A Guide to the CDS Package

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1 Introduction

Over the past three decades, **credit derivatives** have become increasingly common tools for finanical institutions that wish to pass on **credit risk** to investors who accept that risk for a premium, or fee. To put it simply, credit risk is the possibility that a borrower will default on his or her loan. In the modern financial world, there are many types of credit derivatives, including collaterized debt obligations (CDOs) and collaterized loan obligations (CLOs). In this vignette, we will focus on **credit default swaps** (CDSs), a type of credit derivative that has become quite popular among pensions funds, hedge funds, and investment banks, among other financial institutions (see Figure 1). We will explain the mechanics of this financial product and show how our **CDS** package can be used to manipulate and calcuate relevant information associated with CDSs.

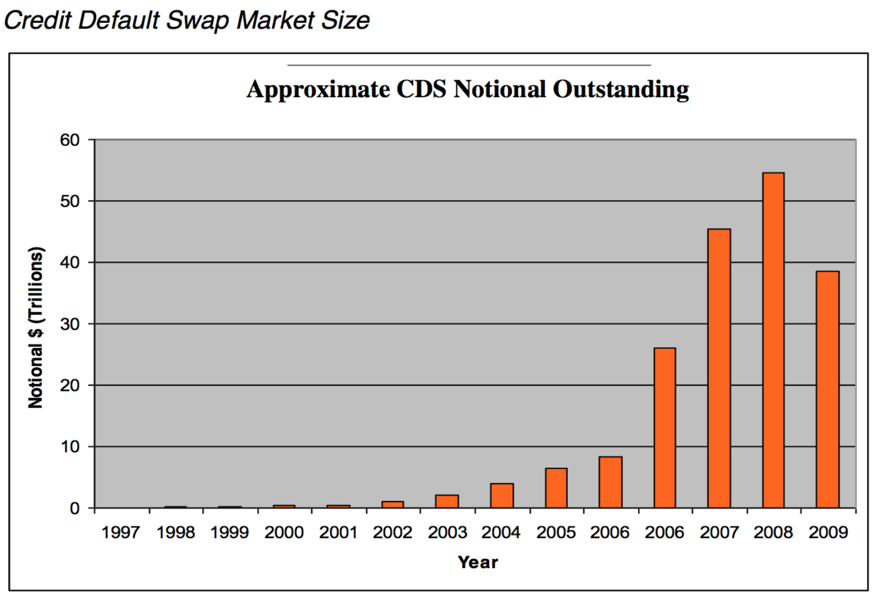

Figure 1: CDS notional outstanding from 1997-2009.

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CDSs originated in the late 1980s and were popularized by a team at J.P. Morgan that included Blythe Masters (Lenzner, 2009; Lanchester, 2009). The CDS market started to develop soon afterwards as banks used CDS contracts to hedge their credit exposures on balance sheets. Many different types of CDSs 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 single-name, or corporate, credit default swaps.

2 Credit Risk associated with Fixed Income

CDSs are used in order to hedge against the **credit risk** associated with **bonds or fixed income**. Before we understand how CDSs work, we must understand the mechanics of a standard coupon bond, and the risk associated with them.

2.1 Bond Mechanics

Let's say that there is a manager of a pension fund who has to allocate her clients' money (a total sum of $100 million). Pension funds are, for the most part, risk averse investors who want to minimize the possibility of making a loss, even if that results in a lower return on their investment. Pension funds also have to constantly return money to their clients so they want to purchase assets that pay a regular interest to the owner. They also want to invest in assets that are **liquid** i.e. whose sale does not affect their price. In such a scenario, coupon bonds seem like an attractive investment.

A **coupon bond** is an agreement in which one party lends money to another party in exchange for that same sum of money, plus interest, at a future date. Since the bonds pays a regular interest to the bondholder, it is also termed as **fixed income**. A major advantage of holding bonds over shares (equity) is that in the case of a liquidiation, a company's bondholders are compensated before the shareholders. Furthermore, bonds can be categorized as "senior" or "junior" (there exist many other classifications, but we'll stick to these two for now). As the terms suggest, senior bonds usually have the greatest seniority in the issuer's capital structure and in the case of default, are repaid before junior bonds.

