A Guide to the CDS Package

Heidi Chen[*], David Kane[†], and Yang Lu[‡]

May 11, 2014

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.

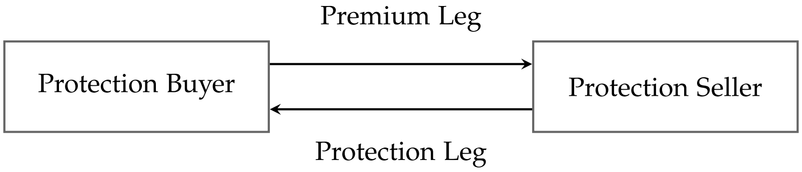
2 CDS Basics

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 (Kallianiotis, 2013). In the **CDS** package, we focus on calculations related to a single-name CDS contract.

A single-name CDS contract provides a transfer of credit risk between two parties. The buyer of a CDS contract, a.k.a. protection buyer, transfers the credit risk to the CDS seller (or called protection 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 Figure 1, the buyer pays a stream of coupon payments, called the premium leg, in order to receive a one-off, contingent payment (notional less recovery amount after a credit event), called the protection leg, in the case of a credit event.

[*]s.heidi.chen@gmail.com
[†]dave.kane@gmail.com
[‡]yang.lu2014@gmail.com

Figure 1: Mechanics of a CDS contract



In the **CDS** package, we call the function `CDS` to construct an object of a class `CDS`. Below we show an example of how to construct a CDS contract in the package.

```
> library(CDS)
> cds1 <- CDS(entityName = "IBM",
+             RED = "49EB20",
+             TDate = "2014-04-15",
+             maturity = "5Y",
+             notional = 1e7,
+             coupon = 100,
+             parSpread = 50)
```

As shown in the example, a CDS contract between two counterparties typically specifies the following key terms:[1]

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

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

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

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

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 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:

[1]Some of the definitions come from *Credit Derivatives Glossary* (Markit, 2009), *Standard Corporate CDS Handbook* (Leeming et al., 2010), *Credit Derivatives* (Green and Witschen, 2012), and *The Pricing and Risk Management of Credit Default Swaps, with a Focus on the ISDA Model* (White, 2013).

- Bankruptcy - It typically occurs when the reference entity has filed under a bankruptcy law (or an 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 rules on the first accrual dates, fixed coupon rates (100 bps or 500 bps), and the recovery rate (40 %).

The default calculations and parameters in the **CDS** package follow the Standard Model. The user can call `summary` on a `cds1` to view essential information on the contract as shown in Section 2. The summary output includes trade date, maturity date, spread, and coupon rate as specified by the user and relevant calculations based on the input CDS contract and the ISDA conventions.

```
> summary(cds1)

Contract Type:                      SNAC   TDate:                     2014-04-15
Entity Name:                         IBM   RED:                           49EB20
Currency:                            USD   End Date:                  2019-06-20
Spread:                               50   Coupon:                           100
Upfront:                        -256,577   Spread DV01:                    5,086
IR DV01:                           66.14   Rec Risk (1 pct):               90.03
```

In order to understand the summary output, we explain the specifications of the Standard Model and the pricing details based on the Model.

3.1 Standard Model Specifications

An ISDA standard CDS contract specifies the following:[2]

[2]Refer to the *ISDA Standard CDS Converter Specification* for details.

Trade Date refers to the date of the trade.

Maturity is the length of the contract. 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; the next available date among those four dates is the maturity date.

Backstop Date is the date from which protection is provided,

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

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 contract 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. There are two types of upfront, dirty and clean. Dirty upfront, a.k.a. **Cash Settlement Amount** refers to the market value of a CDS contract. Clean upfront is dirty upfront less any accrued interest payment, and is also called the **Principal**.

Points Upfront , or simply **points**, 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. 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.

3.2 Standard Model Pricing

The 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:[3]

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

[3]Please refer to `http://bit.ly/1kg5qPw` for more infrmation on the ISDA standard CDS model assumptions.

