1999-2000 cohort, increasing monotonically to 47% by 2007. Clearly, the huge rise in SF ABS CDO issuance combined with increasing concentrations of mortgage securities, with so much coming at the peak of the housing market in 2005 and thereafter, was a major determinant of write-downs in these CDOs. Also significant was the risk on the 10 deals that reported no asset information, which meant, in effect, that investors were likely relying entirely on ratings. Losses on liquidated deals are higher but not significant after controlling for other effects.

Since the asset and deal risk characteristics are so collinear, in Table 16 we report results of treating each category separately in Models (2) and (3). The effect of omitting the deal risk characteristics in Model (2) has the effect of increasing the coefficients on home equity and Alt-A collateral but decreasing the coefficients on the synthetic and CDO collateral. Omitting the asset characteristics has the effect of increasing the effects of deal risk characteristics, since the hybrid and CDO^2 flags are significant and

positive. Omitting assets also makes the intercept term significant, suggesting a large fixed effect from not considering the composition of the assets.

B. Examining the Effects of Dealers[35] and CDO Managers[36]

Perhaps the two most important participants in the CDO structures are the dealers, responsible for underwriting, marketing, and issuing the deals, and the CDO managers, responsible for purchasing the collateral assets before closing and managing the deals post-issuance, including playing the all-important role of replacing assets that pay down or default. To analyze the link between CDO performance and these two groups, we add dealer and CDO manager fixed effects to our full model (Model 1) estimated in subsection V.A. These regressions examine whether the identities of the dealers and CDO managers are significant predictors of performance, after controlling for CDO characteristics. The dealers identified match those in Barnett-Hart (2009). In addition, we examine the fixed effects of the largest CDO managers, which Barnett-Hart (2009) or others do not consider.

There are two competing hypotheses on dealer and collateral manager effects that we can test with our model here. One hypothesis is that the dealers most actively short selling the mortgage market, notably Goldman Sachs and Deutsche Bank,[37] would experience the highest principal write-downs, since they had the most to gain from poor performance of the mortgage market and would be inclined to push out worse deals. Alternatively, the second hypothesis is that the worst-performing deals would be made by firms that had substantial positions themselves in SF ABS CDOs, since they would be the ones most likely to deal up to the point at which the market crashed (see Lewis (2010)). So the strategy is to add dealer fixed effects into the full model for the 17 largest dealers and then rank the coefficients from least to greatest relative to the omitted category (which is the collection of smaller dealers).[38]

Results in the first panel of Table 17 show evidence of a significant dealer effect on CDO performance and provides the strongest support for the second hypothesis. When the dummy variables for the 17 largest dealers are included, the adjusted R^2 for Model (1) increases by more than 1% to 58.5%. The coefficients are significant for the three worst performers. The worst performer, Morgan Stanley, had loss rates that, after controlling for deal effects, were 8.4% higher on average than the collection of smaller dealers. What is most interesting about these results is that the four worst performers, Morgan Stanley, Citigroup, Bear Stearns, and UBS, all took substantial write-downs on SF ABS CDOs, often from holding the senior-most tranches of the CDOs they underwrote.[39] Heavy write-downs in CDOs were in and of

[35] In Barnett-Hart (2009) and other sources, dealers are referred to as underwriters. In practice, they are used interchangeably. Our preference for the designation 'dealer' avoids confusion with underwriters of mortgage loans.
[36] This is defined as CDO manager at original issuance and does not adjust for subsequent mergers that occurred. Intex does not update, nor do we have good information on this.
[37] The shorting of the subprime mortgage market was the basis for the SEC lawsuit against Goldman Sachs. Lewis (2010) reports that Greg Lippman, of Deutsche Bank, was actively shorting the subprime market as early as 2006.
[38] We conducted an F test to test the null hypothesis that the dealer fixed effects were all equal to zero. Our F statistic ($F=2.27$, $p=0.0025$) shows that the null hypothesis can be rejected.
[39] Lewis (2010, Chapter 9) reports that the Global Proprietary Trading Group (GPTG) of Morgan Stanley, our worst performer, bought $2 billion of CDS on some BBB-rated subprime securities but, to finance these shorts, sold $16 billion of CDS (for a fee) on the AAA pieces of some SF ABS CDOs to cover the interest payments on the shorts. They felt certain that the BBB shorts would pay off but otherwise trusted the ratings on the AAA bonds. This resulted in a $9 billion loss for MS, according to Lewis the largest single trading loss in the history of Wall Street. Shortly before this loss was realized, $2 billion of the AAA CDS were sold to UBS, our fourth worst performer.

themselves not a conclusive factor, however, since Merrill was only the ninth worst and otherwise not significantly worse than the omitted group of smaller dealers.[40]

In the second panel of Table 17 we report our fixed effects of the collateral managers (CMs).[41] For statistical reasons, we chose to include only those managers that managed 10 or more deals. This reduced our set to 17 collateral managers, which means that only 243 deals, around one-third of the SF ABS CDO universe, are considered in the regression. Because of the complexities of managing and marketing deals, CMs typically manage only a small number of deals. In our data set, TCW is the CM with the most deals under management, managing 40 SF ABS CDOs. The median number of managed SF ABS CDOs for the top 17 CMs is 11. Note that there are 68 "static" deals, those not allowing for replacement of collateral, that have no CMs. This effect is already included in the full model regression; so we report the fixed effect for these deals to compare against the collateral managers.

Despite the small number of deals considered for our CM fixed effects, results in the second panel of Table 17 show evidence of a significant collateral manager effect on CDO performance, as it is with dealers. When the dummy variables for the 17 largest collateral managers are included, the adjusted R^2 for Model (1) in Table 17 increases 1% to 58.2%. The lowest ranked CMs are all significant in the regressions. Consistent with dealer results, the lowest ranked firms, ACA Management and Bear Stearns, both suffered significant losses from CDO exposures, both eventually going out of business.[42] The better performing CMs, RWT Holding and C-BASS, appear to have benefited from higher concentrations in earlier vintage deals.

C. The Determinants of Performance of AAA-Rated SF ABS CDO Bonds

Our final set of regressions examines the performance of SF ABS CDO tranches, in particular, the AAA-rated securities, including both the junior and senior AAA-rated securities. Initially we had intended to conduct a multivariate analysis on all the rated bonds until we saw that virtually all bonds rated below AAA have been or are expected to be fully written down (see Table 19). As a result, our analysis in this section is limited to the AAA-rated tranches, where a much larger share has at least some variation. The major reason to consider this analysis separately is that this allows us to examine more characteristics of the structures and, very importantly, the performance of the rating agencies that rated the bonds.[43] So our strategy is to add rating agency fixed effects and tranche-level characteristics to the variables of the full model that apply to our multivariate analysis on AAA bonds. All told, 1,840 bonds were either rated AAA, or we could infer an AAA rating from the deal structure.[44]

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[40] Barnett-Hart (2009) came to the same conclusion after she replaced CDO reported losses with the firm fixed effects in her regressions.

[41] Again, we computed an F test to test the null hypothesis that the collateral manager fixed effects were all equal to zero. Our F statistic (F=1.83, p=0.0187) shows that the null hypothesis can be rejected.

[42] ACA was the collateral manager that managed the Abacus 2007-AC1 deal at the center of the SEC lawsuit against Goldman. Its long positions on the super-senior tranche, backed up by ABN Amro, helped bring down the firm.

[43] Rating agencies do not rate the securities trusts, generally only the fixed-income parts of the deal, the bonds. In our 727 CDOs, 705 of the securities are not rated, mainly because they are equity tranches.

[44] There were 123 bonds that were not rated, but which were senior in the structure to the AAA-rated bonds. Since rating agencies do not assign a rating above AAA, we inferred the AAA ratings and assigned them to the appropriate rating agency rather than exclude these observations from the analysis.

Our expanded regression presented in Table 18 shows that the additional tranche features contribute significantly to the variation in write-downs but that relative rating agency effects generally do not. For the rating agency variables, we assigned a dummy variable for each grouping of the three rating agencies. For these rating agency fixed effects, performance in variation is relative to the omitted group, which is the group of 364 AAA bonds rated by all three rating agencies. By far the largest grouping is from the AAA bonds rated by Moody's and S&P, which together rated 1,306 AAA bonds, 71% of the total. For these bonds the coefficient is small and positive but insignificant. The 21 bonds rated by Moody's and Fitch showed a large positive and significant coefficient, and the 23 bonds rated by S&P alone shows a large and significant negative coefficient. But the small number of bonds associated with these groupings could easily be the result of idiosyncratic factors. The most important finding is that the three biggest groups (ratings by all three rating agencies, Moody's, S&P, and Fitch), which account for 94% of the rated AAA bonds, are not significantly different from each other. This result is consistent with the hypothesis that rating agency models were not much different from each other.[45] In short, a consensus formed around valuations at the rating agencies. The 46 securities not rated by any of the rating agencies had a negative coefficient but was not significant, suggesting that AAA securities not rated by the three major rating agencies performed no better.

