Join the game

Abukar M Ali and **Moorad Choudhry**, both GARP members in London, discuss the rule and exception in this piece on the structuring, pricing and market risk associated with credit default swaps. They detail on how to use these increasingly popular instruments effectively and explain what to look out for in terms of operational risks. This is a must-read paper for any credit derivatives player.

Credit derivative instruments enable participants in the financial market to trade in credit as an asset, as they isolate and transfer credit risk. They also enable users to separate funding considerations from credit risk.

While a number of instruments come under the category of credit derivatives, we consider the most commonly encountered credit derivative instrument: the credit default swap. However irrespective of the particular instrument under consideration, all credit derivatives can be described under the following characteristics:

- The reference entity, which is the asset or name on which credit protection is being bought and sold
- The credit event, or events, which indicate that the reference entity is experiencing, or about to experience, financial difficulty and which act as trigger events for payments under the credit derivative contract
- The settlement mechanism for the contract, whether cash or physically settled
- Under physical settlement: the deliverable obligation that the protection buyer delivers to the protection seller on the occurrence of a trigger event

Credit derivatives are grouped into funded and unfunded instruments. In a funded credit derivative, typified by a credit-linked note (CLN), the investor in the note is the credit-protection seller and is making an upfront payment to the protection buyer when it buys the note. Thus, the protection buyer is the issuer of the note. If no credit event occurs during the life of the note, the redemption value of the note is paid to the investor on maturity. If a credit event does occur, then on maturity a value less than par will be paid out to the investor. This value will be reduced by the nominal value of the reference asset that the CLN is linked to. The exact process will differ according to whether cash settlement or physical settlement has been specified for the note.

In an unfunded credit derivative, typified by the credit default swap, the protection seller does not make an upfront payment to the protection buyer. Credit default swaps have a number of applications and are used extensively for flow trading of single reference name credit risks, or in the portfolio swap form, for trading a basket of reference credits. Credit default swaps and CLNs are used in structured products in various combinations, and their flexibility has been behind the growth and wide application of the synthetic collateralised debt obligation and other credit hybrid products.

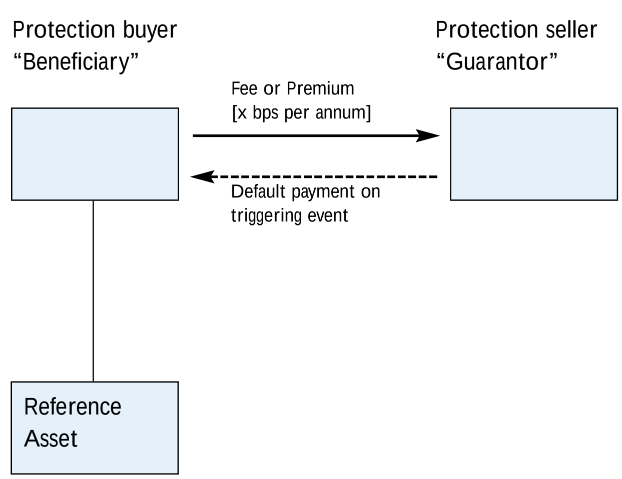
Common plays

The most common credit derivative is the *credit default swap*, *credit swap* or *default swap*.[1] This is a bilateral contract in which a periodic fixed fee or a one-off premium is paid to a *protection seller* and in return that seller will make a payment on the occurrence of a specified credit event. The fee is usually quoted as a basis point multiplier of the nominal value, and it is usually paid quarterly in arrears, as a per annum fee.[2]

The protection seller is buying the credit risk, while the protection buyer is selling credit risk. Since no asset is transferred, there is no need for funding the position – hence, the term unfunded credit derivative.

The swap can refer to a single asset (known as the reference entity, reference asset or underlying asset), or a basket of assets, and the default payment can be paid in whatever way suits the protection buyer or both counterparties. For example, it may be linked to the change in price of the reference asset or another specified asset, it may be fixed at a pre-determined recovery rate, or it may be in the form of actual delivery of the reference asset at a specified price.