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

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, and 30 years, and are provided by ICAP (Markit, 2013). The Standard Model follows the conventions below for interpolation of the entire USD yield curve:

- The day count convention (DCC) for money market instruments and floating legs of the swaps is **ACT/360**.
- DCC for floating legs of the swaps is **30/360**.
- Payment frequency for fixed legs of the swaps is 6 months.
- Payment frequency for floating legs of the swaps is 3 months.[4]
- 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 mark-to-market calculation of a CDS contract is **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,
- $Df(f_i)$ = discount factor until t_i,
- $S(t_i)$ = survival probability until t_i,

[4]See `http://www.fincad.com/derivatives-resources/wiki/swap-pricing.aspx` for details on floating and fixed legs calculation.

- $B(t_i)$ = 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:

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

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 she is short credit and a rising spread is a sign of credit deterioration. Starting with PV01 and taking the derivative with respect to the 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 risk measures of a CDS contract are as follows:

IR DV01 is the change in value of a 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 the value of a CDS contract 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.

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

For example, if a CDS contract 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 will have a price greater than 100 if the points upfront are negative, that is, the CDS buyer needs to receive money to obtain protection because he promises 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 market participant can conduct CDS-related calculations by using the **CDSW Calculator** on a Bloomberg Terminal or the Markit CDS Calculator.[5] The **CDS** package provides tools for valuing a single-name CDS contract. The default setting allows a user to value a USD-denominated CDS contract following the Standard Model. She can also specify her own set of parameters to customize the calculation. We have illustrated the construction of a CDS contract using the **CDS** package in previous sections. In this section, we will demonstrate the use of the **CDS** package in more detail and provide a series of examples.

The default settings of valuing a CDS contract in the **CDS** package follow the Standard North American Corporate (SNAC) CDS Contract specifications.[6] Below we list the ISDA specifications implemented in the **CDS** package. Additional default settings in the package which are not specified by the Standard Model, such as the default notional amount, are also listed.

- 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.
- 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 defalt 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.

[5] The Markit CDS Calculator is available at `http://www.markit.com/markit.jsp?jsppage=pv.jsp`.

[6] See `http://www.cdsmodel.com/assets/cds-model/docs/Standard%20CDS%20Contract%20Specification.pdf` for details.

- 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 the example we have shown in the previous sections,

```
> cds1 <- CDS(entityName = "IBM",
+             RED = "49EB20",
+             TDate = "2014-04-15",
+             maturity = "5Y",
+             notional = 1e7,
+             parSpread = 50)
```

`entityName` indicates the name of the underlying entity which is the subject of the CDS contract. `RED` is 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 matches 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 contract. `coupon` 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. One 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 a CDS contract requires neither the entity name or the RED Code. She does not have to know the information to use the package. As shown below, insofar as she inputs the same `TDate`, `parSpread`, and `maturity` information, the valuation of the contract will be the same.

```
> cds2 <- CDS(TDate = "2014-04-15",
+             maturity = "5Y",
+             coupon = 100,
+             parSpread = 50)
```

Calling `summary` on the two CDS contracts provides the same information.

```
> summary(cds1)
```

```
Contract Type:                 SNAC   TDate:                 2014-04-15
Entity Name:                    IBM   RED:                       49EB20
Currency:                       USD   End Date:              2019-06-20
Spread:                          50   Coupon:                       100
Upfront:                   -256,577   Spread DV01:                5,086
IR DV01:                      66.14   Rec Risk (1 pct):           90.03
```

```
> summary(cds2)
```

```
Contract Type:                 SNAC   TDate:                 2014-04-15
Entity Name:                     NA   RED:                           NA
Currency:                       USD   End Date:              2019-06-20
Spread:                          50   Coupon:                       100
Upfront:                   -256,577   Spread DV01:                5,086
IR DV01:                      66.14   Rec Risk (1 pct):           90.03
```