Several of the tranche characteristics are significant and quite important economically. Most important, a higher margin on the floating rate securities has a very large coefficient and is highly significant. Even after controlling for deal, asset, and tranche effects, higher discount margins translate into significantly greater risks, with a coefficient of 0.16. Since 1,613 of the securities (88%) are floating rate, this effect is material. Higher margins are generated by placing higher yielding, and riskier, securities into the deals. This was a primary reason for the placement of large amounts of BBB-rated subprime securities into the CDOs and may well have been a motive for adding in riskier BBB-rated bonds as well as riskier securities in other asset classes, judging by the positive coefficients on write-downs for all major asset classes in the regression. The subordination level coefficient is also large at -0.20 and also highly significant. Higher levels of subordination translated into smaller write-downs. Likewise, the flag for senior AAA bonds is large at -0.21 and is highly significant. Interestingly, the super senior flag, which represented 123 securities senior to even the AAA-rated bonds, was significant and positive.[46]

As for the other effects, there are some very interesting differences with the deal-level model. For the asset characteristics, only the share of synthetics in the securities and share of CDOs significantly increased risk. As shown in Figure 2, rising shares of synthetic and CDO collateral came very late in 2006 and 2007 and were likely subject to more measurement error. They also had a much stronger negative effect on the senior-most bonds. The pure synthetic flag was negative and significant, suggesting that the knowledge that a deal was purely synthetic was better factored into protection for the AAA bondholders than knowledge about the specific share of synthetic collateral in a deal.

[45] According to the IOSCO Technical Committee (2008, p. 24), a Code of Conduct published by IOSCO in 2004 made disclosures about rating methodologies transparent enough so that dealers could easily anticipate the level of credit enhancement necessary to obtain a desired rating. The SEC (2008) also pointed out that rating agencies often used their own ratings on securities in the CDOs, further increasing uniformity.

[46] For these bonds, they were technically unrated. Since they are senior to all the AAA-rated bonds, we inferred the raters in these cases by matching the raters on the AAA bonds just below them in the structure.

Vintage effects were the biggest single factor explaining the variation in write-downs on the deals; they are even more so for explaining the variation in AAA bond performance. Vintage effects are significant and positive starting in 2003 in the tranche level model (as opposed to 2004 in the deal-level regression), and the coefficient values are much higher in every single year. Clearly, the increasing concentrations of mortgage assets in the CDOs, the increasing risks of the securities being placed in the CDOs, and the increasing use of synthetic collateral in more recent years all increased risks for the senior-most bondholders. Since these were mostly controlled for in the regressions, the vintage effects may have been picking up the economic effects on deal performance, as evidenced by house prices peaking in 2005.

VI. Summary and Conclusions

Before our study, most of what we knew about the size and composition of the "structure finance CDO market" came from qualitative accounts (Gorton 2008); anecdotes in books from the popular press (e.g., Lewis (2010), McLean and Nocera (2011)); or the rating agencies, whose figures contain only the CDOs they rated and which they do not report consistently.[47] Information on write-downs was even more difficult to come by, primarily because what information we have received has come from rating agencies or investment banks, neither of which is interested in conducting studies on markets that have completely shut down. That is why the forensic work and analysis we conduct in this paper are so important. We believe that the 727 securities totaling $641 billion of issuance that we identify represent the population of securities that traded publicly on the ABS CDO trading desks of the largest financial firms active in the market. After identifying the securities, we then examine the linkages of SF ABS CDOs to subprime securities and document the enormous extent of the referencing of these securities in SF ABS CDOs and the multiplication of risks created by the $201 billion of synthetic collateral (see Table 5). While many have speculated on these linkages, we document that some 5,500 of BBB-rated subprime securities were placed or referenced into these CDOs some 37,000 times, transforming $64 billion of BBB subprime bonds into $140 billion of CDO assets (Table 6). We believe our expected write-down figure of $420 billion is close to the tally of ultimate write-downs that will occur, if only because over 70% of these write-downs have already been realized. Finally, we conduct an analysis of variance on the determinants of write-downs in the SF ABS CDO market, which we elaborate on below. Overall, we provide strong support for the conclusion in Goodman, et al. (2008, p. 269) that the SF ABS CDO market meltdown is "indicative of the greatest rating agency and risk management failure ever."

So extraordinary are the write-downs on these CDOs, especially relative to expected write-downs on AAA-rated subprime MBS, that we believe we should rethink the meaning of the "subprime crisis." The IOSCO Technical Committee (2008), Gorton (2008), McLean and Nocera (2010) and others refer to the "subprime crisis" as emanating from the subprime securitization process itself, starting with the MBS. But subprime MBS has a relatively simple senior/subordinated structure with deep subordination for the AAA-rated subprime bonds (23% on average), most often over-collateralized (see Figure 1). Moody's (2010) conducted a review of all the 2005-2007 securities it rated on all forms of mortgage-related deals, from private-label MBS to CDOs. In Figure 3, we summarize Moody's impairment figures on MBS and

[47] The FCIC (2011) used data from Moody's, since it couldn't get figures from independent sources. The FCIC's total figures were around 10% higher than ours, likely for definitional reasons.

combine them with our write-down estimates.[48] Despite well-documented declines in underwriting standards and the worst housing downturn since the Great Depression, at year-end 2009 only 4% of the AAA-rated subprime MBS securities issued from 2005 to 2007 were impaired or are expected to become impaired. By our calculations, 98% of the AAA-rated SF ABS CDOs issued between 2005 and 2007 will suffer write-downs. If these results hold up, the AAA-rated subprime securities performed remarkably well, better even than Alt-A securities. This suggests that one lesson we can take from the crisis is that the senior/subordinated MBS structure is quite resilient and, with reforms, can serve as a primary investment vehicle for the MBS market. This finding could certainly help drive policy reform discussions.

Rather, the "break in the chain" came at the next level, where dealers and rating agencies created structures that gave AAA bondholders of mezzanine CDOs and CDO^2s levels of subordination comparable to *those provided to the AAA mortgage bonds!* As we describe in Section II.A, subprime mortgage losses needed to reach only 1.5 to 2.5 times the consensus view on expected losses reported in Gerardi, et. al. (2008) before the mezzanine CDOs would be nearly or completely written down. For the so-called high-grade CDOs, the story is much the same, with higher levels of losses needed to completely wipe them out, but losses that were well within the range likely for the significant downturn taking shape in 2007.[49] Thus, it was not unexpectedly high losses in subprime HE securities that appeared to be the problem. AAA subordination levels on subprime MBS were set up to withstand extraordinarily high losses. Rather, it was most likely the prospect that the AAA-rated bonds of SF ABS CDOs were either severely impaired or completely worthless, confirmed by our valuation exercise (Table 15), combined with the fact that the AAA tranches of these CDOs were so heavily concentrated in so many of our largest financial institutions (Creditflux (2008), FCIC 2011) that was the more substantive problem in financial markets in August 2007. Hence, we feel a special focus should be on the "subprime CDO crisis."

Our multivariate analysis of the determinants of the losses confirms that firms were choosing securities to place into SF ABS CDOs primarily for yield. It is an important find that none of the different asset categories in these CDOs lowered risk, suggesting that riskier securities were placed into CDOs across all major asset classes (Table 16). When examining the performance of AAA-rated bonds, higher discount margins were a major determinant of losses (Table 18).

As for the dealers at the center of SF ABS CDO issuance, our results support the hypothesis that most were not fully aware of the risks in the CDOs, since the dealers that underwrote the worst-performing CDOs (Morgan Stanley, Citicorp, Bear Stearns, and UBS) all suffered large and debilitating losses from the "super-senior" AAA bonds of the CDOs they underwrote and held (see FCIC (2011) and Lewis (2010) for a list of firms that held CDO risk). Goldman Sachs and Deutsche Bank, which we later learned were selling off their risk and shorting the subprime mortgage market, were 7th and 11th in terms of rank

[48] Moody's defines impaired as having a current rating of Ca or less or suffering a principal write-down. Moody's (2010) figures are 71% for the "structured finance CDOs" it rated, lower than our figures, but still extraordinarily high. Moody's figures might well have been quite close to ours had Moody's done its analysis 15 months later. Moody's CDO figures appear in FCIC (2011).

[49] The IOSCO Technical Committee's report (2008, pp. 3-4) points out that "some observers argue that many of these [AAA] "low risk" tranches…are only "low risk" insofar as no systemic shock or other widespread adverse event has an effect on all assets of a given type that comprise the underlying cash flow for a CDO." Our point is that it did not take a systemic shock to severely impair or completely wipe out the value of these AAA CDO bonds. Rather, it only took only slightly higher than expected losses.

and not statistically different in terms of write-downs from the small issuers. This makes sense given the size of the market. To absorb $641 billion in SF ABS CDOs required the participation of the largest players in the financial system.

With our analysis, we believe we have shown conclusively that the financial crisis was not brought on by the lack of data on the RMBS and HE securities or by the disclosure limitations on SF ABS CDO securities. One of the enduring myths of the crisis is that loan-level data on the mortgage securities in these CDOs were not available to properly value these CDOs.[50] Loan level data were available on most securities directly through Intex, with data on most others available from third-party vendors. Disclosures on securities recommended in the reforms by the IOSCO Technical Committee (2008, p. 3-4) were already mostly available for the SF ABS CDOs. For investors, it was all available upon request.