Figure 1 Basic plain vanilla credit default swap structure



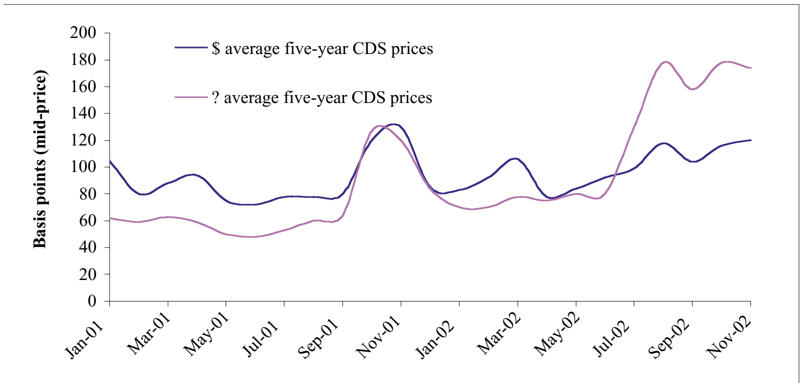
The credit default swap enables one party to transfer its credit risk exposure to another party. Banks may use default swaps to trade sovereign and corporate credit spreads without trading the actual assets themselves. For example, someone who has gone long a default swap (the protection buyer) will gain if the reference asset obligor suffers a rating downgrade or default, and can then sell the default swap at a profit if he can find a buyer counterparty.[3] This is because the cost of protection on the reference asset will have increased as a result of the credit event. The original buyer of the default swap need never have owned a bond issued by the reference asset obligor.

Normally, the default payment on a credit default swap will be (1 -δ) times its notional, where δ is defined as the recovery rate of the reference security. The reason for this payout is clear – it allows a risky asset to be transformed into a risk free asset by purchasing default protection that is referenced to this credit. For example, if the expected recovery rate for a given reference asset is 30% of its face value, upon default the remaining 70% will be paid by the protection seller. Credit agencies, such as Moody's and Standard & Poor's, provide recovery rate estimates for corporate bonds with different credit ratings using historical data.

The default swap contract has a given maturity, but will terminate early if a credit event occurs. The definition of credit event is crucial to the contract, and generally is as defined by ISDA in its standard contract documentation. It can include the default of an issuer or an administration or loan restructuring situation. The maturity of the credit swap does not have to match the maturity of the reference asset, and it often does not. On occurrence of a credit event, the swap contract is terminated and a settlement payment made by the protection seller or guarantor to the protection buyer. This termination value is calculated at the time of the credit event, and the exact procedure that is followed to calculate the termination value will depend on the settlement terms specified in the contract. This will be either cash settlement or physical settlement, as detailed below.

- Cash settlement: the contract may specify a pre-determined pay-out value on occurrence of a credit event. This may be the nominal value of the swap contract. This swap is known in some markets as a *digital credit derivative*. Alternatively, the termination payment is calculated as the difference between the nominal value of the reference asset and its market value at the time of the credit event. This arrangement is more common with cash-settled contracts[4]
- Physical settlement: on occurrence of a credit event the buyer delivers the reference asset to the seller in return for which the seller pays the face value of the delivered asset to the buyer. The contract may specify a number of alternative assets that the buyer can deliver, and these are known as *deliverable obligations*. This may apply when a swap has been entered into on a reference name rather than a specific obligation (such as a particular bond) issued by that name. Where more than one deliverable obligation is specified, the protection buyer will invariably deliver the asset that is the cheapest on the list of eligible assets. This gives rise to the concept of the *cheapest-to-deliver*, as encountered with government bond futures contracts, and is in effect an embedded option afforded the protection buyer

