

# A Guide to the CDS Package (Draft)

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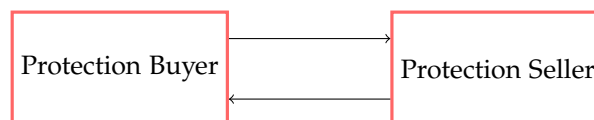
## 1 Introduction

A Credit Default Swap (CDS) is a financial swap agreement between two counterparties in which the buyer pays a fixed periodic coupon to the seller in exchange for protection in the case of a credit event. The International Swaps and Derivatives Association (ISDA) has created a set of standard terms for CDS contracts, the so-called “Standard Model.” This allows market participants to calculate cash settlement from conventional spread quotations, convert between conventional spread and upfront payments, and build the yield curve of a CDS. The **CDS** package implements the Standard Model, allowing users to value credit default swaps and calculate various risk measures associated with these instruments.

## 2 CDS Basics

A CDS is a simple and popular form of credit derivative. It was originated in the late 1980s and was popularized by a team at J.P. Morgan including Blythe Masters in 1994 Lenzner (2009); Lanchester (2009). The CDS market started to develop soon afterwards as banks used CDS contracts to hedge their credit exposures on the balance sheets. Many different types of CDS have since emerged including basket default swaps (BDSs), index CDSs, credit-linked notes, et cetera. In the **CDS** package, we focus on calculations related to a single-name CDS contract.

A single-name CDS contract a private contract between two parties, which provides a transfer of credit risk. The buyer of a CDS contract transfers the credit risk to the seller by paying a series of payments before the contract terminates. In other words, the protection buyer is short credit by selling the credit risk of an underlying loan to the protection seller. As shown in the diagram(?), the buyer pays a stream of coupon payments, called the premium leg in order to receive a one-off, contingent payment (protection leg) in the case of a credit event.



A CDS contract between two counterparties typically specifies the following key terms:<sup>1</sup>

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<sup>1</sup>Partially adapted from *Credit Derivatives Glossary* (Markit, 2009) and *Standard Corporate CDS Handbook* (Leeming et al., 2010).

**Reference Entity** refers to the legal entity which is the subject of a CDS contract.

**Notional** is the amount of the underlying asset on which the payments are based.

**Maturity** a.k.a tenor. It refers to length of a CDS contract. Most CDSs are written within 5 years maturity. The protection buyer continues to make payments to the protection seller till maturity of the contract or the occurrence of a credit event.

**Coupon** is often quoted in basis points. It specifies the amount of payment from the protection buyer to the seller on a regular basis.

**Premium Leg** refers to the cashflows of the fixed payments made by the protection buyer.

**Contingent Leg** , a.k.a. **Protection Leg**, is the payment of notional less recovery amount by the protection seller after a credit event.

**Par spread** is quoted in basis points per annum. It represents the fair rate for a contract of 1 year beginning on the trade date.

**Seniority** specifies the order of which the debt will be paid in liquidation or bankruptcy. In general, there are four different levels of seniority - Senior, Subordinated, Junior, and Preferred.

**Credit Event** triggers the settlement under a CDS contract. Possible credit events specified by the ISDA Credit Derivatives Definitions include:

- **Bankruptcy** - It typically occurs when the reference entity has filed under bankruptcy law (or equivalent law).
- **Failure to pay** - The reference entity fails to make interest or principal payments when due after the applicable grace period expires.
- **Debt restructuring** - The specifications of the debt obligations are changed such that the protection buyer is unfavorably affected.
- **Obligation acceleration** - A debt obligation becomes due before it would otherwise have been because of a default.
- **Obligation default** - A debt obligation becomes capable of being declared due before it would otherwise have been because of a default.
- **Repudiation/Moratorium** - The reference entity announces repudiation or moratorium on debt obligation and subsequently fails to pay.

### 3 The ISDA Standard Model

In April 2009 in North America and June 2009 in Europe, the ISDA introduced a series of mandatory modifications to the CDS contract known as the “Big Bang Protocol.” Among these changes were the standardization of the first accrual dates, fixed coupon (100 bps or 500 bps), and recovery rate (40 %).

