

CDOs and the Credit Crisis

Complexity and model risk in the collateralized debt obligation market are severe

Bank Accounting and Finance, June 2008
This Draft: April 16, 2008

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Accurate valuation is the key to success in financial services. How can one know what to buy or sell without a view as to whether it is “rich” or “cheap”? Once an asset has been purchased or a loan has been made, valuation is the key to successful risk management of that position and to successful reporting of value created to shareholders of the firm. The credit crisis of 2007 and 2008 has cost the jobs of the chief executive officers of Merrill Lynch and Citigroup.

It is now clear that two problems are at the heart of the crisis. The first problem was models that were so limited in scope that they couldn’t link home price changes to the value of securities with mortgages as underlying collateral.² The second problem was an institutionalized lack of disclosure that would have prevented even the best-practice valuation technology from achieving the necessary standard of accuracy.

The first section of this article relates the chronology of the credit crisis and shows the role of home price movements in how it unfolded. The second section discusses the role of bad valuation in creating the current crisis, and it discusses the role of good valuation in preventing exposure to losses in the current and future crises. The third section discusses fair value and the implications for management.

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² The role of home prices in causing bank losses and failures was not a well-kept secret. The Federal Deposit Insurance Corporation explicitly identified home prices (along with interest rates and bank stock prices) as one of three macro factors that caused correlated defaults among US banks. For details, see the Federal Deposit Insurance Corporation Loss Distribution Model published December 10, 2003, especially the appendices.

A Chronology of the Credit Crisis

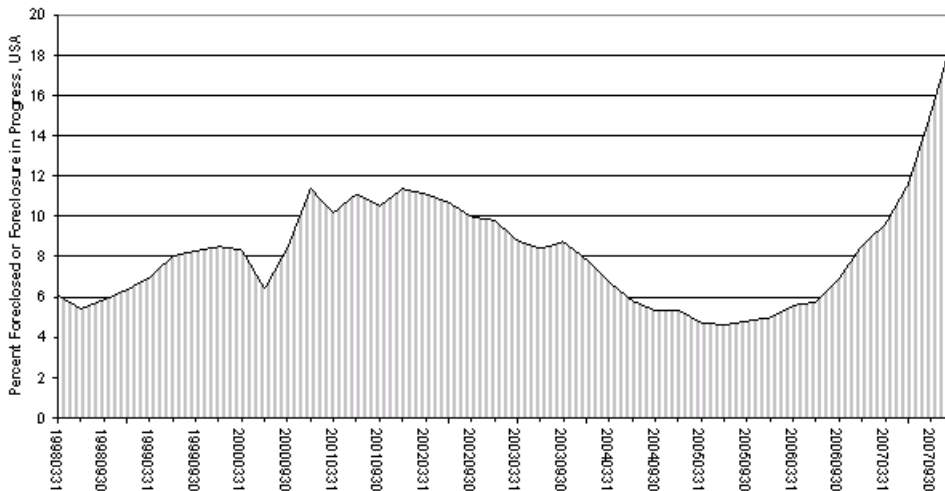
On April 2, 2007, subprime mortgage lender New Century filed for bankruptcy in the United States. On June 21, two hedge funds managed by Bear Stearns collapsed because of losses triggered by investments in subprime mortgage loans. By August, collateralized debt obligations (CDOs) and other investments that involved subprime mortgage loans led to losses at institutions like IKB Deutsche Industrie Bank AG, AXA, BNP, Kohlberg Kravis and Roberts, Countrywide Financial, Basis Capital in Australia, Barclays and most of the major US securities firms. American Home Mortgage filed for bankruptcy in August, and the Bank of England stepped in to rescue mortgage lender Northern Rock on September 14. On October 30, CEO Stanley O'Neal was ousted because of losses at Merrill Lynch. Citigroup CEO Charles Prince resigned November 5 for the same reasons.