Figure 2 Investment-grade credit default swap levels

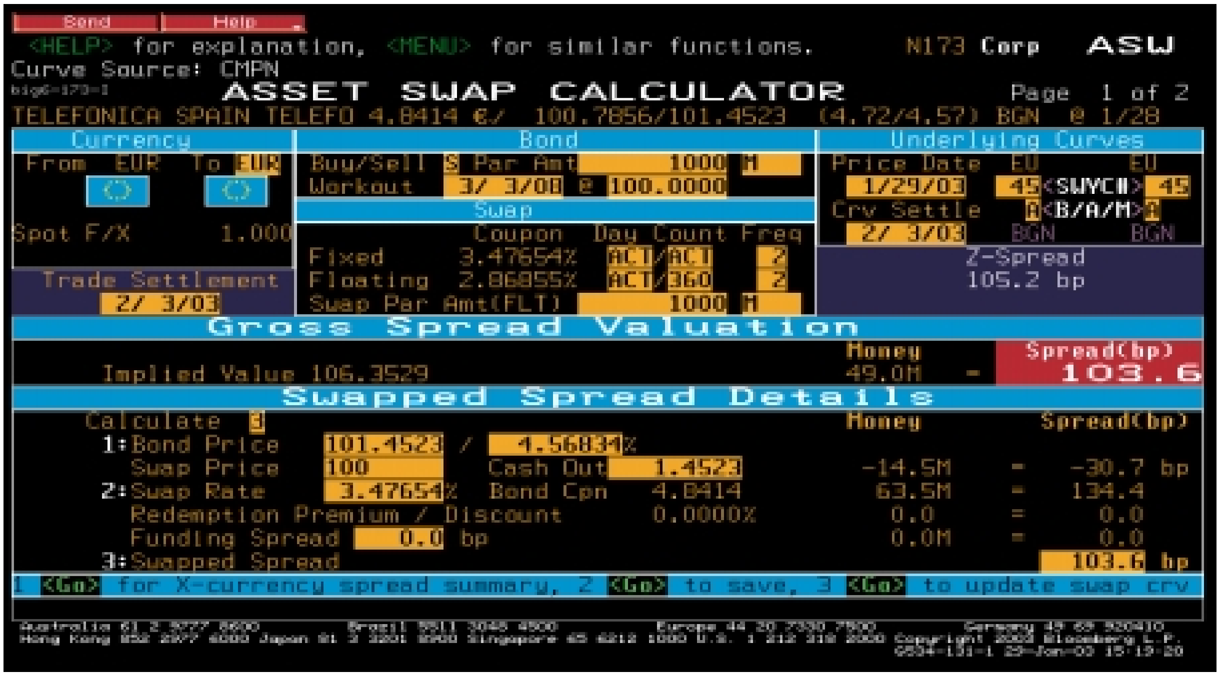


Source: Blomberg

In a digital (binary) default swap, the contingent payment if default occurs equals a pre-specified notional amount, irrespective of the recovery value.

In theory, the value of protection is identical irrespective of which settlement option is selected. However, under physical settlement the protection seller can gain if there is a recovery value that can be extracted from the defaulted asset, or its value may rise as the fortunes of the issuer improve. Swap market-making banks often prefer cash settlement as there is less administration associated with it. It is also more suitable when the swap is used as part of a synthetic structured product because such vehicles may not be set up to take delivery of physical assets. Another advantage of cash settlement is that it does not expose the protection buyer to any risks should there not be any deliverable assets in the market, for instance due to shortage of liquidity in the market. Were this to happen, the buyer may find the value of its settlement payment reduced. Nevertheless, physical settlement is widely used because counterparties wish to avoid the difficulties associated with determining the market value of the reference asset under cash settlement. Physical settlement also permits the protection seller to take part in the creditor negotiations with the reference entity's administrators, which may result in improved terms for them as holders of the asset.