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. Moreover, `summary(cds1)` and `summary(cds2)` give the same output besides `entityName` and `RED`.

```
> cds2.CS10 <- CS10(cds2)
> cds2.CS10
```

```
[1] 25385.2
```

`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.

```
> cds3 <- update(cds1, spread = 55)
```

The `update` method updates a "CDS" class object with a new spread, points upfront or upfront by specifiying the relevant input. `cds3` is a new "CDS" class object with a spread of 52 bps; all other specifications of the contract are the same as those in `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.

```
> cds3
```

```
CDS Contract
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:                  -223,692  Spread DV01:                5,064
Accrual:                      -7,500  IR DV01:                    59.35
Upfront:                    -231,192  Rec Risk (1 pct):           88.87
Default Prob:                  0.047  Default Expo:           6,223,692

Credit curve effective of2014-04-15
 Term     Rate Term     Rate
   1M 0.001517   7Y 0.022630
   2M 0.001923   8Y 0.024580
   3M 0.002287   9Y 0.026265
   6M 0.003227  10Y 0.027590
   1Y 0.005465  12Y 0.029715
   2Y 0.005105  15Y 0.031820
   3Y 0.009265  20Y 0.033635
   4Y 0.013470  25Y 0.034420
   5Y 0.017150  30Y 0.034780
   6Y 0.020160
```

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 based on the specifications (Markit, 2013).

```
   expiry matureDate     rate type
1      1M 2014-02-17  0.00159    M
2      2M 2014-03-17 0.002055    M
3      3M 2014-04-17 0.002368    M
4      6M 2014-07-17 0.003355    M
5      1Y 2015-01-19 0.005681    M
6      2Y 2016-01-17  0.00496    S
```

```
7      3Y 2017-01-17  0.00881    S
8      4Y 2018-01-17  0.01322    S
9      5Y 2019-01-17 0.017375    S
10     6Y 2020-01-17 0.020875    S
11     7Y 2021-01-17  0.02384    S
12     8Y 2022-01-17 0.026155    S
13     9Y 2023-01-17 0.028045    S
14    10Y 2024-01-17 0.029695    S
15    12Y 2026-01-17 0.032195    S
16    15Y 2029-01-17 0.034545    S
17    20Y 2034-01-17  0.03655    S
18    25Y 2039-01-17  0.03742    S
19    30Y 2044-01-17  0.03788    S
```

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

```
                 text
effectiveDate    "2014-01-15"
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. An **R** package, `backtest` Campbell et al. (2007), provides facilities to explore portfolio-based conjectures about credit swaps. It is possible to use the `backtest` package based on the output from the `CDS` package. Before reaching that level of complexity, however, `CDS` provides a good starting point for valuing CDS contracts following either the Standard Model or user specifications.

References

K. Campbell, J. Enos, D. Gerlanc, and D. Kane. Backtests. *R News*, 7(1):36–41, April 2007. URL `http://cran.r-project.org/doc/Rnews/Rnews_2007-1.pdf`.

S. Green and E. Witschen. Credit Derivatives. *Bloomberg*, January 2012.

J. Kallianiotis. *Exchange Rates and International Financial Economics: History, Theories, and Practices*. Palgrave Macmillan, Oct. 2013.

J. Lanchester. Outsmarted. *The New Yorker*, June 2009.

M. Leeming, S. Willemann, A. Ghosh, and R. Hagemans. Standard Corporate CDS Handbook, Ongoing Evolution of the CDS Market. *Barclays Capital*, February 2010.

R. Lenzner. Who's Afraid Of Credit Default Swaps? *Forbes*, March 2009.

Markit. Credit Derivatives Glossary. *Markit*, March 2009.

Markit. Markit Interest Rate Curve XML Specifications Version 1.15. *Markit*, May 2013.

R. White. The Pricing and Risk Management of Credit Default Swaps, with a Focus on the ISDA Model. *OpenGamma*, October 2013.