But clearly data quality was a problem, fueled as it was by declining underwriting standards. One very valid point on the data is that the quality of the data being provided deteriorated significantly in the build-up to the crisis because of declining underwriting standards, by the IOSCO's reckoning, "beginning in late 2004 and extending into early 2007."[51] Demyanyk and Van Hemert (2009, p. 3) argue that "deterioration in loan quality—adjusted for observed characteristics and macroeconomic circumstances—deteriorated monotonically between 2001and 2007." What we need to get a better understanding of is how the feedback loop of demand for subprime mortgage bonds for CDOs, combined with the vertical integration of sellers/servicers and dealers, contributed to the downward spiral of underwriting standards and data quality. Establishing such a causal link empirically is quite challenging but quite important to developing a more complete understanding of the crisis.

What of the rating agency models? Our precursory examination (Table 18) of write-downs tied to rating agency ratings on AAA SF ABS CDO bonds does not show any significant differences between the rating agencies in terms of explaining expected losses. This is consistent with the view that the three major rating agencies employed similar models. Some interesting research on ratings methodologies for CDOs has been undertaken (e.g., Griffin and Tang (2009), Benmelech and Dlugosz (2010)), but no research has yet been done on the apparent disconnect between risks in rating agency models on subprime securities and subprime CDOs mentioned above. Developing a clear understanding of rating agency models is critical to understanding this disconnect.

One issue uncovered by our analysis is the enormous amount of cross-referencing, noted above, of the same securities in these 727 CDOs. The process of assigning ratings deal by deal meant that little opportunity existed to evaluate how the enormous amount of cross-referencing was affecting the asset correlation assumptions in the rating agency models. Did the rating agencies make substantial adjustments to their models' correlation assumptions as the same bonds were going into many different CDOs? (Barnett-Hart (2009) suggests not.) More fundamentally, the colossal write-downs suffered calls into question the entire modeling framework for CDOs, certainly for its application to ABS, but perhaps also for other asset classes as well (see Heitfield (2009)). This is a most important point, since these models are still being employed in corporate CDO and CLO CDO markets.

[50] Lewis (2010) quotes Wall Street and rating agency analysts, who claimed that dealers were withholding this information from them. As we demonstrate, RMBS and HE loan-level data were available from other sources.
[51] See IOSCO Technical Committee (2008, p. 2).

A final area for future work concerns further analyzing risk management practices at the nation's largest financial institutions. What compelled banks to take on such enormous exposures of subprime risk through their exposure to SF ABS CDOs? One explanation uncovered in our analysis is that the concentration of subprime debt in SF ABS CDOs came much later, in 2006-07 (Figure 2). So perhaps the speed with which these CDOs became vehicles for placement of subprime debt, and increasingly synthetic debt, was not fully appreciated at issuance. Another point is that even for firms like AIG, which apparently exited the CDO market in early 2006, existing CDOs allowed for replacement of 2006-2007 subprime bonds into these older vintages of CDOs as CDO balances declined, which meant they were still exposed to later vintages of subprime risk. Analyzing the flows of securities in these CDOs over time is a logical extension of our analysis.

What is more perplexing is how these firms did not uncover the potential for catastrophic losses in these CDOs if market conditions resulted in even slightly higher than expected losses. While few got right the actual path of house prices, Gerardi et al. (2008) show that scenarios that would wipe out the subprime BBB-rated bonds and most of the A-rated bonds, and with it the CDOs, were recognized in the models with a reasonably high probability.[52] These risks, therefore, should have been well within the ranges of the banks' risk models, which meant these firms should have, at a minimum, been reserving for these potential exposures. The SF ABS CDO market may be the quintessential case study for the prescient warnings laid out in Rajan (2006), in which he warned that "perverse incentives" existed so that firms would increase expected short-term profits in exchange for seemingly remote tail risk, in the process increasing the systemic risk to the overall financial system. The way this manifested itself was through the largest dealers placing their own subordinated subprime and CDO bonds into CDOs and CDO^2s and retaining the "super-senior" tranches of the CDOs (Merrill, Citigroup, Morgan Stanley, UBS), while others (Goldman Sachs, Deutsche Bank) passed this risk off to other major players in the financial system (e.g., AIG). As we now know, taking on tail risks on such a large scale greatly increased systemic risk to the overall system, with disastrous consequences. Like Rajan (2006), Lang and Jagtiani (2010) blame the problem on compensation systems at the largest financial institutions, where business line managers earned big bonuses from their investment in SF ABS CDOs, even gaining from the lack of transparency in the CDO structures.[53] Clearly, more needs to be done on this subject, as it remains the most puzzling aspect of the crisis.

In conclusion, by developing a robust classification for the SF ABS CDO market, we have cleared up much confusion about the size, composition, and expected write-downs of the market and how and why it came to be dominated by subprime securities. But it is only the beginning of the analysis needed to get a full understanding of the subprime CDO crisis, its effects on the markets, and, most important, the appropriate policy responses.

[52] In the models they analyzed, a house-price decline or a slowdown large enough to wipe out most of the subordinated subprime bonds was given a 20% probability of occurring. These probabilities for catastrophic losses are far above the probabilities against which firms should have been holding capital.

[53] The FCIC (2011) clearly documents through interviews with senior management at Merrill Lynch, UBS, AIG, Citigroup, and Morgan Stanley that these firms and their boards of directors were unaware of the extent of the subprime exposure their companies held through their holdings of senior AAA-rated SF ABS CDOs.

Bibliography

Amherst Securities. "Amherst Mortgage Insight – PrimeX: Trading Starts April 28th," Amherst Securities Group LP (April 27, 2010).

Barnett-Hart, Anna Katherine. "The Story of the CDO Market Meltdown: An Empirical Analysis," Harvard University undergraduate honors thesis (2009).

Benmelech, Efraim, and Jennifer Dlugosz . "The Alchemy of CDO Credit Ratings," *Journal of Monetary Economics* 56 (2009), pp. 617-34.

Benmelech, Efraim, and Jennifer Dlugosz. "The Credit Rating Crisis," NBER (2010).

BIS Committee on the Global Financial System. "Ratings in Structured Finance: What Went Wrong and What Can Be Done to Address Shortcomings?" Bank for International Settlements (July 2008).

Cordell, Larry, Michael Hopkins, and Yilin Huang. "The Trust Preferred CDO Market: From Start to (Expected) Finish," Federal Reserve Bank of Philadelphia Working Paper 11-22 (2011).

Coval, Joshua, Jakub Jurek, and Eric Stafford. "The Economics of Structured Finance," Harvard Business School (2009).

Covitz, Daniel, Nellie Liang, and Gustavo Suarez. "The Evolution of a Financial Crisis: Panic in the Asset-Backed Commercial Paper Market," Board of Governors of the Federal Reserve System Working Paper (2009-36).

CreditFlux. "Creditflux Tally of Credit Write Downs," as of January 26, 2008. *http://www.creditflux.com/Resources/.*

Demyanyk, Yuliya, and Otto Van Hemert. "Understanding the Subprime Mortgage Crisis," *Review of Financial Studies*, 24:6 (2011), pp. 1848-80.

Fabozzi, Franklin J. *Fixed Income Analysis.* New York: John Wiley and Sons, 2007.

Financial Crisis Inquiry Commission). "The Financial Crisis Inquiry Report," FCIC (January 2011).

Gerardi, Kris, Andreas Lehnart, Shane Sherlund, and Paul Willen. "Making Sense of the Subprime Crisis," Federal Reserve Bank of Boston, Public Policy Discussion Paper (December 2008).

Gibson, Michael S. "Understanding the Risk of Synthetic CDOs," Board of Governors of the Federal Reserve System, Division of Research and Statistics (July 2004).

Goodman, Laurie, Shumin Li, Douglas J. Lucas, Thomas A. Zimmerman, and Frank J. Fabozzi. *Subprime Mortgage Credit Derivatives.* Hoboken, NJ: John Wiley & Sons, Inc., 2008.

Gorton, Gary. "The Financial Panic of 2007," NBER Working Paper, prepared for the Federal Reserve Bank of Kansas City Jackson Hole Conference (August 2007).

Gorton, Gary. "Information, Liquidity and the (Ongoing) Panic of 2007," *American Economic Review, Papers and Proceedings,* 99:2 (2009), pp. 567-72.

Griffin, John M., and Dragon Yongjun Tang. "Did Subjectivity Play a Role in CDO Credit Ratings?" unpublished manuscript, University of Texas at Austin (2009).

Heitfield, Erik. "Parameter Uncertainty and the Credit Risk of Collateralized Debt Obligations," Board of Governors of the Federal Reserve System Working Paper (January 2009).

Hu, Jian. "Assessing the Credit Risk of CDOs Backed by Structured Finance Securities: Rating Analysts' Challenges and Solutions,", *Journal of Structured Finance* (Fall 2007), pp. 43-59.

Inside Mortgage Finance. *Mortgage Market Statistical Annual*. Bethesda, MD: Inside Mortgage Finance Publications, Inc. (2010).

IOSCO Technical Committee. *Report of the Task Force on the Subprime Crisis.* May 2008.