How did problems in one mortgage sector in the United States trigger losses in so many countries? The answer lies in three structured products: collateralized mortgage obligations (CMOs), structured investment vehicles and CDOs. An integral part of the credit crisis lies with the issue of valuation, both for "fair-value" accounting purposes and for risk-management purposes.

Exhibit 1 shows that the default rate on adjustable-rate mortgages of subprime quality has risen sharply since early 2005. Note, however, that it wasn't until September 30, 2007, that the subprime default rate rose above the levels of 2001 and 2002. This rise in defaults was a predictable reaction to two changing macroeconomic conditions: a fall in home prices and a rise in the rates on the borrowers' adjustable-rate mortgages due to a rise in market interest rates in the United States. The rise in defaults was very predictable given the change in market conditions. In fact, macroeconomic factors explain 95 percent of the variation in the subprime adjustable-rate mortgage default rate.³

³ Details on the relationship between macro factors and default rates on mortgages are available from the author at dvandeventer@kamakuraco.com. For more on modeling default as a function of macro factors, see Donald R. Van Deventer, Kenji Imai and Mark Mesler, *Advanced Financial Risk Management: An Integrated Approach to Credit Risk and Interest Rate Risk Management* (Singapore, John Wiley & Sons, 2004). For background on comparing the performance of default models from an accuracy point of view, these three references are key: S. Bharath and T. Shumway, "Forecasting Default with the KMV-Merton Model" (University of Michigan and Stanford University Graduate School of Business, December 2004. Forthcoming in the *Review of Financial Studies*); John Y. Campbell, Jens Hilscher and Jan Szilagyi, "In Search of Distress Risk," (working paper, Harvard University, June 2007, forthcoming in the *Journal of Finance*); R. Jarrow, Mark Mesler and Donald R. van Deventer, *Kamakura Default Probabilities Technical Guide, Kamakura Risk Information Services, Version 4.1* (memorandum, Kamakura Corporation, January 25, 2006).

**Mortgage Bankers Association
Subprime Adjustable Rate Mortgage Default Rate,
1998-2007**



The credit crisis has broadened substantially in recent months, but at first the impact of home price movements and interest rates had a very concentrated impact on the marketplace. Initially, there were three types of securities whose values were sharply impaired by the decline in the credit quality of subprime mortgages: CMOs, asset-backed commercial paper (ABCP) and so-called cash flow CDOs. CMOs have mortgages as underlying collateral. Various tranches of the CMOs are created that divide the flow of interest and principal on the underlying mortgages by maturity and seniority. The highest-quality tranches are those who are paid earliest. Those CMOs that have subprime mortgages as collateral not only have dropped sharply in value but also are almost impossible to trade. Market liquidity in these securities has dried up because of the increased default risk and an increased reluctance by market participants to trade in securities with unnecessarily complex structures.

The second type of security that has been affected severely is ABCP issued by structured investment vehicles (SIVs) that have invested in CMOs and CDOs, particularly those backed by subprime and so-called Alt-A mortgages. Alt-A mortgages are lower than prime quality but generally higher quality than subprime mortgages. Because the SIVs' investments in CMOs and CDOs have declined in value, investors have become extremely reluctant to participate in the ABCP market. Seventeen SIVs in Canada have been liquidated because they could no longer fund themselves. Barclays announced it was taking over the funding of the Cairn SIV on August 31. The Cheyne and IKB SIVs both defaulted on October 19. The MBIA SIV was reported to have funding problems on October 25. Citigroup provided emergency funding to its SIVs on November 6. On November 21, the Axon SIV was liquidated. On November 26, HSBC provided \$35 billion in emergency funding to its SIVs because they could no

longer fund themselves in the commercial paper market. On November 27, the MBIA SIV was liquidated. WestLB and HSH Nordbank bailed out their SIVs on December 3. Citigroup absorbed \$49 billion of its SIV's assets on December 13. The Victoria Finance SIV formally defaulted on January 14, 2008, followed by the default of the Orion Finance SIV on January 16.