2.2 Bond Pricing

To understand the different variables used in determining the cash flows and pricing of a bond, let's take data of an actual bond maturing five years from now, of a company called Alcoa Inc. This data is from a source called Bloomberg, one of the most widely used sources of financial data

Figure 2: Bloomberg Senior Bonds for Alcoa Inc., maturing on February 23, 2019

If we look at the top of Figure 2.2, we can see that these bonds have a **Coupon** of 5.72% and a **price** of $112.063. The third number is the **spread**. When a company first issues bonds,

The key variables to note in order to understand the pricing of a bond are:

Principal: is the sum that will be returned to the investor when the bond reaches its maturity date. So if we own a bond of Alcoa Inc. for $100 on the day it was issued, we will be paid a balloon payment of $100 when it matures. This is, of course, in addition to the interest payments.

Coupon: payments made by the company to the bondholder. This is a fixed amount and is usually paid semi-annually.

Spread: the fair interest payment for owning the bond. Although the coupon is a fixed variable, this could vary based on different factors.

Maturity: length of the bond's life. This will tell us how many coupon payments must be made until the bonds maturity.

2.3 Credit Risk Associated with Bonds

When a company like Alcoa Inc. issues bonds, there is always the possibility that it may not be able to meet its debt obligations. The risk that a company will be unable to meet its debt obligations is known as **credit risk**. The creditworthiness of a company is often represented by the **credit rating**—a score determined by rating agencies such as Standard & Poor's (S&P), Moody's or Fitch. We will not go into the details of how these ratings are determined; we only note that an Investment Grade bond has a rating of BBB- or higher from S&P or Baa3 or higher from Moody's.

A risk-averse investor, like our portfolio manager, would naturally want to purchase senior bonds from a company that has a low credit risk, like Alcoa Inc., which has a rating of BBB- from S&P and Ba1 from Moody's. A company with a low credit risk, such as Alcoa Inc., is considered to be **credit worthy** and its bonds are classified as **Investment Grade** (IG). Another important term assoi A credit event can signify the risk of a company's bankruptcy and resulting default, but the term can also expand to include failure to pay out debt within a certain amount of time, a credit downgrade or the confiscation of assets, among other events

3 CDS Basics

3.1 Why CDSs?

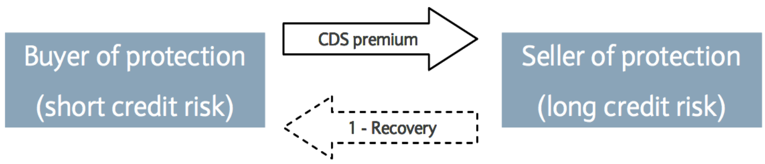
Let's assume that our portfolio manager buys $10 millions dollars of senior Alcoa Inc. bonds maturing 5 years from now. Six months after the she makes this trade, her confidence in the creditworthiness of Alcoa Inc. begins to waiver. The manager may be worried about some credit event related to the company.. Of course, she could simply sell the bonds; however, that may be premature or even unprofitable. Instead, she could textbfhedge her position by purchasing a financial product whose value rises with a drop in the bonds' value. In other words, she could take a position that allows her to *profit* from increased credit risk.

One convenitional technique of doing this is shorting bonds. Shorting is the process of borrowing and selling a security with the obligation to repurchase it in the future and return it to the lender. Clearly, this is profitable if the value of the security drops by the time it is repurchased in the future. However, there are several issues associated with this method. It is difficult to short bonds that are not **liquid**. The portfolio manager may not be able to find enough bonds that will mature at the same time. Moreover, she would have to spend $100 million to hedge her entire portfolio of $100 million, which is a substantial opportunity cost.

3.2 CDS Mechanics

CDSs were invented in order to resolve these issues associated with hedging against risk (as described in Section 3.1).

As shown in Figure 3.2, a CDS is an agreement between two **counterparties**, or opposing groups, in which the buyer (in this case, the portfolio manager) pays a **fixed periodic coupon** to the seller in exchange for protection against a credit event associated with the buyer's bond.



Source: Barclays Capital

Figure 3: Cash flows in a single name CDS contract.

In our example, the portfolio manager is the **protection buyer**. Let's say that the **protection seller** is a hedge fund. The hedge fund sells protection to the portfolio manager for $10 million of senior debt. This amount known as the **notional amount**. In return, she has to pay the hedge fund an annual coupon rate of over 1%, or 100 basis points, for a period of five years. These $100,000 payments are made quarterly, so she would have to pay 0.25% every quarter until the maturity date.

