A Primer on Credit Default Swaps

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A CDS is an OTC contract between the seller and the buyer of protection against the risk of default on a set of debt obligations issued by a reference entity.

It is essentially an insurance policy that protects the buyer against the loss of principal on a bond in case of a default by the issuer.

The protection buyer pays a periodic premium over the life of the contract and is, in turn, covered for the period.

The premium paid by the protection buyer to the seller is often termed as the “CDS spread” and is quoted in basis points per annum of the contract’s notional value and is usually paid quarterly.

If a certain pre-specified credit event occurs, the premium payment stops and the protection seller pays the buyer the par value for the bond.

If no credit event occurs during the term of the swap, the protection buyer continues to pay the premium until maturity.

The contract started in the sovereign market in mid 90s, but the volume has moved to corporate entities.
Credit events

- A CDS is triggered if, during the term of protection, an event that materially affects the cashflows of the reference debt obligation takes place.

- A credit event can be a bankruptcy of the reference entity, or a default of a bond or other debt issued by the reference entity.

- Restructuring is considered a credit event for some, but not all, CDS contracts, referred to as “R”, “mod-R”, or “modmod- R”. Events such as principal/interest rate reduction/deferral and changes in priority ranking, currency, or composition of payment can qualify as credit events.

- When a credit event triggers the CDS, the contract is settled and terminated. The settlement can be physical or cash. The protection buyer has a right to deliver any deliverable debt obligation of the reference entity to the protection seller in exchange for par.

- There can be additional maturity restrictions if the triggering credit event is a restructuring.

- The CDS buyer and the seller can also agree to cash settle the contract at the time of inception or exercise. In this case, the protection seller pays an amount equal to par less the market value of a deliverable obligation.
A schematic chart of the cashflows

CDS Cashflows before Maturity/Default

Protection Buyer → Quarterly Premium → Protection Seller

Protection on Default

Physical Settlement in Case of Default

Protection Buyer → Deliverable Obligation → Protection Seller

Par

Cash Settlement in Case of Default

Protection Buyer → Par – Recovery Value → Protection Seller
A CDS contract specifies the precise name of the legal entity on which it provides default protection.

Given the possibility of existence of several legal entities associated with a company, a default by one of them may not be tantamount to a default on the CDS. —It is important to know the exact name of the legal entity and the seniority of the capital structure covered by the CDS.

Changes in ownership of the reference entity’s bonds or loans can also result in a change in the reference entity covered by the CDS contract.

<table>
<thead>
<tr>
<th>Ownership of bonds/loans</th>
<th>New reference entity</th>
</tr>
</thead>
<tbody>
<tr>
<td>One entity assumes more than 75%</td>
<td>Successor</td>
</tr>
<tr>
<td>No entity assumes more than 75%, but one of more</td>
<td>Divide the contract equally among such</td>
</tr>
<tr>
<td>entities assume 25-75%</td>
<td>entities</td>
</tr>
<tr>
<td>No entity assumes more than 25%</td>
<td>Original legal entity</td>
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If the legal entity does not survive, the CDS contract follows the entity that succeeds to highest percentage of bonds or loans.
Since 2002, a vast majority of CDS contracts have standardized quarterly payment and maturity dates — 20th of March, June, September, and December.

This standardization has several benefits including convenience in offsetting CDS trades, rolling over of contracts, relative value trading, single name vs. the benchmark indices or tranched index products trading.
CDS history

- The 1997 Asian crises, including the rescheduling of some of Indonesia’s debt payments, motivated the creation of working groups to address standardization.

- The shortcomings of the original definitions of restructuring were revealed on numerous occasions through credit events triggered by Russia, Conseco and Xerox. Ultimately, such tests prompted rethinking the restructuring credit events, resulting in modified restructuring, modified modified restructuring, and even the growing use of no restructuring credit events.

- The Armstrong default highlighted the importance of clearly specified reference entities (appropriate level in the capital structure) and the Railtrack bankruptcy motivated specific details concerning the deliverability of convertible bonds.

- In 2002, CDSW default swap pricing tool was introduced on the Bloomberg systems.

- The more recent injections of liquidity came from the near hyper-growth of trading in default swap indices and creations of credit hedge funds...
The risk profile of a CDS is similar to that of a corporate bond of the reference entity, but with several important differences.

- A CDS does not require an initial funding, which allows leveraged positions.
- A CDS transaction can be entered where a cash bond of the reference entity at a particular maturity is not available.
- By entering a CDS contract as a protection seller, an investor can easily create a short position in the reference credit.

Most contracts fall between $10 million to $20 million in notional amount. Maturity ranges from one to ten years, with the five-year maturity being the most common.
The fair CDS spread (premium) is set to equate the present value of all premium payments to the present value of the expected default loss, both in risk-adjusted sense.

There is typically an accrued premium when default does not happen exactly on the quarterly payment dates.

