A Guide to the CDS Package

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May 13, 2014

1 Introduction

A Credit Default Swap (CDS) is an 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 spread 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.(Lenzner, 2009; Lanchester, 2009) The CDS market started to develop soon afterwards as banks used CDS contracts to hedge the credit exposures on their 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, or corporate, credit default swaps.

A single-name CDS contract provides a transfer of credit risk between two parties. The buyer of a CDS contract (protection buyer) transfers the credit risk to the CDS seller (protection seller) by paying a series of coupons until the contract terminates. In other words, the protection buyer is short credit by selling the credit risk of an underlying bond 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-time, contingent payment, called the protection leg, in the case of a credit event. A credit event triggers the settlement under a CDS contract. Possible credit events include banruptcy and debt restructing. The exact definition varies among CDS contracts.

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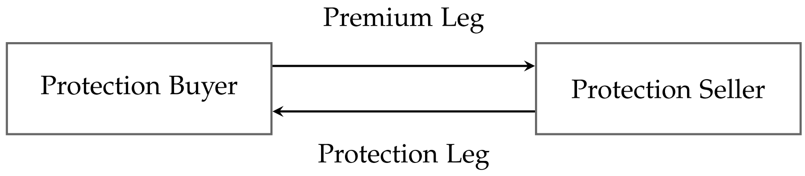
Figure 1: Mechanics of a CDS contract



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. `entityName` in the `CDS` function takes the name of the legal entity and is "IBM" in `cds1`.

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. The input "49EB20" is the six-digit RED code for "IBM".

Trade Date or **TDate** as shown in the argument of the `CDS` function indicates the trade date of the CDS contract and is April 15, 2014 in `cds1`.

Maturity refers to the fixed date on which a CDS contract terminates. However, speaking colloquially, it can also be the length of time remaining until that date. This length is also called the **tenor** of a CDS contract. The most commonly traded CDS are the 5 years. The protection buyer continues to make payments to the protection seller till maturity of the contract or the occurrence of a credit event. The maturity is 5 years in `cds1`.

[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).

Notional is the amount of the underlying asset on which the payments are based. It is $10 million in cds1.

Coupon is quoted in basis points. It specifies the payment amount from the protection buyer to the seller on an annual basis. Coupons are paid quarterly. This contract has a coupon of 100 bps.

Spread is quoted in basis points per year. If, instead of using a fixed coupon and exchanging upfront fees, the buyer and seller of protection were to agree on a variable coupon, then the spread is the coupon size that they would agree on. It is quoted as 50 bps in cds1.

Here the user enters the CDS contract with "IBM" as the underlying entity and sets the spread at 50 bps and the coupon 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)
```

Besides parSpread, a market paricipant can choose to specify either ptsUpfront or upfront to construct a CDS class object.[2] ptsUpfront or upfront refer to 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.

3 The ISDA Standard Model

In April 2009 in North America, 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%).

An ISDA standard CDS contract specifies the following:[3]

Trade Date refers to the date of the trade.

Maturity is the length of the contract. The most commonly traded 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,

[2] See Section 3 for definitions on both terms.

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

Backstop Date = T - 60 Calender Days.

Notional Amount is in millions.

Standard Coupon is either 100 or 500 bps per year for CDS contracts in North America.

Recovery Rate is the estimated percentage of par value that bondholders will receive after a credit event. It is commonly reported in percentage of notional value. CDS contracts for corporate bonds assume a 40% recovery rate for valuation purposes.

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 par spread. There are two types of upfront, dirty and clean. Dirty upfront (**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 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.

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:[4]

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

Days of Protection is 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:

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

- 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.[5]
- 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).

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.[6] 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 as mentioned in Section 3. 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.

Recall that in Section 2, a `CDS` class object called `cds1` has been constructed. Its maturity is 5 years. Its spread is set at 50 bps and the coupon, 100 bps. The notional amount is $10 million. A user can call `summary` on a `cds1` to view essential information on the 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:                     100
Upfront:                   -256,577   Spread DV01:              5,086
IR DV01:                      66.14   Rec Risk (1 pct):         90.03
```

In the summary output, it shows that the type of the CDS contract is "SNAC". `TDate` refers to the trade date and is April 15, 2014. `entityName` refers to the entity name of the CDS contract and is "IBM". The `RED` code is "48EB20" as specified by the user. `spread` shows that the quoted spread for the contract is 50 bps and the coupon is 100 bps as shown in the `coupon` field. `upfront` indicates the

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

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

dirty upfront payment in dollars or the cash settlement amount. It is -256,577 dollars, which means that from a buyer's perspective, the net present value of the remaining expected cashflows is -$256,577.

