# 20. Credit Derivatives

FT publishes various credit indices. See www.markit.com and click through products to find information on various indices, specifically CDX (a portfolio of corporate bonds), and ABX (a portfolio of top tranche mortgage CDOs).

To keep us focused on the big picture, I begin with a quotation from Fischer Black, from an unpublished paper way back in 1970. He writes:

> "Thus a long term corporate bond could actually be sold to three separate persons. One would supply the money for the bond; one would bear the interest rate risk; and one would bear the risk of default. The last two would not have to put up any capital for the bonds, although they might have to post some sort of collateral."
>
> **Fischer Black, 1970**
> "Fundamentals of Liquidity"

You can see that he is thinking about the kind of world that we live in today; the latter two instruments he mentions are today's interest rate swaps and credit default swaps, and the collateral he mentions is the margin that participants in these markets may have to post to ensure performance.

The main instruments we'll be talking about today are credit default swaps (CDS), and collateralized debt obligations (CDO). Both of these arose initially to handle problems of corporate credit risk, so the underlying assets were corporate bonds and bank loans. There are extensions however to the case where the underlying assets are sovereign bonds and loans, and commercial and household mortgages. It is the latter extension that is important to understand for the current subprime mortgage crisis, but we'll have to get to it in stages.

From a finance view (which is Fischer Black's approach), the key idea for understanding credit derivatives is the following:

Price of risky asset + Price of insurance on risky asset = Price of riskfree asset

Or

Yield on risky asset = Yield on riskfree asset + Credit Risk Premium

Thus, from this perspective, credit default swaps look like a kind of credit risk insurance.

From a money view, the instruments look a bit different. Translating Fischer Black into our parallel loan balance sheet construction, we can see how credit default swaps enter the picture analogously to interest rate swaps:

| Me<br>Buyer of Insurance<br>Long Swap<br>Short Credit Risk | | Seller of Insurance<br>Short Swap<br>Long Credit Risk | |
|---|---|---|---|
| Assets | Liabilities | Assets | Liabilities |
| Corporate bond | | | |
| | | | |
| [Treasury bond | Corporate bond] | [Corporate bond | Treasury bond] |
| [Treasury bill | Treasury bond] | [Treasury bond | Treasury bill] |
| Credit default swap | | | Credit default swap |
| Interest rate swap | | | Interest rate swap |

In brackets I am showing the parallel loan construction—one side promises to make the same payments the corporation makes (and to miss the same payments the corporation misses), while the other side promises to make the same payments that the Treasury makes on a bond of the same maturity. So long as the corporate bond does not default, this swap of IOUs involves a net cash flow from the long swap to the short swap, simply because the coupon on the corporate bond is larger than the coupon on the Treasury. In the event the corporate bond defaults, however, there is a large cash flow in the opposite direction; in effect the long swap delivers the defaulted bond to the short swap, and receives in return a perfectly good Treasury bond.

**Corporate Bonds**

Conceptually, it is easiest to introduce the basic ideas while thinking of the underlying as a corporate bond. Such bonds are often complicated instruments, because of the various warrants attached (call provisions and protection), but we'll abstract from that and think of them as simply promises to pay a certain **coupon** at regular intervals over the life of the bond, and the **face value** upon maturity. Standard valuation considerations suggest that the price of such a bond can be thought of in present value terms as

$$P(0) = \Sigma\delta^t C_t + \delta^T F_T$$

where C is the coupon, F is the face value, and $\delta$ is a discount factor that we can think of as (1/1+R) where R is some risk-adjusted interest rate. You can see from the formula that there is an inverse relationship between R and P. Fluctuations in the price of the bond after issue can be thought of as fluctuations in the risk-adjusted interest rate.

One reason for those fluctuations is fluctuation in the risk-free interest rate, but we've already talked about that in previous lectures. Here we want to focus on fluctuations that come from

(1) changes in the price of credit risk and
(2) changes in the quantity of credit risk.

Bonds are typically rated by one of the various rating agencies, such as Fitch. Ratings go from AAA to B-, to NR. Lower rated bonds sell at a discount, which means that the risk-adjusted interest rate is higher. Usually however there is an attempt to set the coupon at a level that counteracts this effect so that, at least when the bond is issued, bonds of various ratings all sell near par.

At any moment in time there is a pattern of credit spreads over Treasuries, or perhaps over the swap rate, small spreads for AAA and larger spreads for lower ratings. The important point to realize is that these spreads fluctuate over time, which is one source of risk (price), and that individual bond ratings can also change over time, which is a second source of risk (quantity). The basic idea of credit derivatives is to create an instrument that will allow these sources of risk to be carved off of the bond and priced (maybe even sold) separately.