Lang, William W., and Julapa A. Jagtiani. "The Mortgage and Financial Crises: The Role of Credit Risk Management and Corporate Governance," *Atlanta Economic Journal* 38 (2010), pp.123-44.

Lehman Brothers . "Residential Credit Losses—Going Into Extra Innings?" U.S. Securitized Products (April 11, 2008).

Lewis, Michael. *The Big Short: Inside the Doomsday Machine*. New York: W.W. Norton & Company,2010.

Lowenstein, Roger. "Triple-A Failure," *New York Times Sunday Magazine,* April 22, 2008.

Markit. "TABX.HE Marketing Launch Presentation," Markit Group Limited; http://www.markit.com/assets/en/docs/products/data/indices/structured-finance/ABX%20Marketing%20Presentation.pdf.

Mason, Joseph R., and Joshua Rosner. "Where Did the Risk Go? How Misapplied Bond Ratings Cause Mortgage Backed Securities and Collateralized Debt Obligation Market Disruptions," SSRN, http://ssrn.com/abstract=1027475 (May 14, 2007).

Mayer, Chris, Karen Pence, and Shane Sherlund. "The Rise in Mortgage Defaults," Board of Governors of the Federal Reserve System, Finance and Economics Discussion Series (November 20, 2008).

McLean, Bethany and Joe Nocera. *All the Devils Are Here: The Hidden History of the Financial Crisis*. New York: Penguin Group, 2010.

Mian, Atif, and Amir Sufi. "The Consequences of Mortgage Credit Expansion: Evidence from the 2007 Mortgage Default Crisis," Working Paper 13936 (April 2008); http://www.nber.org/papers/w13936.

Moody's. "Moody's Approach to Rating Multisector CDOs," Moody's Investor Services (April 14, 2000).

Moody's. "Announcement: Moody's Downgrades Subprime First-Lien RMBS," Moody's Investor Services (July 10, 2007).

Moody's. "Special Comment: Default & Loss Rates of Structured Finance Securities: 1993-2009," Moody's Investor Services (September 24, 2010).

Osinski, Michael. "My Manhattan Project: How I Helped Build the Bomb That Blew Up Wall Street," *New Yorker Magazine* (March 29, 2009).

Rajan, Raghuram. "Has Financial Development Made the World Riskier?," prepared for the Federal Reserve Bank of Kansas City Jackson Hole Conference (August 2006).

Securities and Exchange Commission. "Summary Report of Issues Identified in the Commission Staff's Examinations of Select Credit Rating Agencies," (July 2008).

Standard & Poor's. "Global Cash Flow and Synthetic CDO Criteria: CDO of Structured Finance CDO," (March 21, 2003).

Standard & Poor's. "612 Subprime RMBS Classes Put on Watch Neg; Methodology Revisions Announced," (July 10, 2007).

Tavakoli, Janet. "Structured Finance: Rating the Rating Agencies," *GARP Risk Review*, 22 (January/February 2005).

Table 1

Composition of Structured Finance ABS CDO Collateral Original Unique Assets 1999--2007			
Detailed Collateral Asset	**Number**	**Share**	**Cumulative Share**
Home Equity	17,947	45%	45%
RMBS-Alt A	7,124	18%	63%
RMBS-Prime	2,222	6%	68%
SF ABS CDOs	4,177	10%	79%
CMBS	2,518	6%	85%
Restricted/Private	1,555	4%	89%
Credit Card Receivable	235	1%	90%
Small Business Loan	154	0%	90%
Franchise	122	0%	90%
High Yield CDOs	114	0%	91%
Trust Preferred CDOs	71	0%	91%
CLO	52	0%	91%
Agency MBS	14	0%	91%
Manufactured Housing	10	0%	91%
Other	3,530	9%	100%
Total	39,845		
Notes: This table details various collateral types that went into SF ABS CDOs issued between 1998-2007. RMBS = residential mortgage-backed securities, SF ABS CDOs = structured finance asset-backed security collateralized debt obligations, CMBS = commercial mortgage-backed securities, CLO = collateralized loan obligations.			
Source: Intex			

Table 2

SF ABS CDOs by Synthetic Collateral Type									
By Original Collateral Balance ($Millions)					By Deal Count				
Year	Cash	Hybrid	Synthetic	Total	Year	Cash	Hybrid	Synthetic	Total
1999	304			304	1999	1			1
2000	6,391		600	6,991	2000	18		1	19
2001	14,891			14,891	2001	34			34
2002	14,456		3,000	17,456	2002	36		1	37
2003	25,431		130	25,561	2003	44		1	45
2004	52,135	422	6,000	58,558	2004	76	1	4	81
2005	86,270	8,306	14,302	108,877	2005	97	14	13	124
2006	109,334	68,568	53,809	231,711	2006	97	75	51	223
2007	63,697	99,602	13,459	176,759	2007	48	99	16	163
Total	**372,909**	**176,898**	**91,300**	**641,107**	**Total**	**451**	**189**	**87**	**727**

Notes: This table summarizes our final classification of SF ABS CDOs from Intex after reclassifying 115 CDOs. From Table 2, 92 deals from the CDO^{2}s, 16 deals from synthetic CDOs, and 7 deals from cash CDOs were reclassified into other categories. The table columns separate pure cash, pure synthetic and hybrids. SF ABS CDOs = Structured Finance Asset-Backed Securities Collateralized Debt Obligations.

Source: Intex

Table 3

CDO Classifications LehmanLive Versus Our Study		
Deal Category (SF ABS CDOs)	**Deal Count (Lehman Live)**	**Deal Count (SF ABS CDOs)**
SF ABS CDOs	593	593
CMBS/CRE/REIT	87	
CLO CDOs	30	
European ABS CDOs	11	
High Yield CBOs	6	
Trust Preferred CDOs	5	
High Yield CDOs	2	
Student Loan CDOs	1	
Additional SF ABS CDOs		134
Total	**735**	**727**

Note: This table compares CDO classifications by LehmanLive used in Barnett-Hart (2009) and other studies with our SF ABS CDO classification. SF ABS CDO = Structured Finance ABS CDO, CMBS = Commercial Mortgage-Backed Security, CRE = Commercial Real Estate, REIT = Real Estate Investment Trust, CLO CDO= Collateralized Loan Obligation-backed CDOs, CBO = Collateralized Bond Obligation.

Table 4

SF ABS CDO Cash and Synthetic Collateral by Vintage 1999-2000				
Year	**Cash**	**Synthetic**	**Total**	**% Synthetic**
1999	304	-	304	0%
2000	6,391	600	6,991	9%
2001	14,891	-	14,891	0%
2002	14,456	3,000	17,456	17%
2003	25,431	130	25,561	1%
2004	52,502	6,056	58,558	10%
2005H1	25,633	3,827	29,460	13%
2005H2	64,071	15,346	79,417	19%
2006H1	52,608	18,501	71,109	26%
2006H2	83,287	77,315	160,602	48%
2007H1	73,948	49,065	123,013	40%
2007H2	26,230	27,516	53,746	51%
Total	**439,751**	**201,356**	**641,107**	31%

Notes: This table breaks out SF ABS CDO issuance between cash and synthetic by year through 2004, then semi-annually from 2005. SF ABS CDOs = Structured Finance Asset-Backed Securities Collateralized Debt Obligations.

Table 5

Share of CDO Issuance by Vintage and High Grade or Mezzanine By Count and Issuance Balance ($ Millions)						
	Counts			**Balances ($ Millions)**		
Year	**High Grade**	**Mezzanine**	**Total**	**High Grade**	**Mezzanine**	**Total**
1999		1	1		304	304
2000		19	19		6,991	6,991
2001	5	29	34	3,950	10,940	14,891
2002	4	33	37	2,800	14,656	17,456
2003	8	37	45	9,792	15,769	25,561
2004	35	46	81	35,997	22,561	58,558
2005	52	72	124	65,293	43,584	108,877
2006	84	139	223	121,602	110,109	231,711
2007	67	96	163	102,988	73,771	176,759
Total	**255**	**472**	**727**	**342,423**	**298,683**	**641,107**

Notes: This table breaks out structured finance CDOs by whether the securities are classified as High Grade or Mezzanine. High Grade are those where the underlying securities are primarily A-rated bonds; Mezzanine are primarily BBB-rated. SF ABS CDOs = Structured Finance Asset-Backed Securities Collateralized Debt Obligations.
Source: Intex

Table 6

Home Equity Bonds Placed into SF ABS CDOs by Original Rating 1998-2007						
Counts						
Original Tranche Rating	**Total # Issued**	**Total Placed or Referenced in CDOs**	**% Placed or Referenced in CDOs**	**# Occurrences in CDOs**	**Share of Occurrences to Total Issued**	**Share of Occurrences to Total Placed in CDOs**
AAA	12,948	1,463	11%	2,509	19%	171%
AA	5,486	3,893	71%	11,292	206%	290%
A	5,891	4,579	78%	14,714	250%	321%
BBB	6,993	5,496	79%	36,901	528%	671%
BB/B	1,976	899	45%	2,091	106%	233%
Amounts ($ Thousands)						
Original Tranche Rating	**Total $ Issued**	**$ Amount Placed or Referenced in CDOs**	**% Placed in CDOs**	**$ Amount of Occurrences in CDOs**	**Share of $ of Occurrences to Total Issued**	**Share of $ of Occurrences to Total Placed in CDOs**
AAA	2,011,451	160,090	8%	25,897	1%	16%
AA	173,150	125,152	72%	80,449	46%	64%
A	100,183	82,916	83%	71,245	71%	86%
BBB	77,025	64,061	83%	140,046	182%	219%
BB/B	18,002	9,055	50%	7,981	44%	88%