Of all of the instruments that have caused damage to the SIVs and investors in general, the most damaging has been the cash flow CDOs backed by subprime and Alt-A-related CMO tranches. Many of the failed SIVs listed above had invested heavily in these CDOs. A CDO can be of two types: cash flow CDOs and synthetic CDOs. Synthetic CDOs have as underlying reference collateral credit default swaps on 10, 20, 100 or 200 large corporations. Losses are divided into tranches, with a common tranche bearing losses once they exceed 3 percent of the notional principal on the reference collateral, capped at 7 percent of notional principal. Cash flow CDOs have as their reference collateral real (not synthetic) securities, such as bonds, CMO tranches, asset-backed securities tranches and so on. The tranching of losses is similar to that for synthetic CDOs.

Valuation for Investment Strategy, Risk Management and Fair-Value Accounting

Both types of CDOs have caused enormous losses to investors. By their very nature, CDOs only exist because the firms who structure them sell the tranches for more than the cost of the reference collateral. Investors who ignore this “deadweight” loss from structuring are hopelessly naïve about the nature of the CDO market. One of the most important rules of financial markets is that “if you can't value a security, don't buy it and don't sell it, because you will be taken advantage of if you do.” This critical but often ignored maxim will be ignored no longer because of the requirements for fair-value accounting across a wide array of financial instruments.

The credit crisis was created because many investors violated this fundamental rule of financial markets. The most naïve investors simply looked at the ratings on CDO tranches and then bought the tranche if they liked the rating—they didn't even attempt to confirm if the price they were asked to pay was “fair value.” They ignored the fact that the rating agencies are paid by the structurer and that they have a bias in favor of a rating that is better than the real risk level. Unless CDO tranches were rated too favorably, structurers could not make money by packaging securities freely available in the market and then reselling them at a higher price in the form of tranches. Investors who participated in the CDO market based on ratings alone have been and should be severely punished by the boards of directors of their firms and by regulatory agencies.

The next level up in sophistication is that class of investors who believed what Wall Street and the rating agencies recommended for valuation technology—the use of the so-called copula method, usually based on a single-period simulation. For example, if a CDO was structured as a five-year synthetic CDO, the risk of the CDO would be simulated as a single period of five years in length. The copula technique is so flawed that the *Wall Street Journal* featured it in a page one story on August 12, 2005,

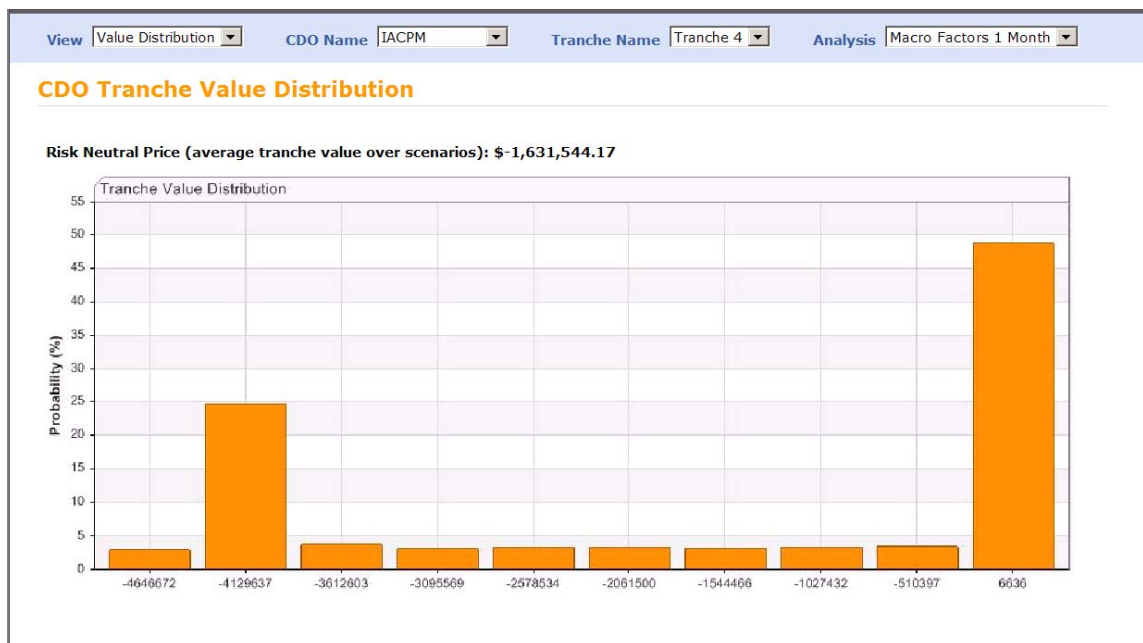
describing how investors lost hundreds of millions of dollars when using the copula method during the downgrade of Ford and General Motors. The copula method implicitly assumes there is only one macroeconomic risk factor driving default, and it assumes that default probabilities remain constant over the modeling period.⁴ Just looking at the history of defaults in Japan and the United States makes clear the obvious—default probabilities rise and fall over the business cycle. Users of the copula method ignore this. They consistently underestimated the worst-case scenario and overvalued CDO tranches. That is why Wall Street and the rating agencies urged the use of this technique; it maximizes their profits by getting people to buy CDO tranches that they wouldn't purchase if they had accurately measured value.