This section provides the specifications of an ISDA standard CDS contract and an introduction of the ISDA standard CDS model.<sup>2</sup> The default calculations and parameters in the **CDS** package follow the ISDA Standard Model. Additional default settings in the package that are not specified by the Standard Model, such as the default notional amount, are also listed.

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<sup>2</sup>Refer to the *ISDA Standard CDS Converter Specification* for details.

### 3.1 Standard Model Specifications

The ISDA Standard CDS Contract specifies the following:

**Trade Date** refers to the date of the trade.

**Maturity** : most of the standard contracts have a maturity of 5 years.

**Maturity Date** falls on one of the four dates (Mar/Jun/Sep/Dec 20th) in a year. One can add the maturity of the contract to the trade date and find the next available date among those four dates.

**Backstop Date** is the date from which protection is provided.

$$\text{Backstop Date} = T - 60 \text{ Calendar Days.}$$

**Notional Amount** is denoted in millions.

**Standard Coupon** is quoted either 100 bps or 500 bps per annum for CDS contracts in North America, and 25 bps, 100 bps, 500 bps or 1000 bps in Europe.

**Recovery Rate** is the estimated percentage of par value that bondholders will receive after a credit event. It is commonly reported in percentages. A CDS for investment grade bonds are assumed a 40% recovery rate when it is valued. The recovery rate is assumed to be 20% when valuing a subordinate level CDS. 25% is assumed for emerging markets' CDSs (both senior and subordinate).

**Par Spread** is the spread value which makes the present value of a CDS contract zero. It is quoted in basis points.

**Upfront Payment** is quoted in the currency amount. Since a standard contract is traded with fixed coupons, upfront payment is introduced to reconcile the difference in contract value due to the difference between the fixed coupon and the conventional par spread. The protection buyer pays the upfront payment if points upfront are positive, and the buyer is paid by the seller if the points are negative. There are two types of upfront, dirty and clean. Dirty upfront refers to the market value of a CDS contract, which is also called the **Cash Settlement Amount**. Clean upfront is dirty upfront less any accrued interest payment, and it is also called the **Principal**.

**Points Upfront** are quoted as a percentage of the notional amount. They represent the upfront payment excluding the accrual payment. High Yield (HY) CDS contracts are often quoted in points upfront.

### 3.2 Standard Model Pricing

The ISDA Standard Model allows market participants to convert between the par spread and the upfront payment, and compute the cash settlement amount for a standard contract. A few key assumptions and definitions used when valuing a Standard CDS contract are the following:<sup>3</sup>

**Trade Date (T)** means 11:59pm on the trade date.

**Days of Protection** is the difference in the number of days from Maturity Date to Trade Date.

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<sup>3</sup>Please refer to <http://bit.ly/1kg5qPw> for more information on the ISDA standard CDS model assumptions.

**Mark-to-market (MTM)** represents the contract value to the protection buyer. It is computed by discounting the expected protection leg and premium leg cashflows to T.

**Accrued Premium** is the premium that has accrued from accrual begin date to T where both dates are inclusive.

The ISDA also standardizes the interest rates used by the Standard Model in valuing a CDS contract. There are two types of rates used in valuing a USD denominated CDS contract - cash rates and swap rates. Cash rates are of maturity 1, 2, 3, 6 months, and 1 year. They are provided by the British Bankers' Association (BBA). Swap rates are of maturity 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 25, 30 years and are provided by ICAP. The Standard Model follows the conventions below for interpolation of the entire USD yield curve:<sup>4</sup>

- The day count convention (DCC) for money market instruments and the floating legs of swaps is **ACT/360**.
- DCC for the floating legs of swaps is **30/360**.
- Payment frequency for fixed legs of swaps is 6 months.
- Payment frequency for floating legs of swaps is 3 months.<sup>5</sup>
- A business day calendar of weekdays (Monday to Friday) is assumed. Saturdays and Sundays will be the only non-business days.
- If a date falls on a non-business day, the convention used for adjusting coupon payment dates is **M** (Modified Following).