In the case of default, the hedge fund would have to pay a compensation equal to the notional amount minus the company's **recovery rate**. The recovery rate is defined as the amount that the company is able to give back to its debt holders after default. When a company goes into bankruptcy and is forced to default on its debt, whatever remains in the company's assets is paid out according to the firm's capital structure. This transaction protects the portfolio from the bonds' associated credit risk without having to sell them. The hedge fund, on the other hand, receives a fee and walks away without any losses if there is no credit event.

Our example above can be described as a single-name CDS contract, in which the transfer of credit risk takes place between two parties. The protection buyer of a CDS contract transfers the credit risk to the CDS 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. Note that there is no involvement of the Alcoa Inc. in the transaction; this exchange only takes place between the two counterparties.

4 CDS Terminology and Cash Flows

Although the cash flows involved in a CDS seem pretty simple in figure 3.2, the underlying mechanics of a CDS are a bit more complex. To understand this, let's look at actual CDS data for Alcoa Inc., from Bloomberg. Bloomberg and Markit are the two most commonly used sources for CDS related data; we will discuss these extensively in a later section. Figure 4 below displays many different variables such as RED Pair Code, REF Entity, Trade Date, Debt Type etc. for the CDS of Alcoa Inc. for June 02, 2014. These are standard terms of CDS contracts that were set by the **International Swaps and Derivatives Association (ISDA)**, the organization that regulates over-the-counter derivatives such as CDSs. Let us understand what these variables are and how they are important for understanding the cash flow[1].

[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).

Figure 4: CDS figures from Bloomberg for Alcoa Inc. Note that this **REF Obligation** (Reference Obligation) matches the ISIN in Figure 2.2

4.1 Entity-Specific Variables

Some of these variables seem self-explanatory. **REF Entity** (Reference Entity) refers to the name of the company (Alcoa Inc., in this case) that the buyer wants protection against. The **ticker** is an abbreviated reference symbol for the reference entity, which is 'AA' for Alcoa Inc. Moreover, the **Trade Date** is the date on which we are making the trade – June 02, 2014.

The **RED Pair Code** is a Markit product that stands for Reference Entity Database. Each entity/seniority pair has a unique six-digit RED code that matches the first six digits of the nine-digit RED pair code. Each entity also has a "preferred reference obligation," which 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 "014B98" is the six-digit RED code for "Alcoa Inc.".

We can also note the label **Debt type**, marked as 'Senior'. Clearly, this refers to the seniority of the debt. The **notional amount** is printed as '10' or $10 million USD (US Dollars). The 'MM' between the amount and the currency refers to the type of restructuring of the contract—in this case, 'Modified Modified' Restructuring (explained further in Section 4.3). The **REF Obligation** (Reference Obligation) is the reference for the bond to which this CDS is tied. Since our portfolio manager is purchasing protection on the same bonds she purchased before, this **REF Obligation** (Reference Obligation) matches the ISIN in Figure 2.2.

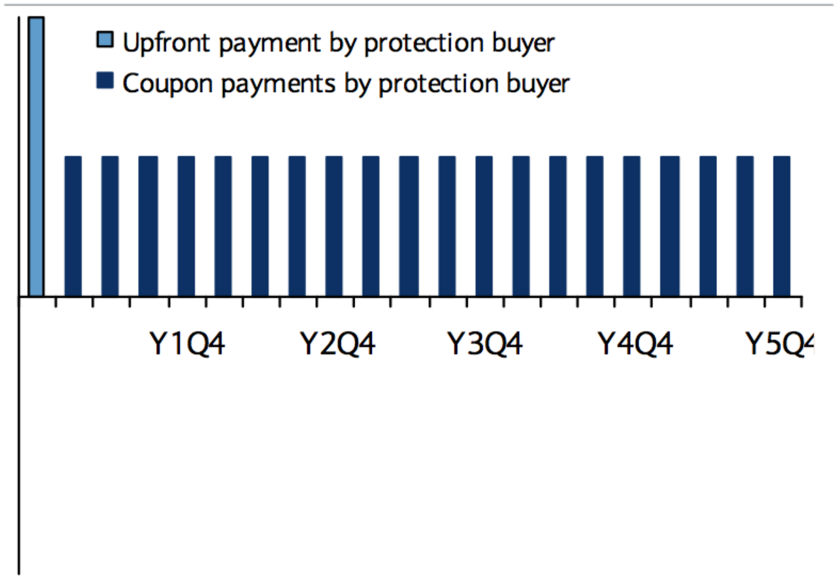
Maturity refers to the **tenor**, or length, of the contract. The most commonly traded contracts have a maturity of five years. The Bloomberg screenshot displays the length of the contract, as well as the implied maturity date. Interestingly, the maturity date for the CDS of Alcoa on June 02, 2014 is June 20, 2019. This seems odd since we would expect it to be on June 02, 2019, exactly five years from the Trade Date. However, the maturity date always falls on one of the four **roll dates**: March 20, June 20, September 20 and December 20. Therefore, the maturity date for this contract will be on the roll date after June 02, 2019, which is – June 20, 2019. Also note that this contract is of the type **SNAC** or Standard North American Contract, which is a convention that specifies how North American single-name CDSs are supposed to trade.