Figure 3 Bloomberg asset swap valuation page



Default swap case

XYZ plc credit spreads are currently trading at 120 basis points over government for five-year maturities and 195 basis points over for 10-year maturities. A portfolio manager hedges a $10 million holding of 10-year paper by purchasing the following credit default swap, which is written on the five-year bond. This hedge protects the buyer for the first five years of the holding, and in the event of XYZ's credit spread widening it will increase in value and may be sold on before expiry at profit. The 10-year bond holding also earns 75 basis points over the shorter-term paper for this portfolio manager.

Term	5 years
Reference credit	XYZ plc five-year bond
Credit event	The business day following occurrence of specified credit event
Default payment	Nominal value of bond x [100 – price of bond after credit event]
Swap premium	3.35%

Assume now that midway into the life of the swap there is a technical default on the XYZ plc five-year bond such that its price now stands at $28. Under the terms of the swap the protection buyer delivers the bond to the seller, who pays out $7.2 million to the buyer, as shown below:

Default payment = $10,000,000 x [100% - 28%]
= $7,200,000.

Figure 4 Bloomberg NW-market monitor

The credit default swap basis

Market observation shows that the asset-swap pricing approach, in which the reference entity asset swap spread is used as the benchmark to determine the fair value for pricing credit default swaps, can lead to discrepancy. This is because of the various reasons why the credit default swap price is different to the asset swap rate, Choudhry (2003).

This difference is the default swap basis (a positive basis is the CDS trading wider than the debt itself). Hence, a model approach becomes vital for market-making banks due to the shortcomings of the asset-swap approach.The existence of the basis presents arbitrage trading opportunities across the synthetic and cash markets, which we introduce now.

Asset swap spreads can be used to gauge arbitrage opportunities between the asset swap market and the credit default swap market. Consider a scenario where you would wish to synthetically transform fixed cash-flows from a position into floating-rate cash-flows by entering into an asset swap. Via an asset swap transaction, one could determine the spread above Libor that one would receive or give up depending on the value of the bond. If we assume that the spread is positive, we can then compare the spread we receive above Libor to the market quote of the credit default swap spread on the same reference asset. If the cost of buying protection is lower than the spread received from the asset swap, then this in theory represents an arbitrage opportunity.

We illustrate this with an example on the Bloomberg ASW screen. Figure 3 shows the asset swap spread on a Telefonica bond with a maturity date of March 3, 2008. The page has been accessed by typing: Telefo 4.8414 3/3/08 <corp> ASW <go>.

The asset swap spread is positive at approximately 103 basis points above Libor. We can compare this spread with the par credit default swap market quote (in this case from a market making bank) of 94 basis points for five years for credit risk protection. We see therefore that this negative basis indicates a potential arbitrage opportunity across the cash and synthetic market.

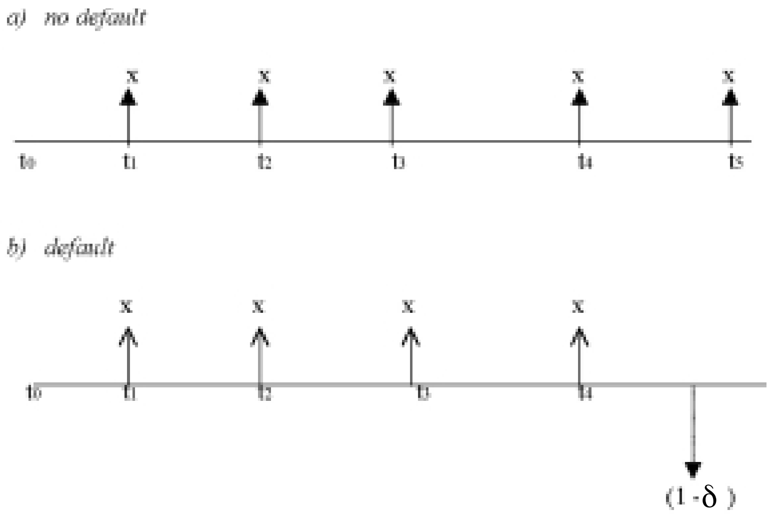
Of course, there are a number of reasons why these spreads will differ (Choudhry *ibid*). We illustrate these differences in the figure below. This shows the basis for three corporate bonds from the telecommunication sector and the historical credit default swap spread market levels (from the same bank we obtained the CDS price above). That the arbitrage-free pricing approach (which would indicate that the CDS price is equivalent to the asset-swap spread) is not sufficient for obtaining accurate CDS prices necessitates a model approach, which we consider next.