When it comes to cash flow CDOs with CMO tranches and asset-backed securities as collateral, valuation becomes even more difficult to do well. For any type of security, especially cash flow CDOs, we need accurate valuations for three reasons: for the initial buy/don't buy decision, for risk management after the fact and for fair-value accounting purposes. Best practice in valuing cash flow CDOs is to simulate the performance of the mortgage loans underlying the CMO tranches, loan by loan, then simulate the losses and cash flows of the CMO tranches in the CDO structure. Finally, we simulate the parsing of cash flows from interest, principal and losses to the appropriate CDO tranche. Most investors until recently have done no analysis—because they didn't have such software capabilities at their disposal. As a result, they consistently overpaid for cash flow CDO tranches, and they took on risk that they didn't understand.

For both cash flow and synthetic CDOs, the narrow bands of the commonly sold tranches mean it is very likely that the investor either loses nothing or loses everything. This loss pattern is completely different from the loss pattern on bonds with similar ratings. In the case of bonds, 100 percent losses are very rare even in the event of bankruptcy of the issuer. Losses of 30 percent, 40 percent or 50 percent of principal are more typical. Rating agency assertions that an AAA CDO tranche has the same risk profile as an AAA-rated bond are simply false. Exhibit 2 shows how big that risk of a total loss can be—it shows the distribution of mark-to-market values that can result on a typical CDO tranche.⁵

⁴ For more on the implicit assumptions of the copula method and their impact on valuation, please see R. Jarrow and Donald R. van Deventer, "Synthetic CDO Equity: Short or Long Correlation Risk?" (2008, forthcoming in the *Journal of Fixed Income*) and R. Jarrow, Li Li, Mark Mesler and Donald R. van Deventer, "CDO Valuation: Fact or Fiction," (2007, forthcoming in *The Definitive Guide to CDOs*, Risk Publications).

⁵ Calculations were done by the Kamakura Risk Information Services KRIS-CDO service using 500,000 iterations and reduced-form default probabilities distributed by Kamakura Corporation.



In the current credit crisis, trading in all types of CDOs and many types of mortgage-backed securities has come to a near standstill. CDO issuance for the first two months of 2008 was reported by Bloomberg.com to be down 96 percent to \$3.3 billion from \$89 billion in the first two months of 2007. Senior managements, who allowed purchases of these securities without proper analytics, are now afraid for the first time that they have made bad investments. Many have called in outside experts to assist in valuing securities that have already been purchased to plan a course of action. Others have moved quickly to liquidate their portfolios in spite of very poor market conditions. Even synthetic CDOs, which have nothing directly to do with the subprime mortgage crisis, are now traded much less actively because investors realize that complex structures have been made complex for only one reason—to get the investment community to overpay. Recently, hedge funds have taken over from banks as the largest investors in CDOs, so one should expect losses in hedge funds to be even more severe than those losses (like the Bear Stearns funds) that have been publicized already.