Why do the spreads move as they do? In the industry, most of the attention focuses on default. As a matter of fact there is considerable dispute about what exactly constitutes default, but we'll put that aside. The point to hold on to is that the lower rated bonds tend to have higher default risk. Thus, instead of getting 10 years of coupons followed by the face value, you might only get 3 years of coupons, and the liquidation value of the bond. That's the risk for someone who owns the bond. Credit default swaps are a way to sell off that risk while retaining ownership of the bond.

**CDS Pricing**

Suppose that I own a bond that promises to pay a constant coupon C for 10 years.[1] Suppose further that I buy an interest rate swap in which I pay fixed and receive LIBOR. In effect, my combined portfolio now pays LIBOR + S%, where S is the credit spread over the fixed rate on the swap. Now we're ready to think about selling off the credit risk.

| Assets | Liabilities |
|---|---|
| Corporate Bond (LIBOR + S%) | |
| If no default: | |
| [LIBOR | LIBOR + U%] |
| If default: | |
| [Face value of Bond, F | Liquidation Price of Bond, P] |

As I mentioned at the beginning, a credit default swap can be understood as a swap of IOUs. I issue an IOU that promises to make periodic payments of LIBOR+U% on the face value of the bond, so long as the bond issuer keeps up his own payments. In the event of default, I promise to pay the liquidation value of the bond and then we are done. Call my IOU a "mirror bond", because the time pattern of payments exactly mirrors the corporate bond I'm holding. In return for this promise I accept an IOU that promises to

[1] This example is inspired by Duffie and Singleton, p. 180, though they don't do the full parallel loan analysis.

pay simply LIBOR as long as the issuer keeps up his payments, and the full face value of the bond in the event of default. Thus on net I am paying U until default, and then receiving the difference between the full face value of the bond and its liquidation value.

Here are the net cash flows from the swap of IOUs, assuming default at period 5:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| -U*F | -U*F | -U*F | -U*F | +F-P(5) |

I'm paying a small amount for four periods in order to receive a possibly big amount in period 5.

What is U? U is a number that makes the present value of the small payments exactly equal to the present value of the large payment, so that at inception the swap is a zero value instrument, i.e. a swap of IOUs that have the same exact value. In the finance view, we think of that U as a kind of insurance premium. So long as I pay U, I am insured against the risk of default on the bond I hold. Why so? If there is default, then the liquidation value of my bond is P(5), but my swap of IOUs pays F-P(5), so on net I recover F, the full face value of the bond.

At inception the CDS is a zero value instrument, but not after. Any change in the credit spread S%, whether market-wide or idiosyncratic to the specific bond, will change the value of the CDS. In theory, the value moves inversely to the value of the underlying bond. In this way, CDS is not so much insurance against eventual default as it is insurance against change in the credit spread.

**Market making**

Now let's think about the same transaction from the point of view of the seller of insurance, who might be a bank or an investment bank. The seller receives a stream of small payments but faces the possibility of having to make a single large payment in the event of default. It is possible to create portfolios of such swaps, which pool the idiosyncratic default risk so that the risk of the pool is less than the risk of any component. (This depends crucially on the correlation of the individual risks. The less correlation, the better, and the law of large numbers can help us out.) This pooling then allows the seller of the swap to charge a lower spread to the buyer.

| Buyer of Insurance | | Dealer | | Seller of Insurance | |
|---|---|---|---|---|---|
| A | L | A | L | A | L |
| Risky Bond<br>$CDS_i$ | | CDS on<br>index CDX | $CDS_i$<br>$CDS_j$<br>$CDS_k$ | | CDS on<br>Index CDX |

This pooling is very important. In a sense we can say that the incentive to create a swap comes from mis-pricing of credit risk in the original corporate bond, and so we should expect that the creation of a flourishing swap market will reduce the price of credit risk overall. That is exactly what happened.

Diversification reduces risk, but does not eliminate it. If the seller seeks matched book, this pool of OTC swaps might then be hedged against a general bond index, perhaps by trading an exchange traded swap such as CDX with a hedge fund. (In the case of subprime mortgages, the swaps on the ABX index were key.)