Reduced-form model approach

There are a number of variations on the standard credit default swap. In *binary credit default swap*, the payoff in the event of default is a specific dollar amount. In a *basket credit default swap*, a group of reference entities are specified and there is a payoff when the first of these reference entities defaults. In a *contingent credit default swap*, the payoff requires both a credit event and additional trigger. The traditional trigger might be a credit event with respect to another reference entity or a specified movement in some market variable. We consider the plain vanilla structure pricing approach.

A default swap, like an interest rate swap, consists of two legs: one corresponding to the premium payments and the other to the contingent default payment. The present

Figure 5 Illustration of cash-flows in a default swap



value (PV) of a default swap can be viewed as the algebraic sum of the present values of its two legs. The market premium is similar to an interest rate swap in that the premium makes the current aggregate PV equal to zero.

The valuation of each leg of the cash-flows is considered below. As these cash-flows may terminate at an unknown time during the life of the deal, their values are computed in a probabilistic sense, using the discounted expected value as calculated under the risk-neutral method and assumptions.

The theoretical pricing of credit derivatives has attracted some attention in the academic literature. Longstaff Schwartz (1995) present the pricing of credit spread options based on exogenous mean-reverting process for credit spreads. Duffie (1999) presents a simple argumentation for the replication of, as well as a simple reduced form model of, the instrument. Here we introduce a reduced-form type pricing model developed by Hull and White (2000). Their approach was to calibrate their model based on the traded bonds of the underlying reference name on a time series of credit default swap prices. Like most other approaches, their model assumes that there is no counterparty default risk. Default probabilities, interest rates and recovery rates are independent.

Finally, they also assume that the claim in the event of default is the face value plus accrued interest. Consider the valuation of a plain vanilla credit default swap with $1 notional principal. See the notation below.

- T: Life of credit default swap in years
- $q(t)$: Risk neutral probability density at time
- R: Expected recovery rate on the reference obligation in a risk-neutral world (independent of the time of default)
- $u(t)$: Present value of payments at the rate of $1 per year on payment dates between time zero and time t
- $e(t)$: Present value of an accrual payment at time t equal to $t - t^*$ where t^* is the payment date immediately preceding time t
- $v(t)$: Present value of $1 received at time

w: Total payment per year made by credit default swap buyer

s: Value of that causes the value of credit default swap to have a value of zero

π: The risk-neutral probability of no credit event during the life of the swap.

A(t): Accrued interest on the reference obligation at time *t* as a percent of face value

The value π is one minus the probability that a credit event will occur by time *T*.
This is also referred to as the survival probability and can be calculated from *q(t)*:

$$\pi = 1 - \int_0^T q(t)dt \tag{1}$$

The payments last until a credit event or until time *T*, whichever is sooner. If default occurs at *t(t<T)*, then the present value of the payment is *w[u(t) + e(t)]*. If there is no default prior to time *T*, then the present value of the payment is *wu(T)*. The expected present value of the payment is, therefore:

$$w\int_0^T q(t)[u(t)+e(t)\}dt + w\pi u(T) \tag{2}$$

Given the assumption about the claim amount, the risk neutral expected payoff from the credit default swap (CDS) contract is derived as follows:

$$1-R[1+A(t)] \text{ multiplying } -R \text{ by } [1+A(t)]$$
$$1-R[1+A(t)] = 1-R-A(t)R$$