4.2 Cash flows in the Absence of a Credit Event

The two terms in Figure 4 that are essential for understanding the cash flow are **Trd Sprd** (Trade Spread) and **Coupon**, both given in basis points (bps). In section 3.2, we stated that the protection buyer pays the protection seller a fixed coupon for purchasing protection. Until 2009, the two counterparties in a CDS contract would agree on the coupon level before the trade. Then, as the market moved, this tradable coupon would vary. In this type of contract, the present value of the contract (the current worth of a future sum of money) would be zero. So if our portfolio manager was purchasing a CDS before 2009, she would have had to negotiate a fixed coupon with the hedge fund, which would then vary as the company's credit risk varied.

In April 2009 in North America, the ISDA introduced a series of mandatory modifications to the CDS contract known as the "Big Bang Protocol." Under the new rules, coupon rates were standardized in North America, and even in Europe from June 2009. Dealers would now have to quote **standard coupons** of 100bps or 500bps in North America, or 25bps, 100bps, 500bps or 1000bps in Europe. The coupon is also paid quarterly on one of the four roll dates. The **Coupon** printed in the figure above is the fixed coupon for Alcoa Inc., which is 100bp or 1% of the notional amount. However, the dealers may not feel that this is the fair premium for protection. For instance, the hedge fund selling protection to the portfolio manager may feel that the fair premium should be 160bps, and not 100bps. This fair premium rate is known as **Trade Spread** (or **Par Spread**, or just **Spread**), labeled as 160 in the figure above.

Naturally, if the hedge fund believes that the fair premium should be 160bps, it would like to be compensated for receiving just 100bps. As a result, the portfolio manager would have to make what is known as an **Upfront Payment** at the trade inception. Therefore, in the absence of a credit event, the cash flow between the two parties, over the life of the contract, would look like Figure 4.2.



Source: Barclays Capital

Figure 5: CDS cash flows when there is no credit event.

The ISDA protocol, since April 2009, specifies that all premium payments, by default, start on the roll date before the Trade Date. So if the Trade Date is June 02, 2014, the **Accrual Begin Date** is, by default, March 20, 2014. Now if the Accrual Begin Date is 75 days before the Trade Date, the portfolio manager would not want to pay interest for the 75 days she has not received protection for.

We must note that we are dividing 75 by 360 instead of 365 in the above calculation. This is to do with the **Day Count Convention** (**Day Cnt** in Figure 4) of the contract, which specifies that the accrual factor between two dates is ACT/360 or Actual/360.

If we subtract the **Accrued Interest** over the past 75 days from the upfront payment, we get the **Dirty Upfront** or **Cash Settlement Amount**. With the information for Alcoa given in the Figure 4, the dirty upfront value for this contract is $258478. **Clean Upfront**, on the other hand, is the dirty upfront less any accrued interest payment, and is also called the **Principal**. In this case, it is $279311. Moreover, we can also note a variable called **Pts Upf** in Figure 4. This is the **Points Upfront**, or simply **points**, which is the Clean Upfront experessed as a percentage of the notional amount.

As we can see, the Upfront and Points Upfront values are positive, since the spread of the CDS is higher than the fixed Coupon rate. If instead, the portfolio manager and hedge fund agree that the fair premium should be 60 points, the Upfront value would be negative i.e. the hedge fund would pay the portfolio manager a compensation for receiving a Coupon higher than the fair premium or spread. The cash flows would then look like the values in Figure 4.2. The clean and dirty value are now both negative.