Notes: This table breaks out the total number and dollar balances of Home Equity (HE) securities that were either placed or referenced in SF ABS CDOs by original rating agency rating. It then computes the share of bonds that went into SF ABS CDOs, then computes the number of occurrences in the CDOs, then computes shares of occurrences per total bonds issued and per total placed in CDOs. SF ABS CDOs = Structured

Source: Intex

Table 7

Summary Statistics for High Grade Structured Finance ABS CDOs					
Variable	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
CDO Issue Year	255	2005.53	1.3508956	2001	2007
% Collateral Synthetic	255	10.06%	26.80%	0	100.00%
% Collateral Fixed	255	23.96%	25.72%	0	100.00%
% Collateral: Home Equity	255	48.97%	21.70%	0	100.00%
% Collateral: Alt_A	255	11.72%	12.84%	0	82.62%
% Collateral: Prime	255	4.77%	6.99%	0	46.93%
% Collateral: CDO	255	19.27%	19.45%	0	100.00%
% Collateral: CMBS	255	4.15%	8.30%	0	48.90%
% Collateral: ABS	255	6.46%	9.41%	0	65.88%
% Collateral: Other	255	3.48%	8.12%	0	62.47%
Dummy: Asset Detail	255	0.01	0.11	0.00	1.00
# of Original Assets	253	156	51	20	394
Deal Original Balance	255	$ 1,335,446,519	$ 769,100,841	$57,440,000	$ 5,048,750,000
Deal Current Balance	255	$ 990,395,933	$ 764,789,955	$ -	$ 4,336,813,739
Collateral Original Balance	255	$ 1,342,836,935	$ 689,071,134	$57,440,000	$ 4,984,700,000
# Tranches in the Deal	255	7.20	1.93	1	15
WARF	255	52	37	1	200

Note: This table compiles deal level data on the High Grade Structured Finance CDOs that are used in the empirical analysis later. CDO=collateralized debt obligation. WARF=weighted average rating factor.

Table 8

Summary Statistics for Mezzanine Structured Finance ABS CDOs					
Variable	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
CDO Issue Year	472	2004.78	2.0428748	1999	2007
% Collateral Synthetic	472	38.18%	43.71%	0	100.00%
% Collateral Fixed	472	43.19%	36.06%	0	100.00%
% Collateral: Home Equity	472	59.31%	31.31%	0	100.00%
% Collateral: Alt_A	472	5.04%	10.73%	0	88.98%
% Collateral: Prime	472	1.79%	5.91%	0	83.20%
% Collateral: CDO	472	11.54%	20.69%	0	100.00%
% Collateral: CMBS	472	5.26%	7.98%	0	49.32%
% Collateral: ABS	472	9.95%	14.46%	0	100.00%
% Collateral: Other	472	5.60%	12.96%	0	91.50%
Dummy: Asset Detail	472	0.01	0.12	0.00	1.00
# of Original Assets	466	127	50	1	390
Deal Original Balance	472	$ 607,218,757	$ 428,029,884	$ 5,000,000	$ 2,500,000,000
Deal Current Balance	472	$ 324,393,355	$ 346,592,989	$ -	$ 2,190,337,809
Collateral Original Balance	472	$ 632,803,980	$ 439,982,248	$10,000,000	$ 3,000,000,000
# Tranches in the Deal	472	7.05	2.05	1	14
WARF	472	512	196	360	940

Note: This table compiles deal level data on the Mezzanine Structured Finance CDOs that are used in the empirical analysis later. CDO=collateralized debt obligation. WARF=weighted average rating factor.

Table 9

Summary Losses for Liquidated SF ABS CDOs by Issuance Year				
Vintage	**# of Deals**	**Deal Balance ($ million)**	**Deal Loss ($ million)**	**Total Loss %**
2000	4	1,437	82	6%
2001	8	4,172	1,008	9%
2002	7	4,198	207	5%
2003	12	7,673	1,376	18%
2004	10	9,380	7,259	76%
2005	14	13,662	9,899	72%
2006	80	79,652	63,910	82%
2007	78	88,295	78,275	88%
Grand Total	**213**	**208,469**	**162,015**	**78%**

Notes: This table summarizes losses on all liquidated SF ABS CDOs (as of March 2011) by vintage, CDO type and risk classification. SF ABS CDOs = Structured Finance ABS CDOs.

Source: Intex, Bloomberg, RBS (2011).

Table 10

Valuation Methodology for Underlying Collateral				
Detailed Collateral Asset	**Count**	**Current Face ($) as of March 2011**	**Share**	**Pricing Description**
Home Equity	10,804	101,714	46%	Proprietary Model with Discount Rate = Index + 800 basis points; if unavailable, used IDC Pricing (237), Ratings-Based Pricing (27) or Bloomberg Valuation (1)
RMBS-AltA	4,518	33,528	15%	Proprietary Model with Discount Rate = Index + 600 basis points; if unavailable, used IDC Pricing (70) or Ratings-Based Pricing (7)
SF ABS CDOs	1,252	23,816	11%	Internal Results
CMBS	1,392	16,612	7%	IDC Pricing; if unavailable, used Ratings-Based Pricing (8)
RMBS-Prime	1,764	13,342	6%	Proprietary Model with Discount Rate = Index + 400 basis points; if unavailable, used Ratings-Based Pricing (6)
Miscellaneous Private ABS*	1,339	11,684	5%	IDC Pricing; if unavailable, used Ratings-Based Pricing (327) or Bloomberg Valuation (7)
CRE/CMBS CDOs	474	6,162	3%	IDC Pricing; if unavailable, used Ratings-Based Pricing (137)
High Yield CDOs	608	4,977	2%	IDC Pricing; if unavailable, used Ratings-Based Pricing (151)
Collateralized Loan Obligations	324	2,886	1%	Prices based on Moody's Idealized Default Curve with a 45% Recovery (run with Intex); if unavailable, used Ratings-Based Pricing (21) or IDC Pricing (8)
Trust Preferred CDOs	156	2,767	1%	Cordell, Hopkins and Huang (2011)
Credit Card Receivables ABS	77	2,135	1%	IDC Pricing
Agency CMO/Passthrough	251	918	0%	Proprietary Model with Discount Rate = Index + 50 basis points (100 basis points if collateral is Reperforming); if unavailable, used IDC Pricing (2)
Small Business Loans ABS	124	809	0%	IDC Pricing; if unavailable, used Ratings-Based Pricing (8)
Franchise ABS	63	451	0%	IDC Pricing
Other CDOs/Collateralized Bond Obligations	47	410	0%	IDC Pricing; if unavailable, used Ratings-Based Pricing (14)
Credit Linked Notes	4	78	0%	Ratings-Based Pricing
Totals	**23,197**	**222,290**	100%	

Notes: This table categorizes the active underlying collateral for non-liquidated SF ABS CDOs and explains how we calculated fair values or obtained fair values from market sources. Counts in this table represent the 23,197 unique and active securities that serve as collateral for non-liquidated SF ABS CDOs. Face values in this table represent the total current invested face of each collateral category for non-liquidated SF ABS CDOs. Methodology for Ratings-Based Pricing can be found in the table below.

SF ABS CDOs = Structured Finance ABS CDOs, CRE/CMBS CDOs = Commercial Real Estate/ Commercial Mortgage Backed Security CDOs

*Includes Private Auto Loans, Boat Loans, Credit Cards, Commercial Mortgages, Manufactured Housing, Utilities, European Securities and Student Loans

Ratings Based Pricing	
Current Composite Rating	**Market Price**
AAA	70
AA	60
BBB	50
BB	40
B	30
CCC	20
CC	10
C	0

Table 11

Distribution of Prices for SF ABS CDO Tranches								
Seniority	N Obs	Mean	Std Dev	Minimum	25% Quartile	50% Quartile	75% Quartile	Maximum
Sr_AAA	470	35.3	29.6	0.0	8.2	31.9	52.2	100.0
Jr_AAA	808	16.3	30.7	0.0	0.0	0.2	18.9	100.0
AA	566	6.0	20.7	0.0	0.0	0.1	0.5	100.0
A	446	3.6	17.6	0.0	0.0	0.0	0.0	100.0
BBB	595	2.0	12.7	0.0	0.0	0.0	0.0	100.0
BB/B	184	0.4	4.8	0.0	0.0	0.0	0.0	65.1
NR	487	1.1	9.9	0.0	0.0	0.0	0.0	100.0

Note: This table summarizes the distribution of market prices for outstanding SF CDO classes (as of March 2011) by seniority. SF ABS CDOs=Structured Finance CDOs. Sr_AAA includes 67 still active super senior SF ABS CDO tranches.