**UBS Example: Market Making and Liquidity Risk**

In fact, if U<S, then the buyer of the swap can swap out the credit risk and wind up with an investment that pays a small spread (S-U) over LIBOR. That is what UBS was doing in its most important risk arbitrage trade, as follows

| Assets | Liabilities |
|---|---|
| AAA CDO tranche, floating rate<br>Credit default swap (AIG) | Money Market Funding (ABCP, RP) |

UBS was doing something it called a Negative Basis Trade in which it paid AIG 11 bp for 100% credit protection on a supersenior CDO tranche, and financed its holding of that tranche in the wholesale money market. In its report to shareholders[2], to explain f why it lost so much of their money, it states that this trade netted an apparently riskfree arbitrage profit of 20 bp. Because it was apparently riskfree, they did massive amounts of it. The risk turned out to be liquidity risk, when money market funding dried up and they could not sell their AAA tranche. Their CDS hedge did them no good since they could not use it to raise funding. (To make matters worse, the CDS hedge was typically only against the first 2% loss, leaving UBS exposed for everything more than that.)

**Goldman Sachs Example: Hedging CDS with CDS**

The recent SIGTARP report on AIG[3] explains the relationship between Goldman and AIG, which I translate into our balance sheet language as follows

| Goldman Sachs | | AIG | |
|---|---|---|---|
| Assets | Liabilities | Assets | Liabilities |
| CDS, AIG | CDS, clients | | CDS |

Goldman Sachs was in effect acting as a CDS dealer, selling protection to clients but buying protection from AIG. AIG was a naked seller of protection. When the referenced

[2] Google "UBS Shareholder Report" and you will find it.

[3] http://www.sigtarp.gov/reports/audit/2009/Factors_Affecting_Efforts_to_Limit_Payments_to_AIG_Counterparties.pdf

risky asset started to fall in price, the value of the insurance rose. This is a liability of AIG, so it cut into their capital buffer (AIG had no dedicated reserves against these CDS because it thought they were essentially riskfree). Not only that, but AIG had agreed to post collateral, and mark the CDS to market, so these losses were not just book losses but involved payments into a segregated account that Goldman Sachs controlled, about 30 billion at the time AIG failed.

AIG failed because it was no longer able to meet these collateral calls; instead the government took over, lending 85 billion. There has been a lot of loose talk about how the government paid off Goldman at par instead of forcing Goldman to take a loss. This is not exactly what happened. Rather, because the CDS was marked to market, Goldman already had possession of the collateral, it had already been paid. The government money was used to acquire the referenced securities at liquidation value in order to end the swap. In terms of our algebraic example, AIG had already paid F-P(5); what the government did was to lend AIG money to pay P(5) for the bond which the government then took onto its own (the Fed's) balance sheet as Maiden Lane 2 and 3.

**Goldman Abacus example: Synthetic CDO as Collateral Prepayment**

Paulson, the hedge fund manager, paid Goldman to help him bet against subprime, and the way he did it was by establishing a so-called "synthetic CDO".[4] (The very first CDS was established in this way for JP Morgan to hedge tail risk its portfolio of corporate loans. See Gillian Tett, Fool's Gold.) Here is a simplified version of the balance sheets:

| Paulsen | | Abacus | | IKB | |
|---|---|---|---|---|---|
| Assets | Liabilities | Assets | Liabilities | Assets | Liabilities |
| | | T bills | CDO tranche | CDO tranche | |
| CDS on RMBS | | | CDS on RMBS | | |

Abacus is a synthetic CDO, not a cash CDO, because its exposure to credit risk comes from its CDS position, not from any actual holdings of RMBS (residential mortgage backed securities). It sells that exposure to IKB in the form of bonds (CDO tranche), and invests the proceeds in Treasury bills. (The point is that the combination of long riskfree securities and short CDS is equivalent to an outright position in the referenced risky security. Refer back to the arbitrage relation I mentioned at the beginning of lecture.)

How was this supposed to work? So long as the RMBS was not in default, Paulsen paid a regular premium to Abacus, which added that premium to the Tbill return to pay interest to IKB on its bond holding. Once the RMBS was in default, however, Abacus paid Paulsen by delivering its holding of Treasury bills, while Paulsen delivered the underlying RMBS which he bought at liquidation value. The difference between face

[4] See The Greatest Trade Ever, by Greg Zuckerman

value and liquidation value is absorbed in the value of the CDO tranche bonds owned by IKB.

For this class the important point is that, in effect, the Abacus arrangement went one step farther than the AIG mark to market CDS. In the AIG case, falling value of the referenced securities forced collateral payments to Goldman Sachs. In the Abacus case, the collateral payments were all made at the very inception of the contract when IKB bought the bonds, so IKB did not have to come up with any additional collateral (which it could have refused). Instead, the falling value of the referenced securities merely caused a transfer of the collateral, already collected, from Abacus to Paulsen.

Darell Duffie and Ken Singleton, Credit Risk: Pricing, Measure, and Management. Princeton UP, 2003
David Lando, Credit Risk Modeling, Theory and Applications. Princeton UP, 2004.
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