One component essential to the MTM calculation of a CDS contract is the PV01. It is the present value of a stream of 1 basis point payments at each CDS coupon date. It is sometimes referred to as the **CDS duration** or **risky duration**.

Analytically, PV01 can be calculated by

$$PV01 = \sum_t Df(t_i)S(t_i)B(t_i),$$

where

- $i$  = coupon index,
- $t_i$  = coupon date,
- $Df(t_i)$  = discount factor until  $t_i$ ,
- $S(t_i)$  = survival probability until  $t_i$ ,
- $B(t_i)$  = day count fraction at  $t_i$ .

We can thus calculate the principal amount (clean upfront payment) paid from the protection buyer to the seller using the following formula:

$$\text{Principal Amount} = (\text{Par Spread} - \text{Coupon}) \times PV01.$$

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<sup>4</sup>See <http://bit.ly/1iuI8ZA> for details on the interest rate sources and calculation used by the Standard Model.

<sup>5</sup>See <http://www.fincad.com/derivatives-resources/wiki/swap-pricing.aspx> for details on floating and fixed legs calculation.

Using the concept of PV01, we show the calculation of the main risks (exposures) of a CDS position, **Spread DV01**. Spread DV01 reflects the risk duration of a CDS trade, also known as **Sprd DV01**, **Credit DV01**, **Spread Delta**, and just **DV01**. It measures the sensitivity of a CDS contract mark-to-market to a parallel shift in the term structure of the par spread. DV01 should always be positive for a protection buyer since the protection buyer is short credit and a rising spread is a sign of credit deterioration. Starting with PV01 and taking the derivative with respect to spread give us:

$$\begin{aligned} PV &= (S - C) * PV01 \\ DV01 &= \frac{\partial PV}{\partial S} \\ &= PV01 + (S - C) \frac{\partial PV01}{\partial S}, \end{aligned}$$

where  $S$  is the spread of the contract and  $C$  is the coupon.

Both DV01 and PV01 are measured in dollars and are equal if the spread equals the coupon.

Some other related risk measures of a CDS contract are as follows:

**IR DV01** is the change in value of the CDS contract for a 1 bp parallel increase in the interest rate curve. IR DV01 is, typically, a much smaller dollar value than Spread DV01 because moves in overall interest rates have a much smaller effect on CDS value than does a move in the CDS spread itself.

**Recovery Risk 01** is the dollar value change in market value if the recovery rate used in the CDS valuation were increased by 1%.

**Price** refers to the clean dollar price of the contract.

$$\begin{aligned} \text{Price} &= (1 - \text{Principal/Notional}) * 100 \\ &= 100 - \text{points}. \end{aligned}$$

For example, if a CDS is quoted as 3 points to buy protection, the price will be 97. The protection buyer still pays the 3% as an upfront fee. A CDS has a price greater than 100 if the points upfront are negative, that is, if the CDS buyer needs to receive money to get protection because he is promising to pay a coupon of, say, 100 even if the spread is 60. This is analogous to a bond investor paying more than the face value of a bond because current interest rates are lower than the coupon rate on the bond.

## 4 Using the CDS package

Currently, a portfolio manager can conduct CDS-related calculations by using the **CDSW Calculator** on a Bloomberg Terminal or the Markit CDS Calculator.<sup>6</sup> The **CDS** package provides tools for valuing a single-name CDS contract based on the Standard Model. The default setting allows a portfolio manager to value a USD-denominated CDS contract following the Standard Model. She can also specify her own set of parameters to customize the calculation. In this section, we will demonstrate the use of the **CDS** package with a series of examples.

The default settings of valuing a CDS contract in the **CDS** package follow the Standard North American Corporate CDS Contract specifications:<sup>7</sup>

<sup>6</sup>The Markit CDS Calculator is available at <http://www.markit.com/markit.jsp?jspage=pv.jsp>.

<sup>7</sup>See <http://www.cdsmodel.com/assets/cds-model/docs/Standard%20CDS%20Contract%20Specification.pdf> for details.