Table 12

Summary Expected Losses for Active SF ABS CDOs by Issuance Year				
Vintage	# Deals	Deal Balance ($ million)	Deal Loss ($ million)	Total Loss %
1999	1	304	60	20%
2000	15	5,554	1,765	32%
2001	26	10,719	2,124	20%
2002	30	13,257	3,397	26%
2003	33	17,889	6,105	34%
2004	71	49,178	18,563	38%
2005	110	95,215	51,728	54%
2006	143	152,059	103,492	68%
2007	85	88,464	70,561	80%
Grand Total	**514**	**432,638**	**257,797**	**60%**

Notes: This table summarizes losses on all non-liquidated SF ABS CDOs (as of March 2011) by vintage. SF ABS CDOs = Structured Finance ABS CDOs.

Source: Intex, Bloomberg, RBS (2011)

Table 13

Actual and Expected Pay Downs and Writedowns for All SF ABS CDOs					
SF ABS CDOs	**Pay Down ($ million)**	**Writedowns ($ million)**	**Total Balance ($ million)**	**% Loss Rate**	**Write-down as % of Total Writedown**
Liquidated Deals	46,454	162,015	208,469	78%	39%
Active Deals					
Already Paid Down	75,904	-	75,904	0%	
Already Written Down	-	134,444	134,444	100%	32%
Current Collateral	98,937	123,353	222,290	55%	29%
Subtotal for Active Deals	174,841	257,797	432,638	60%	100%
Total SF ABS CDOs	**221,295**	**419,812**	**641,107**	**65%**	**100%**
Notes: This table summarizes actual and expected writedowns and pay downs for all SF ABS CDOs (as of March 2011) as described in Section IV. SF ABS CDOs = Structured Finance CDOs.					
Source: Intex, Bloomberg, RBS (2011)					

Table 14

Summary Expected Losses for All SF ABS CDOs by Issuance Year				
Vintage	**# Deals**	**Deal Balance ($ million)**	**Deal Loss ($ million)**	**Total Loss %**
1999	1	304	60	20%
2000	19	6,991	1,847	26%
2001	34	14,891	3,132	21%
2002	37	17,456	3,604	21%
2003	45	25,561	7,481	29%
2004	81	58,558	25,822	44%
2005	124	108,877	61,627	57%
2006	223	231,711	167,402	72%
2007	163	176,759	148,836	84%
Grand Total	**727**	**641,107**	**419,812**	**65%**
Notes: This table summarizes expected losses on all active SF ABS CDOs (as of March 2011) by vintage. SF ABS CDOs = Structured Finance CDOs.				
Source: Intex, Bloomberg, RBS (2011)				

Table 15 (a)

Distribution of Losses for SF ABS Tranches

Seniority	N Obs	Mean	Std Dev	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Senior AAA	768	55%	35%	0%	0%	22%	59%	90%	100%
Junior AAA	1072	80%	35%	0%	1%	79%	100%	100%	100%
AA	803	91%	26%	0%	78%	99%	100%	100%	100%
A	669	93%	24%	0%	88%	100%	100%	100%	100%
BBB	876	91%	23%	1%	78%	96%	100%	100%	100%
BB and B	261	95%	16%	76%	91%	99%	100%	100%	100%
Not Rated	716	96%	18%	100%	100%	100%	100%	100%	100%

Note: This table summarizes the distribution of tranche losses by original rating or seniority.
Sources: Intex, Bloomberg, RBS(2011)

Table 15 (b)

Distribution of Losses for SF ABS Tranches by Vintage

Issue Year	N Obs	Senior AAA	Junior AAA	AA	A	BBB	BB and B	Not Rated
1999-2000	101	4%	10%	88%	66%	93%	67%	82%
2001	168	6%	9%	64%	11%	74%	81%	91%
2002	209	13%	20%	64%	65%	78%	91%	78%
2003	264	16%	44%	61%	63%	64%	93%	93%
2004	495	26%	71%	84%	95%	84%	99%	97%
2005	858	44%	83%	94%	94%	93%	97%	99%
2006	1696	67%	94%	99%	97%	96%	97%	99%
2007	1374	76%	93%	98%	99%	98%	96%	99%

Note: This table summarizes the distribution of tranche losses by original rating/seniority and issue year.
Sources: Intex, Bloomberg, RBS(2011)

Table 16

Determinants of SF ABS CDO Deal Performance

CDO Deal Characteristics

This table presents results of the regression from Section V.A. The dependent variable is the total loss rate on each of the 727 SF ABS CDOs issued between 1999—2007 based on the valuation exercise in Section IV. All regressions are ordinary least squares (OLS). Independent variables are all at the deal level and include deal characteristics, asset characteristics, deal risk characteristics and controls. Standard errors are reported in parentheses below OLS coefficients with significance levels reported at the 10% (*), 5% (**) and 1% (***) levels. SF ABS CDOs = structured finance asset-backed securities collateralized debt obligations; RMBS = residential mortgage-backed securities; CMBS = commercial mortgage-backed securities; WARF = weighted average rating factor.

	(1)	(2)	(3)
Dependent Variable	**Writedown Percentage**	**Writedown Percentage**	**Writedown Percentage**
Intercept	-.0159 (.0971)	-.0220 (.0922)	.1371** (.0578)
Deal Characteristics			
Original Deal Balance	.0000 (.0000)	.0000 (.0000)	.0000 (.0000)
Number of Assets	.0006*** (.0002)	.0007*** (.0002)	.0006*** (.0002)
Number of Tranches	.0039 (.0049)	.0050 (.0048)	.0037 (.0049)
No Deal Triggers	.0189 (.0241)	.0243 (.0240)	.0435* (.0233)
Static Deal	.0098 (.0332)	-.0111 (.0316)	.0184 (.0332)
Asset Characteristics			
% Fixed	.0413 (.0287)	.0398 (.0284)	-
% Synthetic	.1459** (.0588)	.0845*** (.0309)	-
% Home Equity	.1588** (.0794)	.1863** (.0780)	-
% Alt A RMBS	.2033* (.1043)	.2123** (.1033)	-
% Prime RMBS	.0430 (.1531)	.0657 (.1523)	-
% CDO	.3199*** (.1088)	.3014*** (.0845)	-
% ABS	.1247 (.0985)	.1486 (.0973)	-
% CMBS	.0836 (.1289)	.0670 (.1279)	-

Table 16 (cont'd)

	(1)	(2)	(3)
Dependent Variable	**Writedown Percentage**	**Writedown Percentage**	**Writedown Percentage**
Deal Risk Characteristics			
Mezzanine CDO Flag	.0393 (.0315)	-	.0201 (.0216)
Hybrid CDO Flag	-.0197 (.0371)	-	.0639*** (.0243)
Synthetic CDO Flag	-.1056* (.0579)	-	.0326 (.0320)
CDO2 Flag	-.0361 (.0655)	-	.0722** (.0323)
WARF	-.0001 (.0001)	-	-
Controls			
Issue Year 2001	-.0037 (.0590)	-.0059 (.0587)	-.0295 (.0581)
Issue Year 2002	.0076 (.0578)	.0046 (.0573)	-.0087 (.0572)
Issue Year 2003	-.0170 (.0592)	-.0229 (.0591)	-.0272 (.0558)
Issue Year 2004	.1275** (.0591)	.1145* (.0587)	.1282** (.0527)
Issue Year 2005	.2783*** (.0598)	.2620*** (.0592)	.2814*** (.0518)
Issue Year 2006	.4266*** (.0626)	.4086*** (.0617)	.4382*** (.0521)
Issue Year 2007	.4711*** (.0649)	.4609*** (.0635)	.4979*** (.0547)
Liquidation Flag	.0252 (.0185)	.0320* (.0183)	.0421** (.0179)
No Assets Flag	.6852*** (.1637)	.6902*** (.1638)	.4739*** (.1474)
Assets Missing Flag	-.3429** (.1638)	-.3549** (.1639)	-.3331** (.1649)
Regression Summary Statistics			
Adjusted R^2	0.5885	0.5838	0.5749
Root MSE (SER)	0.20152	0.20193	0.20351

Table 17

Effects of Dealers and Collateral Managers on CDO Performance

These tables are results discussed in Section V.B. and rank each dealer according to the performance of their CDOs, using their actual/expected loss percentages as the measure of performance. The first regression uses model (1) in Table 19 and adds in the dealer fixed effects. Coefficients on variables other than the dealer effects are not shown. The second regression looks only at the dealer fixed effects. Parameter values and standard errors are next to the ranks, with significance levels reported at the 10%(*), 5%(**) and 1%(***) levels.