Fair Value and Its Implications

I have often noted that one needs a license to drive a car, but no license is needed to be the CEO of a major financial institution. When it comes to driving, the purpose of the license is to ensure that the driver has sufficient knowledge and skill of the task at hand to minimize the chances of harming others. The strong trend toward market valuation, both in risk management and for accounting purposes, is in effect a licensing requirement. Institutions are increasingly forced to prove that they are able to make intelligent and defensible valuations of assets and liabilities on their balance sheet, including the three complex asset classes described above.

In the process of earning this “license” from company auditors, firms have often been surprised when senior management for the first time devotes serious attention to financial models. As described above, many have found in fact the worst-case scenario: that no valuations were done at all prior to purchase and that there was no capability of making any calculation of market value if the securities were traded thinly or not traded at all. In response, many institutions have now changed investment policies from a ratings-based policy (“Only securities with a rating of BBB- or above are eligible for investment”) to a valuation-based policy: “Purchase of securities, derivatives or other complex instruments are forbidden unless an independent valuation capability exists and is used prior to purchase.”

A second kind of problem is perhaps even worse: Management has often discovered that the working-level staff has been depending heavily on models, like the copula approach, that were known or should have been known to be wrong. In the current environment, it is well known that no value of corporate default correlation leads to copula model valuations that match some CDO market tranche prices. It is also well known that the copula method implies a different level of default correlation for different tranches of the same CDO, a sure sign that the model is misspecified and is fundamentally flawed. Senior management that discovers a problem of this nature has no recourse but to halt trading in these instruments and to seek outside consultants for an independent valuation.

A third finding that is also all too common is the discovery that only the trading unit has valuation tools of any type and that there is no independent confirmation of values by a risk-management unit or an audit unit. This situation is extraordinarily dangerous and again calls for immediate calls for outside assistance.

The fourth finding that management makes is perhaps best summarized by the experiences at Merrill Lynch and Citigroup. Newly appointed Merrill Lynch CEO John Thain hinted at the nature of the problems that led to the huge losses at Merrill Lynch: “There were at least two major problems. One was that credit risk management was separate from market risk management, and that doesn't make sense, because they are both permutations of the other. We are combining market and credit risk.” He went on to say, “Merrill had a risk committee. It just didn't function. So now when we have a weekly meeting, the head of fixed income and equities show up. I show up, and the risk heads show up. It functions and functions across the businesses.”⁶

In fact, the problems at Merrill Lynch and Citigroup were even more serious than these quotes indicate. As we indicated above, the very nature of the structured products market is one of selling the parts (the CDO tranches) for more than the cost of the whole (the underlying reference collateral). This implies that the CDO structurers should have made a ton of money and that the losers in the end would be the investors

⁶ Susanne Craig and Randall Smith, “Merrill's Risk Manager, New Chief John Thain on What Led to the Losses and Why He's Hiring Goldman Sachs Executives,” *Wall Street Journal*, January 18, 2008, p. C1.

who bought the tranches and the rating agencies, who would suffer both immense reputational damage and extensive legal costs. On December 4, Citigroup executive William Mills told Parliament in the United Kingdom, “Our losses greatly exceeded the profits we made in this field over several years.”