The present value of the expected payoff from the CDS is given as

$$\int_0^T [1-R-A(t)R]q(t)v(t)dt \tag{3}$$

The value of the credit default swap to the buyer is the present value of the expected payoff minus the present value of the payments made by the buyer, or

$$\int_0^T [1-R-A(t)R]q(t)v(t)dt - w\int_0^T q(t)[u(t)+e(t)]dt + w\pi u(T) \tag{4}$$

In equilibrium, the present value of each leg of the above equation should be equal. We can now calculate the credit default swap spread *s* which is the value of *w* that makes the equation equal to zero by simply rearranging the equation, as shown below.

$$s = \frac{\int_0^T [1-R-A(t)R]q(t)v(t)dt}{\int_0^T q(t)[u(t)+e(t)]dt + \pi u(T)} \tag{5}$$

The variable *s* is referred to as the credit default swap spread or CDS spread. The formula at (5) is simple and intuitive for developing an analytical approach for pricing credit default swaps because of the assumptions used. For example, the model assumes that interest rates and defaults events are independent. Also, the possibility of counterparty default is ignored. The spread *s* is the payment per year, as a percent of notional principal for a newly issued credit default swap.

Market illustration

By way of example, Figure 6 shows the mid market-market value of *s* for the Daimler-Chrysler name, as at October 2002 for a 5-year CDS is 148/158 basis points, or 0.0148/0.0158 (bid and ask) per dollar of principal value.

The implementation of the above pricing methodology is frequently carried out by using the Bloomberg credit default swap analytics page. This is accessible on Bloomberg by typing (CDSW <go>).

Figure 7 shows the CDSW page using the modified Hull and White model with certain default parameter inputs, as selected for the Daimler-Benz five-year CDS. This implementation links the rates observed in the credit protection market and the corporate bond market via probabilities of default of the issuer. The input used to price the CDS contract is selected from a range of market-observed yield curves, and it can include:

- A curve of CDS spreads
- An issuer (credit-risky) par yield curve
- A default probability curve (derived from the default probabilities of the underlying reference for each maturity implied by the par credit default swap spreads)

The assumptions based on the independence of recovery rates, default probabilities and interest rates may not hold completely in practice since high interest rates may cause companies to experience financial difficulties and