- Currency: USD.
- Trade Date (T): the current business day.
- CDS Date: Mar/Jun/Sep/Dec 20th of a year.
- Maturity: 5 years.
- Maturity Date (End Date): It falls on a CDS date without adjustment.
- Coupon Rate: 100 bps or 500 bps.
- Notional Amount (MM): 10MM.
- Recovery Rate (%): 40% for senior debts.
- Premium Leg:
  - Payment Frequency: quarterly
  - DCC: ACT/360
  - Pay Accrued On Default: It determines whether accrued interest is paid on a default. If a company defaults between payment dates, there is a certain amount of accrued payment that is owed to the protection seller. "True" means that this accrued will need to be paid by the protection buyer, "False" otherwise. The default is "True,"
  - Adjusted CDS Dates: "F". It means that it assumes the next available business day when a CDS date falls on a non-business day except the maturity date.
  - First Coupon Payment: It is the earliest Adjusted CDS Date after  $T + 1$ .
  - Accrual Begin Date (Start Date): It is the latest Adjusted CDS Date on or before  $T + 1$ .
  - Accrual Period: It is from previous accrual date (inclusive) to the next accrual date (exclusive), except for the last accrual period where the accrual end date (Maturity Date) is included.
- Protection Leg:
  - Protection Effective Date (Backdrop Date):  $T - 60$  calendar days for credit events.
  - Protection Maturity Date: Maturity Date.
  - Protection Payoff: Par minus Recovery.

For illustrative purposes, we call the function `CDS` to construct an object of class "CDS". Below we use the default settings as mentioned.

```
> library(CDS)
> cds1 <- CDS(entityName = "IBM",
+             RED = "49EB20",
+             TDate = "2014-04-15",
+             maturity = "5Y",
+             couponRate = 100,
+             parSpread = 50)
```

`entityName` indicates the name of the underlying entity which is the subject of the CDS contract. `RED` are a Markit product. It stands for Reference Entity Database. Each entity/seniority pair has a unique 6 digit RED code. Each deliverable bond has a 9 digit RED code, the first 6 digits of which match the 6 digit code of the associated entity/seniority. Each entity also has a “preferred reference obligation” that is the default reference obligation for CDS trades. A user can input either the six-digit RED code or the nine-digit RED pair code. `TDate` indicates the trade date of the CDS contract. `maturity` is the maturity of the CDS contract. `couponRate` is the fixed coupon of the contract. `parSpread`, `ptsUpfront` and `upfront` refer to the par spread (in bps), points upfront (in %), and upfront payment (in dollar amount) of a CDS contract, respectively. Any of the three arguments has to be specified in order to construct the “CDS” class object.

Here the user has entered the CDS contract which has IBM as the underlying entity with “49EB20” as the RED Code. She sets the spread at 50 bps and the coupon rate at 100 bps. However, the valuation of this CDS contract requires neither the entity name or the RED Code. She does not have to know the information to use the package.

Calling `summary` on the “CDS” class object `cds1` provides some of the essential information of the CDS contract (including trade date, maturity date, spread, and coupon rate as specified by the user) and some relevant calculations based on the input CDS contract.

```
> summary(cds1)
```

Contract Type:	SNAC	TDate:	2014-04-15
Entity Name:	IBM	RED:	49EB20
Currency:	USD	End Date:	2019-06-20
Spread:	50	Coupon Rate:	100
Upfront:	-256508.4	Spread DV01:	5084.23
IR DV01:	66.11	Rec Risk (1 pct):	89.99

In the `summary` output, `Upfront` shows the cash settlement amount (dirty upfront). It is the sum of the principal and the accrual. `Spread DV01`, `IR DV01`, and `Rec Risk (1 pct)` are the eponymous results mentioned in Section 3.2.

```
> cds1.CS10 <- CS10(cds1)
```

```
> cds1.CS10
```

```
[1] 25378.11
```

`CS10` is a method which calculates the change in value of the CDS contract when the spread of the contract increases by 10%. `CS10` takes in a CDS class object formed by calling the `CDS` function.

```
> cds2 <- update(cds1, spread = 55)
```

The `update` method updates a “CDS” class object with a new spread, points upfront or upfront by specifying the relevant input. `cds2` is a new “CDS” class object with a spread of 52 bps; all other specifications of the contract are the same as those of `cds1` since it is updated from `cds1`. One can also specify `upfront` (in dollar amount) or `ptsUpfront` (in bps) in the `update` method.