How could that be? How could major structurers of CDOs like Merrill Lynch and Citigroup lose money with the inherent profit margin that triggered the creation of a given CDO in the first place? Again, the answer comes down to valuation issues, the imbalance of expertise within these two institutions and a complete lack of transparency internally. As the CDO boom matured, structurers at these two institutions began to find that they could sell some but not all of the tranches on a given pool of reference collateral. With complete transparency, the logical conclusion when that happens is that there is no longer profit in the structure and CDO generation should stop; it means one can no longer sell the parts for more than the cost of the whole (the reference collateral). At Citigroup and Merrill, this natural brake on the CDO business didn't work. Why not? The Wall Street bonus system was the culprit in this case, in combination with a lack of internal diligence on the risk-management front that excellent independent valuation could provide. Since the traders were the first to know that the structuring process was only hitting on a few cylinders, they had to hide the “bad cylinders.” In Merrill Lynch's case, the traders simply kept the tranches they couldn't sell, according to press reports on the rapid rise in CDO tranches held by Merrill. There was no penalty to the traders for doing this, because there was no independent valuation that showed why the tranches couldn't be sold: Their true value was a lot less than the values the traders held them at on the books of Merrill Lynch.

In Citi's case, press reports claimed that the hard-to-sell tranches were placed with hedge funds and other investors with puts that allowed the tranche holders to sell them back to Citi on demand at a prearranged price. At both institutions, no red flags were raised. Traders looked to receive bonuses that were the usual giant multiples of their salaries before anyone discovered what was being swept under the rug. A high-quality risk-management system would have discovered this early on, but as Mr. Thain's quote indicates, the risk process at Merrill “didn't function.”

There is a fifth problem that management often finds when it takes a hard look at valuations of tranced products. Tranced products exist because Wall Street makes money from them, and they make money because investors misvalue the securities. As we discussed above, much of the misvaluation stems from bad mathematics. Just as important, it stems from a lack of disclosure at all levels of the structuring process that makes it almost impossible, even for a firm with excellent valuation technology, to correctly value a structured product.

Consider this typical pattern. A special-purpose legal entity is created for a mortgage-backed security. Assume there are 1,000 mortgage loans that are the underlying reference collateral. Loan-level information is not disclosed to the purchasers of tranche B of this structure by the trustee. Assume tranche B is made one of 100 asset-

backed securities that become the reference collateral in a cash flow CDO. Trustees typically resist disclosure of the CUSIP (Committee on Uniform Security Identification Procedures) numbers that would identify what the 100 investments of the CDO actually are. Assume tranche 6 of this structure is purchased by a SIV that issues ABCP. This SIV may own 200 CDO tranches, which again are frequently not disclosed to the purchasers of ABCP. Assume ABC Money Fund owns this ABCP. How does one value it? Ultimately, the only correct valuation goes all the way back to the individual collateral items like the 1,000 mortgage loans. If ABC Money Fund seeks to get this information, they will be blocked at every step of such an attempt.

Why is this level of detail necessary to protect investors? A story illustrates the reason. I was invited to lunch at Salomon Brothers in the mid-1980s when the mortgage operation was a major profit maker for the firm. My host was exceptionally cheerful, and he explained the reason why: “We had a huge profit day today. The US government is closing lots of military bases, and we went looking for the mortgage-backed securities with the largest concentration of loans in those areas, where we know home prices are going to drop and lots of people are going to default. We just ripped the ears off of investors who were too lazy to figure that out.”⁷ The moral of this story is very simple. If one side of a trade has the ultimate reference collateral detail and the other side does not, we know which side of the trade is the loser.

Valuation technology is the only protection against these losses, and only complete transparency allows first-class valuation technology to produce accurate values.

The Importance of Accurate Measures of Value

The subprime crisis has made two things obvious to the financial community. First, complexity and model risk in the CDO market are so severe that even the most careful analysts would put a wide bid-offered spread on any complex transaction’s valuation. Second, a complete lack of disclosure of reference collateral for cash flow CDOs is an institutional reality that can’t be overcome in the short run.

Investors are now on strike. The first rule of investing—“if you can’t value a security, don’t buy it and don’t sell it”—is the reason for the 96 percent decline in CDO volume so far in 2008. The ultimate result will be an end to complex structures that don’t provide value to investors. Measuring this value accurately is at the very heart of successful investing and risk management.

⁷ My host was a managing director of the financial institutions group at Salomon Brothers.