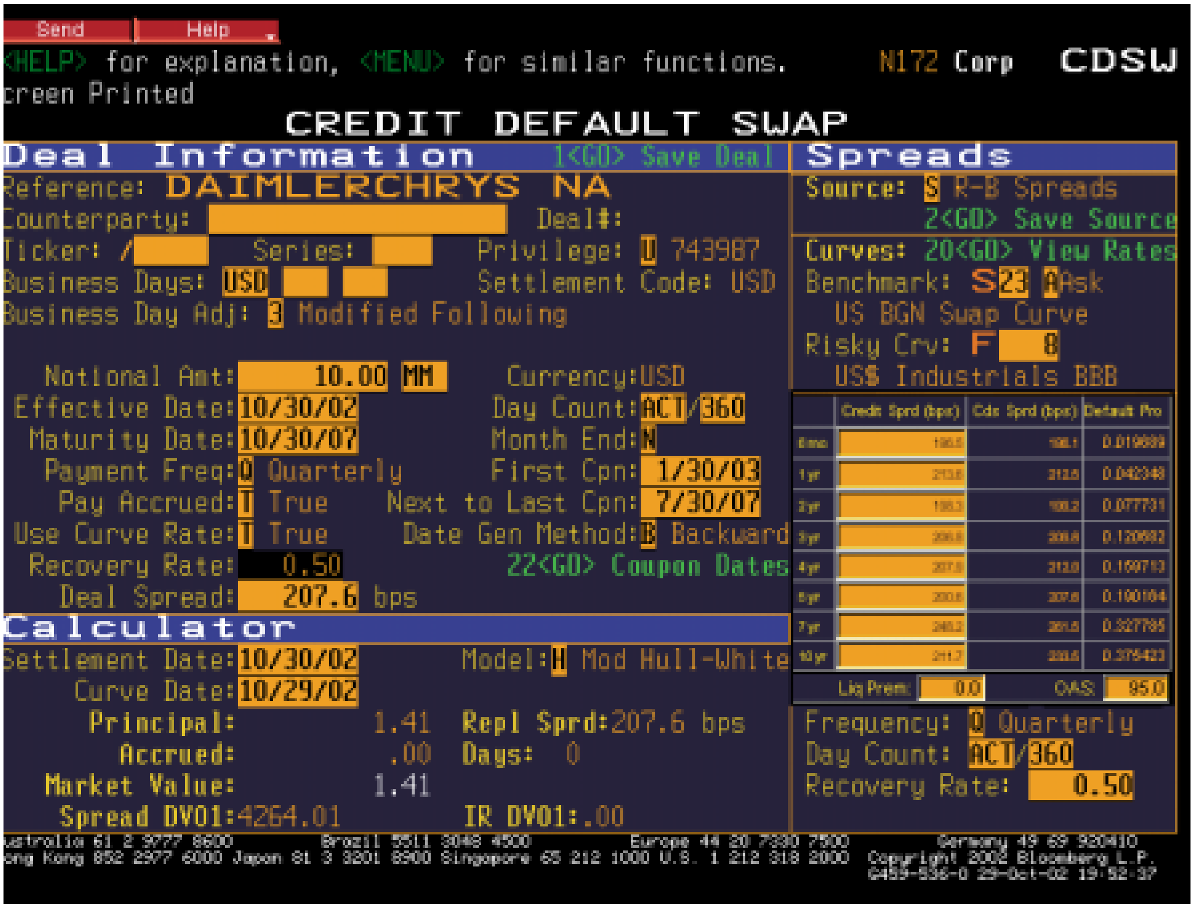
Figure 6 Credit default swap quotes for auto manufacturer reference credits

Autos & Transport – 5 year protection

Credit	**Rating**	**Bid**	**Ask**	**Change**
BMW	A!/NR	38	48	2
Daimler Chrysler	A3/BBB+	148	158	-4.5
Fiat	NR/NR	675	775	25
Renault	Baa2/BBB	100	115	2.5
Volvo	A3 *-/NR	72	82	2
VW	A1/A+	68	78	0

Source: Bloomberg LP

Figure 7 Bloomberg page CDSW using modified Hull-White pricing on selected CDS



default or administration, and as a result of this default probabilities would increase. Thus, a positive relation between interest rates and default probabilities may be associated with high discount rates for the CDS payoffs, and this would have the effect of reducing the credit default swap spread.

Nevertheless, the modified Hull-White approach presents a neat and intuitive approach that allows for a closed-form pricing approach for credit default swaps, using parameter inputs from the market. ■

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Notes

1. The authors prefer the first term, but the other two terms are common. We feel that "credit swap" does not adequately describe the actual purpose of the instrument.

2. The counterparty to the protection seller is of course the protection buyer. The protection buyer's position can also be defined as a long put option position on the reference asset, as the bond can be put back to the seller in the event of default.

3. Be careful with terminology here. To "go long" of an instrument generally is to purchase it. In the cash market, going long the bond means one is buying the bond and so receiving coupon; the buyer has therefore taken on credit risk exposure to the issuer. In a credit default swap, going long might be thought of as buying the swap, but a buyer of a credit default swap is purchasing protection and therefore paying premium; the buyer has no credit exposure on the name and has in effect "gone short" on the reference name (the equivalent of shorting a bond in the cash market and paying coupon). So buying a credit default swap is frequently referred to in the market as "shorting" the reference entity.

4. Determining the market value of the reference asset at the time of the credit event may be a little problematic: the issuer of the asset may well be in default or administration. An independent third-party Calculation Agent is usually employed to make the termination payment calculation.