Consider a one period toy example, in which the premium \(s\) is paid at the end of the period and default can only happen at the end of the period with risk-adjusted probability \(p\). In case of default, the bond's recovery rate is \(R\).

- The present value of the premium payment is: \(N(1-p)s/(1+r)\).
- The present value of the expected default loss: \(Np(1-R)/(1+r)\).
- Equating the values of the two legs, we have \(s = \frac{p(1-R)}{(1-p)} \approx p(1-R)\).
- Or from a CDS quote \(s\), we can learn the risk-adjusted default probability as \(p = \frac{s}{s+1-R} \approx \frac{s}{1-R}\).
CDS pricing: A continuous time setup

- Let $r_t$ denote the continuous compounded interest rate.
- Let $s$ denote the annual premium rate paid continuously until default.
- Default arrives unexpectedly in a Poisson process with arrival rate $\lambda_t$.
  - The probability that a default will occur in the small time interval $[t, t + \Delta t]$ is approximately $\lambda_t \Delta t$.
  - The probability that the entity survives up to $t$ is $S(t) = e^{-\int_0^t \lambda_s ds}$. Default probability is $Q(t) = 1 - S(t)$.
- The value of the premium leg is: $E_0 \left[ s_0 \int_0^T e^{-\int_0^t (r_s + \lambda_s) ds} dt \right]$.
- The value of the protection leg is: $E_0 \left[ (1 - R) \int_0^T \lambda_t e^{-\int_0^t (r_s + \lambda_s) ds} dt \right]$.
- Hence, the fair CDS spread can be written as
  $$s_0 = \frac{E_0 \left[ (1-R) \int_0^T \lambda_t e^{-\int_0^t (r_s + \lambda_s) ds} dt \right]}{E_0 \left[ \int_0^T e^{-\int_0^t (r_s + \lambda_s) ds} dt \right]} \text{ (weighted average default arrival).}$$
- Under constant default arrival rates (flat CDS curve), we have $s_0 = \lambda (1 - R)$. 
CDS pricing: The Bloomberg CDSW function

- CDSW strips the CDS term structure to obtain a term structure of default probabilities...
- by assuming piece-wise constant default arrival rates $\lambda$, piece-wise constant forward interest rates $r$, and a constant bond recovery $R = 40%$.
  - $\lambda_1$ is determined by the first (shortest maturity) CDS quote: $\lambda_1 = s_1/(1 - R)$.
  - Given $\lambda_1$, $\lambda_2$ is determined by the second CDS quote $s_2$ ...
  - Given $\{\lambda_i\}_{i=1}^N$, the risk-adjusted default probability up to time $t \in (t_n, t_{n+1}]$ is given by
    \[
    Q(t) = 1 - e^{-\int_0^t \lambda_s ds} = 1 - \exp \left[ -\lambda_{n+1}(t - t_n) - \sum_{i=1}^n \lambda_i(t_i - t_{i-1}) \right].
    \]
- The stripping procedure can break down when the quoted CDS term structure allows arbitrage opportunities.
CDS pricing: Dynamic term structure models of interest rates and credit spreads

- CDSW assumes deterministic interest rates and credit spreads.
- In reality, both are stochastic and they interact dynamically.
- Their dynamics and interaction also affect the no-arbitrage pricing of the CDS term structure.
- An affine example (Chen, Cheng, and Wu, 2006):

\[
\begin{align*}
    r_t &= a_r + b_r^T X_t, \\
    \lambda_i^t &= a_i + b_i^T X_t + c_i^T Y_t \\
    dX_t &= (\theta_x - \kappa_x X_t) \, dt + dW_{xt}, \\
    dY_t &= (\theta_y - \kappa_{xy} X_t - \kappa_y Y_t) \, dt + dW_{yt},
\end{align*}
\]

- These types of models do not fit the observed LIBOR/swap rates and CDS quotes exactly.
- Market deviations from the values of a well-specified model often reflect temporary market dislocations and can be exploited in statistical arbitrage strategies.
Statistic arbitrage based on dynamic term structure models

Basic idea:

- Interest rates (CDS quotes) across different maturities are related.
- A dynamic term structure model provides a (smooth) functional form for this relation that excludes arbitrage.
  - The model usually consists of specifications of risk-neutral factor dynamics and the short rate/spread as a function of the factors.
- A model is well-specified if
  - it can fit most of the term structure shapes reasonably well.
  - Pricing errors from the model are more transient (predictable) compared to observed interest rates or CDS quotes.
- Use the model as a decomposition tool: \( y_t = f(X_t, Y_t) + e_t \).
  - What the model captures \( f(X_t, Y_t) \) is the persistent component.
  - What the model misses (the pricing error \( e \)) is the more transient and hence more predictable component.
- Form portfolios that
  - neutralize their first-order dependence on the persistent factors.
  - only vary with the transient residual movements.
A 3-factor example on LIBOR/swap rates

- For a three-factor model, we can form a 4-swap rate portfolio that has zero exposure to the factors.
  - The portfolio should have duration close to zero
  - No systematic interest rate risk exposure.
  - The fair value of the portfolio should be relatively flat over time.