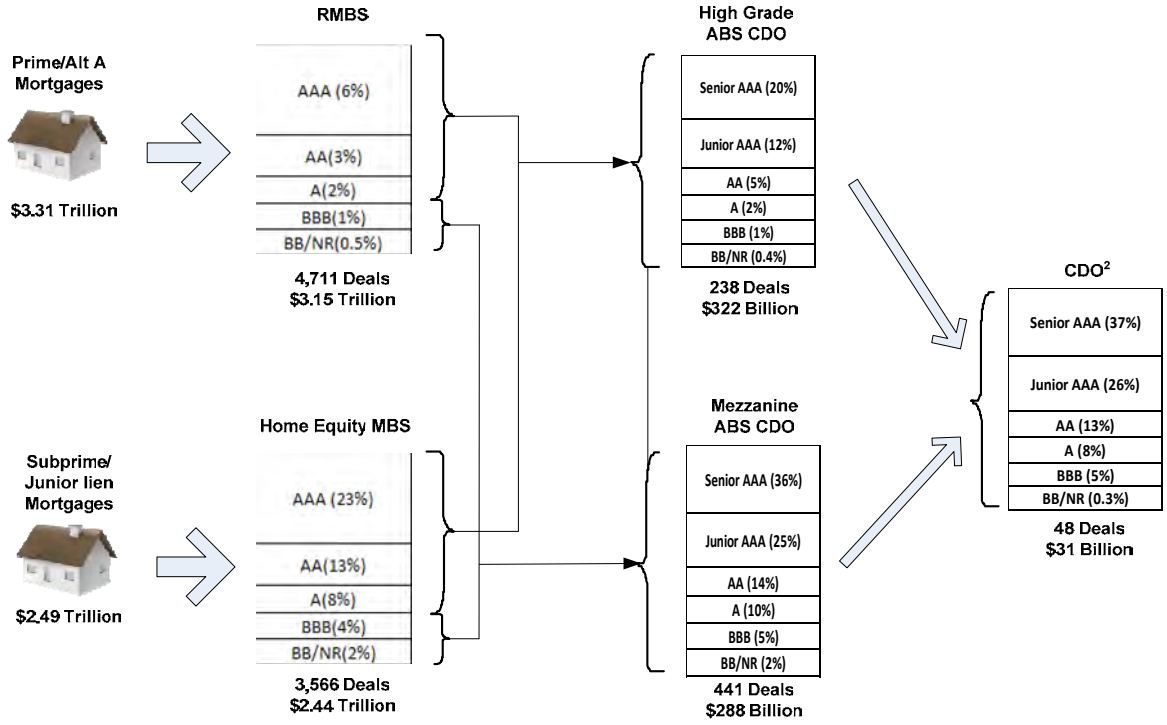
Dealer Rank - Full Regression			**Collateral Manager Full Regression**		
Dealer	**Rank**	**Parameter (St. Error)**	**Collateral Manager**	**Rank**	**Parameter (St. Error)**
Dresdner	1	-.0847 (.0873)	RWT Holdings	1	-.1466** (.0708)
RBS	2	-.0716 (.0458)	C-BASS	2	-.1250** (.0499)
Barclays	3	-.0644 (.0536)	Princeton Advisory	3	-.0962 (.0637)
Calyon	4	-.0459 (.0664)	Rabobank Int'l.	4	-.0866 (.0627)
JP Morgan	5	-.0335 (.0700)	GSCP	5	-.0765 (.0586)
Lehman Brothers	6	-.0289 (.0469)	WestLB-NY	6	-.0633 (.0649)
Deutsche Bank	7	-.0229 (.0421)	Vanderbilt Capital Advisors	7	-.0335 (.0505)
Wachovia	8	-.0136 (.0473)	TCW Asset Mgt.	8	-.0101 (.0340)
Merrill Lynch	9	-.0060 (.0372)	Static Deals	9	.0108 (.0338)
WestLB	10	-.0036 (.0649)	Strategos Capital Mgt.	10	.0186 (.0486)
Goldman Sachs	11	.0176 (.0448)	State Street Global Advisors	11	.0264 (.0621)
Credit Suisse	12	.0333 (.0392)	Deerfield Capital Mgt.	12	.0272 (.0596)
Bank of America	13	.0537 (.0494)	Terwin Money Mgt.	13	.0433 (.0617)
UBS	14	.0740* (.0400)	Harding Advisory	14	.0644 (.0634)
Bear Stearns	15	.0759* (.0454)	Vertical Capital	15	.0716 (.0627)
Citigroup	16	.0824** (.0408)	Duke Funding Mgt.	16	.1092* (.0610)
Morgan Stanley	17	.0835 (.0549)	Bear Stearns	17	.1264* (.0680)
			ACA Management	18	.1356** (.0622)
Adjusted R^2		**0.5848**	**Adjusted R^2**		**0.5815**
Root MSE (SER)		**0.19847**	**Root MSE (SER)**		**0.19926**

Table 18

Determinants of Performance on AAA-rated SF ABS CDO Bonds			
This table shows results discussed in Section V.C. and examines the performance of AAA-rated SF ABS CDOs through mult-variate analysis. Parameter values and standard errors are next to the ranks, with significance levels reported at the 10%(*), 5%(**) and 1%(***) levels.			
AAA-Rated SF ABS CDOs - Full Regression			
Variable	**Parameter (St. Error)**	**Variable (cont'd)**	**Parameter (St. Error)**
Intercept	0.0000 (0.0997)	Home Equity Loan (Collateral)	0.1186 (0.0775)
Rated by Moody and S&P	0.0232 (0.0169)	AltA (Collateral)	0.1113 (0.0955)
Rated by Moody and Fitch	0.2206*** (0.0619)	Prime (Collateral)	0.0130 (0.1335)
Rated by S&P and Fitch	0.0316 (0.0395)	CDO (Collateral)	0.2544** (0.1000)
Rated by S&P	-0.1648*** (0.0590)	ABS (Collateral)	0.0263 (0.0953)
Rated by Fitch	0.1843** (0.0904)	CMBS (Collateral)	0.0852 (0.1236)
Rated by Moody	0.0414 (0.1108)	Mezzanine (Collateral)	0.0130 (0.0275)
Not Rated	-0.0514 (0.0426)	Hybrid (Deal)	-0.0408 (0.0270)
% Subordination	-0.2002*** (0.0655)	Synthetic (Deal)	-0.0928** (0.0441)
Floater Margin	0.1577*** (0.0279)	CDO^2 (Deal)	-0.1119** (0.0524)
Fixed Coupon	-0.0130* (0.0079)	WARF	-0.0001** (0.0000)
Sr AAA	-0.2154*** (0.0156)	Issue Year 2001	0.0355 (0.0688)
Super Senior	0.0521* (0.0272)	Issue Year 2002	0.0922 (0.0657)
Trigger Flag	0.0155 (0.0195)	Issue Year 2003	0.2136*** (0.0648)
Size	0.0000 (0.0000)	Issue Year 2004	0.3859*** (0.0657)
# of Original Assets	0.0005*** (0.0001)	Issue Year 2005	0.5245*** (0.0661)
# of Tranches	0.0040 (0.0041)	Issue Year 2006	0.6534*** (0.0686)
Static Flag	-0.0264 (0.0295)	Issue Year 2007	0.6393*** (0.0700)
Fixed (Collateral)	-0.0113 (0.0237)	Liquidated	0.0107 (0.0153)
Synthetic (Collateral)	0.1856*** (0.0443)	No Asset Information Available	0.2127** (0.1032)
Adjusted R^2	**0.5188**		
Root MSE (SER)	**0.2581**		

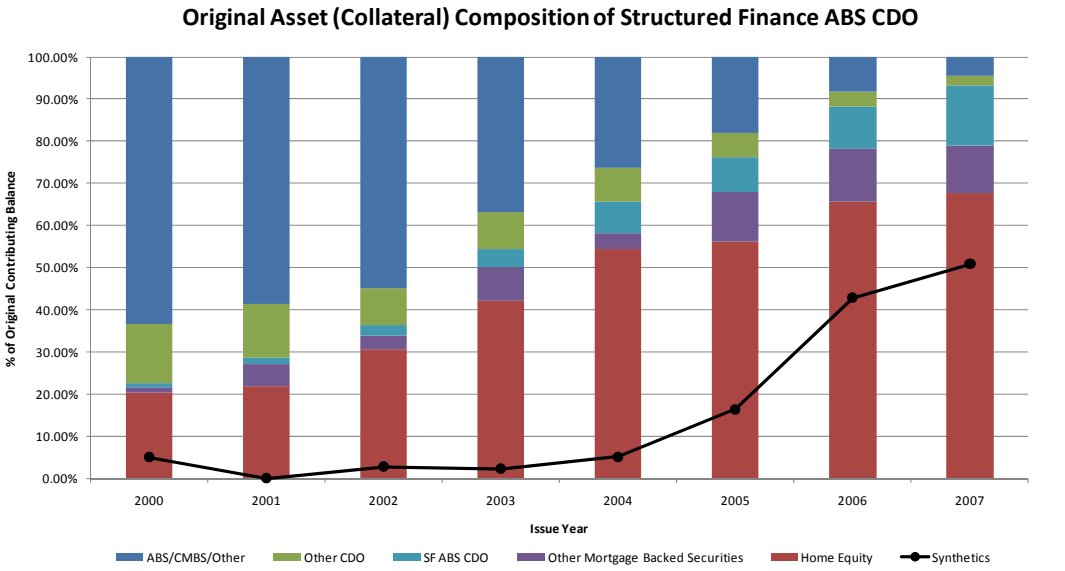
Figure 1

Transformation of Mortgage Loans to CDO^{2}s 1998 – 2007



Note: This figure shows the total dollar amounts and counts for the various sources of mortgages, mortgage-backed securities, CDOs and CDO^{2}s that made up the mortgage market from 1998 – 2007. CDO = Collateralized Debt Obligation; RMBS = Residential Mortgage-Backed Securities; HEL = Home Equity loans; ABS = Asset-Backed Securities. Subordination levels are in parentheses.