Besides calling the `summary` method, one can type in the name of the “CDS” class object in the current R Session and obtain a full description of the CDS contract

```
> cds2
```

# CDS Contract IBM

Contract Type:	SNAC	Currency:	USD
Entity Name:	IBM	RED:	49EB20
TDate:	2014-04-15	End Date:	2019-06-20
Start Date:	2014-03-20	Backstop Date:	2014-02-14
1st Coupon:	2014-06-20	Pen Coupon:	2019-03-20
Day Cnt:	ACT/360	Freq:	Q

## Calculation

Value Date:	2014-04-18	Price:	102.24
Spread:	55	Pts Upfront:	-0.0224
Principal:	-223630.29	Spread DV01:	5062.73
Accrual:	-7500	IR DV01:	59.33
Upfront:	-231130.29	Rec Risk (1 pct):	88.83
Default Prob:	0.047	Default Expo:	6223630.29

## Credit Curve

	Term Rate	Term Rate
1	1M 0.001514	7Y 0.022585
2	2M 0.001920	8Y 0.024505
3	3M 0.002264	9Y 0.026105
4	6M 0.003209	10Y 0.027445
5	1Y 0.005455	12Y 0.029545
6	2Y 0.005130	15Y 0.031575
7	3Y 0.009420	20Y 0.033330
8	4Y 0.013595	25Y 0.034120
9	5Y 0.017270	30Y 0.034480
10	6Y 0.020190	

There are three parts of the output. They are the basic contract information, the valuation of the contract, and the interest rates used in the calculation.

Calling the function `getRates` produces the rates used in building a curve for CDS valuation.

```
> cds1Rates <- getRates(date = "2014-01-15")
```

The output consists of two list objects. The first list contains rates of various maturities. They are directly obtained from the Markit website.

	expiry	matureDate	rate	type
1	1M	2014-02-20	0.001587	M
2	2M	2014-03-20	0.00203	M
3	3M	2014-04-21	0.002379	M
4	6M	2014-07-21	0.003356	M
5	1Y	2015-01-20	0.005716	M
6	2Y	2016-01-20	0.0052	S
7	3Y	2017-01-20	0.00907	S
8	4Y	2018-01-20	0.01353	S



9	5Y	2019-01-20	0.01761	S
10	6Y	2020-01-20	0.02114	S
11	7Y	2021-01-20	0.02401	S
12	8Y	2022-01-20	0.02638	S
13	9Y	2023-01-20	0.028315	S
14	10Y	2024-01-20	0.02982	S
15	12Y	2026-01-20	0.032345	S
16	15Y	2029-01-20	0.03476	S
17	20Y	2034-01-20	0.036705	S
18	25Y	2039-01-20	0.0376	S
19	30Y	2044-01-20	0.037965	S

The second list reports the specific day count conventions and payment frequencies regarding the interest rate curve used.

	text
badDayConvention	"M"
mmDCC	"ACT/360"
mmCalendars	"none"
fixedDCC	"30/360"
floatDCC	"ACT/360"
fixedFreq	"6M"
floatFreq	"3M"
swapCalendars	"none"

## 5 Conclusion

In this paper, we describe the basics of a CDS contract, the ISDA Standard Model, and its valuation. We also provide a simple collection of tools to implement the Standard Model in R with the CDS package. Moreover, the flexibility of R itself allows users to extend and modify these packages to suit their own needs and/or execute their preferred models for CDS contracts. Before reaching that level of complexity, however, CDS provides a good starting point for valuing CDS contracts adhering the Standard Model.

## References

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