To understand the remaining three items from the `summary` output (`Spread DV01`, `IR DV01`, and `Rec Risk (1 pct)`), one needs to understand **PV01**, an essential component to the mark-to-market calculation of a CDS contract. PV01 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,
- $B(t_i)$ = 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. The Spread DV01 of `cds1` is $5,086.

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. In `cds1`, the IR DV01 is $66.14. **Recovery Risk 01** or `Rec Risk (1 pct)` as shown in the `summary` output, is the dollar value change in market value if the recovery rate used in the CDS valuation were increased by 1%. It is $90.03 in `cds1`.

The default settings of valuing a CDS contract in the **CDS** package follow the Standard North American Corporate (SNAC) CDS Contract specifications.[7] 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.
  - 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.

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

4.1 More on CDS pricing

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. The CS10 of cds1 is $25385.2.

```
> cds1.CS10 <- CS10(cds1)
> cds1.CS10
[1] 25385.2
```

A market participant can also update the CDS class objects she has constructed by calling the update method. It updates a CDS class object with a new spread, points upfront or upfront by specifiying the relevant input.

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

cds3 is a new CDS class object with a spread of 55 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 of 2014-04-15
 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. The first part "CDS Contract" provides basic information on the contract including "Contract Type", "Currency", "Entity Name", "RED", "TDate", various dates related to the contract, and the day count conventions for `cds3`.

The second part of the output contains relevant risks measures of `cds3`. `Price` refers to the clean dollar price of the contract and is calculated by

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

The price of `cds3` is 102.24, greater than 100. 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.

"Default Prob" refers to the default probability which is the estimated probability of default for each maturity by a given time. It can be approximated by

$$\text{Default Prob} \approx \left[1 - exp\left(\frac{rt}{1-R}\right)\right],$$

where r is the spread, t is the time to maturity, and R is the recovery rate. The default probability for `cds3` is 4.7%.

"Default Expo" refers to the expoure to the default of a CDS contract based on the formula below.

$$\text{Default Exposure} = (1 - \text{Recovery Rate}) * \text{Notional} - \text{Principal}.$$

The last part of the output reports the interest rates used in the calculation.

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

```
> cds3Rates <- getRates(date = "2014-04-15")
```

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 2014-05-19 0.001517    M
2      2M 2014-06-17 0.001923    M
3      3M 2014-07-17 0.002287    M
```

```
4       6M 2014-10-17 0.003227    M
5       1Y 2015-04-17 0.005465    M
6       2Y 2016-04-17 0.005105    S
7       3Y 2017-04-17 0.009265    S
8       4Y 2018-04-17  0.01347    S
9       5Y 2019-04-17  0.01715    S
10      6Y 2020-04-17  0.02016    S
11      7Y 2021-04-17  0.02263    S
12      8Y 2022-04-17  0.02458    S
13      9Y 2023-04-17 0.026265    S
14     10Y 2024-04-17  0.02759    S
15     12Y 2026-04-17 0.029715    S
16     15Y 2029-04-17  0.03182    S
17     20Y 2034-04-17 0.033635    S
18     25Y 2039-04-17  0.03442    S
19     30Y 2044-04-17  0.03478    S
```

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

```
                 text
effectiveDate    "2014-04-15"
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 and the ISDA Standard Model. 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 this package to suit their own needs and/or create their preferred models for valuing CDS contracts. An **R** package, `backtest` Campbell et al. (2007), provides facilities to explore portfolio-based conjectures about credit default 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 credit default swaps.

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