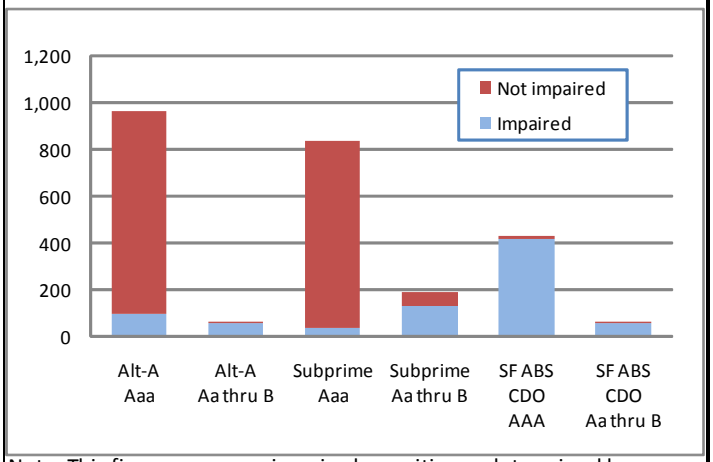
Figure 2



Note: This table summarizes shares of assets for structured finance ABS CDOs by five asset categories in the bar charts, and also includes shares of synthetic collateral in the line plot. Synthetics = Credit Default Swaps, Home Equity = Home Equity Mortgage-Backed Securities, SF ABS CDO = structured finance asset-backed security collateralized debt obiligations, ABS = asset-backed security, CMBS = commercial mortgage-backed securities, Other = all remaining asset collateral within the SF ABS CDO

Figure 3

Impaired MBS and SF ABS CDO Securities
2005-2007 Issuance
(in $ billions)



Note: This figure compares impaired securities as determined by Moody's (2010) for Alt-A and subprime MBS issued from 2005-2007 to our loss estimates on SF ABS CDOs issued over the same time period. Impairment of MBS is as of year-end 2009 and is defined when a security is downgraded to C or Ca, or when it suffers a principal loss. Impairment of 2005-2007 vintage CDOs is defined by securities where expected loss is greater than zero. Categorization is by initial rating. MBS = mortgage-backed securities. SF ABS CDO = structured finance asset-backed securities collateralized debt obligation.

Sources: Moody's (2010), FCIC (2011, p. 229), Intex.

Appendix 1

CDO Original Balance by Vintage by Revised Collateral Type from Intex
$ Millions

Year	CDO[2]	Structured Finance Cash	Structured Finance Synthetic	Subtotal Structure Finance CDOs and CDO2	CMBS/REIT/CRE	Trust Preferred	Emerging Market	High Yield	Investment Grade	Leveraged Loans	Project Finance Loans	Synthetic	Grand Total
1995								151					151
1996							697	4,045				240	4,982
1997		486		486			4,136	12,298					16,920
1998		650		650			1,926	23,914	413				26,904
1999	908	300		1,208	500		1,369	35,459	1,419				39,955
2000	2,370	5,915	600	8,885	1,407	753	908	30,581	4,597	1,282	499	696	49,607
2001	1,732	12,841	160	14,733	2,212	3,376	502	26,306	6,173	1,640		1,878	56,820
2002	1,565	13,634	100	15,299	10,051	4,953	790	16,993	2,577	775		7,064	58,501
2003	2,522	28,355	100	30,978	4,804	7,793		15,141		4,081		3,976	66,773
2004	4,713	57,019	2,380	64,111	6,194	7,751	300	26,734	1,500	8,191	605	4,185	119,571
2005	5,032	89,302	11,055	105,389	18,531	9,803	855	50,048	567	8,584	1,440	3,759	198,975
2006	8,362	146,242	80,478	235,082	45,244	15,064	431	73,440		18,570		1,936	389,767
2007	9,973	105,776	64,479	180,228	37,270	9,895	1,025	73,529		25,140		10,956	338,042
2008	257				4,185			9,293		13,045			26,780
2009	517	3,796								4,954			9,268
2010										499			499
Grand Total	**37,951**	**464,316**	**159,351**	661,618	**130,398**	**59,387**	**12,939**	**397,931**	**17,246**	**86,761**	**2,543**	**34,689**	**1,403,513**
						By Deal Count							
1995								1					1
1996							4	13				1	18
1997		1		1			14	30					45
1998		1		1			7	55	1				64
1999	2	1		3	1		6	83	3				96
2000	6	17	1	24	4	3	3	73	8	2	1	4	122
2001	8	33	1	42	4	6	2	67	13	4		8	146
2002	17	36	1	54	16	10	4	45	4	2		17	152
2003	12	48	1	61	10	18		40		7		3	139
2004	26	78	3	107	14	19	1	58	1	16	1	5	222
2005	14	100	17	131	28	16	2	97	2	17	1	4	298
2006	14	142	83	239	51	21	1	144		36		9	501
2007	13	88	71	172	39	16	1	126		47		11	412
2008	2			2	2			21		25			50
2009	3	2		5						7			12
2010										2			2
Grand Total	**117**	**547**	**178**	**842**	**169**	**109**	**45**	**853**	**32**	**165**	**3**	**62**	**2280**

Note: This table provides deal counts and balances by vintage for the universe of CDOs in Intex. CDO = Collateral Debt Obligation; CMBS = Commercial Mortgage-Backed Securities; REIT = Real Estate Investment Trust; CRE = Commercial Real Estate.
Source: Intex

Appendix 2

Translation of Moody's and Fitch Credit Ratings Into Numerical Scores

Moodys	WARF	Fitch	Score
Aaa	1	AAA	1
Aa1	10	AA+	2
Aa2	20	AA	3
Aa3	40	AA-	4
A1	70	A+	5
A2	120	A	6
A3	180	A-	7
Baa1	260	BBB+	8
Baa2	360	BBB	9
Baa3	610	BBB-	10
Ba1	940	BB+	11
Ba2	1350	BB	12
Ba3	1780	BB-	13
B1	2220	B+	14
B2	2720	B	15
B3	3490	B-	16
Caa1	4770	CCC+	17
Caa2	6500	CCC	18
Caa3	8070	CCC-	19
Ca	10000	CC	20
C	10000	C	21
D	10000	D	22

Note: This table summarizes the translation of ratings into ranking scores for purposes of classifying our structured finance CDOs into those comprised primarily of 'A' rated securities against those comprised primarily of BBB-rated securities. WARF = weighted average rating factor. CDO = collateralized debt obligations.

Source: Moodys, Fitch

Appendix 3

Calculation of Composite Rating			
Moody's	S&P	Fitch	Composite Rating Score
Aaa	AAA	AAA	1
Aaae	AAAe	AAAe	1
Aa1	AA+	AA+	2
Aa1/*+	AA+/*+	AA+/*+	2
Aa2e	Aae	AAe	3
Aa2e	AA	AA	3
Aa2e/*+	AA/*+	AA/*+	3
Aa3/*-	AA-/*-	AA-/*-	3
Aa3	AA-	AA-	4
Aa3e	AA-e	AA-e	4
A1	A+	A+	5
A1/*+	A+/*-	A+/*-	5
A2	A	A	6
A2e	Ae	Ae	6
A2/*+	A/*+	A/*+	6
A2/*-	A/*-	A/*-	6
A3	A-	A-	7
A3e	A-e	A-e	7
A3/*-	A-/*-	A-/*-	7
Baa1/*-	BBB+/*-	BBB+/*-	8
Baa1e	BBB+e	BBB+e	8
Baa1	BBB+	BBB+	8
Baa1/*+	BBB+/*+	BBB+/*+	8
Baa2	BBB	BBB	9
Baa2/*+	BBB/*+	BBB/*+	9
Baa2e	BBBe	BBBe	9
Baa2/*-	BBB/*-	BBB/*-	9
Baa3	BBB-	BBB-	10
Baa3/*+	BBB-/*+	BBB-/*+	10
Baa3e	BBB-e	BBB-e	10
Baa3/*-	BBB-/*-	BBB-/*-	10
Ba1	BB+	BB+	11
Ba1e	BB+e	BB+e	11
Ba1/*-	BB+/*-	BB+/*-	11
Ba2	BB	BB	12
Ba2/*-	BB/*-	BB/*-	12
Ba2e	BBe	BBe	12
Ba3	BB-	BB-	13
Ba3/*-	BB-/*-	BB-/*-	13
B1	B+	B+	14
B2	B	B	15
B2/*-	B/*-	B/*-	15
B3	B-	B-	16
Caa1	CCC+	CCC+	17
Caa2	CCC	CCC	18
Caa2/*-	CCC/*-	CCC/*-	18
Caa3	CCC-	CCC-	19
Caa3/*-	CCC-/*-	CCC-/*-	19
Ca	CC	CC	20
C	C	C	21
D	D	D	22
NR	NR	NR	0

Note: Above is our method for converting letter-grade ratings into a numerical score for use in our multivariate analysis.