- The variation of the portfolio’s market value is mainly induced by short-term liquidity shocks...

- Long/short the swap portfolio based on its deviation from the fair model value.
  - Provide liquidity to where the market needs it and receives a premium from doing so.

- Reference: Bali, Heidari, Wu, Predictability of Interest Rates and Interest-Rate Portfolios.

- Key distinction for CDS term structure trading: We also need to maintain default-neutral.
The time-series of 10-year USD swap rates

Hedged (left) v. unhedged (right)

It is much easier to predict the hedged portfolio (left panel) than the unhedged swap contract (right panel).
Back-testing results from a simple investment strategy

95-00: In sample. Holding each investment for 4 weeks.
Roughly, the CDS premium should be equal to the spread over LIBOR for the issuers floating rate note trading at par.

If the CDS premium is lower than the bond spread, one can buy a par bond and buy CDS protection on the reference entity, and finance the transaction at LIBOR.

The transaction generate positive cashflow during the life of the contract.

If the entity defaults, the investor can deliver the bond and receive par from the protection and then use the par to close out the financing branch.

It is harder to do the reverse (and bond) when CDS premium is high.
Cross-market arbitrage II: Sovereign CDS and currency options

- When a sovereign country’s default concern (over its foreign debt) increases, the country’s currency tend to depreciate, and currency volatility tend to rise.
  - “Money as stock” corporate analogy.

- Observation: Sovereign credit default swap spreads tend to move positively with currency’s
  - option implied volatilities (ATMV): A measure of the return volatility.
  - risk reversals (RR): A measure of distributional asymmetry.

Co-movements between CDS and ATMV/RR

Mexico

Brazil

Dec01 Jul02 Jan03 Aug03 Feb04 Sep04 Mar05

Dec01 Jul02 Jan03 Aug03 Feb04 Sep04 Mar05

Dec01 Jul02 Jan03 Aug03 Feb04 Sep04 Mar05

Dec01 Jul02 Jan03 Aug03 Feb04 Sep04 Mar05

CDS Spread, %

Implied Volatility Factor, %

CDS Spread, %

Risk Reversal Factor, %
A no-arbitrage model that prices both CDS and currency options

Model specification:
- At normal times, the currency price (dollar price of a local currency, say peso) follows a diffusive process with stochastic volatility.
- When the country defaults on its foreign debt, the currency price jumps by a large amount.
- The arrival rate of sovereign default is also stochastic and correlated with the currency return volatility.

Under these model specifications, we can price both CDS and currency options via no-arbitrage arguments. The pricing equations is tractable. Numerical implementation is fast.

Estimate the model with dynamic consistency: Each day, three things vary: (i) Currency price (both diffusive moves and jumps), (ii) currency volatility, and (iii) default arrival rate.
The hedged portfolio of CDS and currency options

Example: Suppose we start with an option contract on the currency (e.g., 3-month straddle). We need four other instruments to hedge the risk exposure of the option position:

1. The underlying currency to hedge infinitesimal movements in exchange rate
2. A risk reversal (e.g., 6-month) to hedge the impact of default on the currency value.
3. Another straddle (e.g., 2-month) to hedge the currency volatility movement.
4. A CDS contract (e.g., 5-year) to hedge the default arrival rate variation.

The portfolio needs to be rebalanced over time to maintain neutral to the risk factors.

- The value of hedged portfolio is much more transient than volatilities or cds spreads.
The example portfolio

2m & 3m straddle + 6m 25-delta risk reversal + 5y CDS + currency
Bloomberg LAB function: CDFX

2 straddle + 2 CDS + currency
Similar linkages between corporate CDS and stock options

All series are standardized to have similar scales in the plots.
Reference:  Carr and Wu, Stock Options and Credit Default Swaps: A Joint Framework for Valuation and Estimation
A simpler and more direct linkage

between far-out-of-the-money American puts and credit insurance.

- **Assumption:** Stock price stays above a barrier $B$ before default and drops below $A$ and stays below afterwards.

- **Linkage:** The spread between two American put options on the same stock at the same expiry and with the two strikes falling between the corridor $[A, B]$, further scaled by their strike difference, $(P_2 - P_1)/(K_2 - K_1)$, replicates a standard insurance contract that pays one dollar when default occurs prior to option expiry and zero otherwise.

  - An important special example: Stock prices drops to zero upon default.
  - Then, the value of the credit insurance contract can be determined by one put: $P/K$.

- **Reference:** Carr and Wu, A simple robust link between American puts and credit insurance.