Calculation Results

Market Value	-117,057
Cash Settlement	-117,061
Accrued Days	75
Accrued Amt	20,833.33
Currency	USD

Details — Show Cash Flows

	Transformed	User
Market Value	-117,057	-117,059
Clean Price	100.96 %	100.96 %
Cash Settlement	-117,058	-117,061
Accrued Days	75	75
Accrued Amt	20,833.33	20,833.33
Credit DV01	4,849	4,849
IR DV01	25	25

Figure 6: CDS cash flows for Alcoa Inc. when Spread is 60bp and and Coupon is 100bp. These have been calculated using the calculator provided by Markit

4.3 Protection Leg

So far we have only discussed the stream of payments for a contract in which a credit event does not occur **Protection leg** refers to the If, however, there is a credit event, the cash flow would look like Figure 4.3.

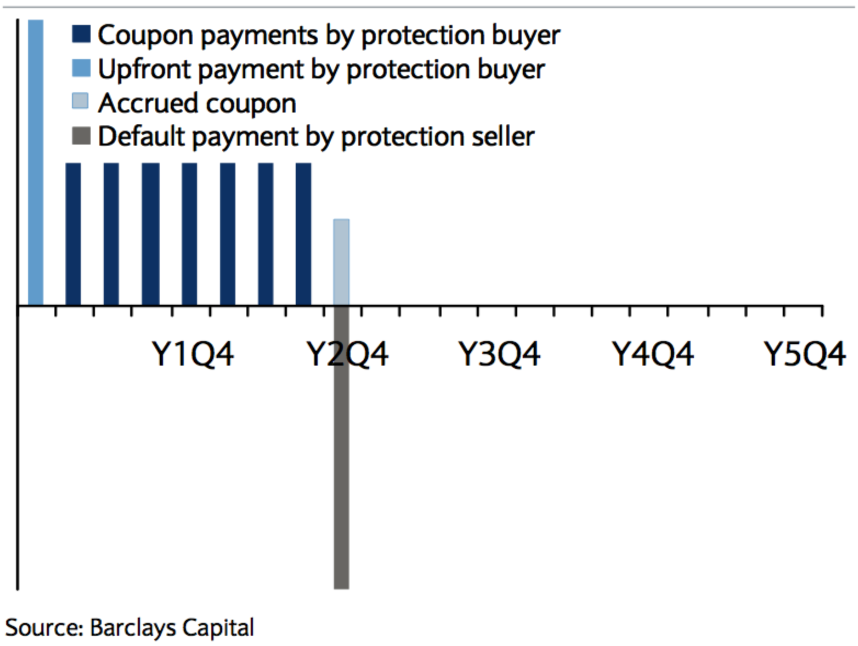


Figure 7: CDS cash flows when there is a credit event.

5 CDS Pricing

In this section we will discuss the methods and formulas used for calculating certain information related to CDSs, and the assumptions involved in doing so.

In section 2.2, we discuss the present value of a bond.

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 the following maturities: one, two, three, and six month(s), and one 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.[2]
- 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).

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.

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.

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.

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

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

An ISDA standard CDS contract specifies the following:[4]

Backstop Date is the date from which protection is provided,

Backstop Date = T - 60 Calender Days.

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

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:

Principal Amount = (Par Spread - Coupon) $\times$ 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 he or 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 gives us:

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

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

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

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.

`Price` refers to the clean dollar price of the contract and is calculated by

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

"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.

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

6 CDS Indices

Holding a portfolio of a disproportionate number of Alcoa Inc. bonds is naturally a risky idea. It is akin to putting all your eggs in one basket, as the saying goes. In the real world, most successful portfolio managers prefer to distribute their risk by holding a portfolio with hundreds, if not thousands, of different positions. Instead of holding a 100 million USD of Alcoa Inc. bonds, let's say our portfolio manager decides to take less risk by holding bonds of 100 different Investment Grade companies. This is known as **diversification**. Although this strategy reduces her exposure to the credit risk of any particular company, she hasn't reduced her exposure to factors that might affect a wide variety of assets simulatenously, such as interest rate risk or political risk. Fortunately, in the modern financial world, she has the option of purchasing multi-name CDSs, or CDS indices, which contain a basket of CDSs.

Moreover, if our portfolio manager has a high-risk appetite and wants to earn a higher return for her investors, she may invest a portion of her portfolio in bonds that have a lower credit rating but provide a higher yield. She may consider investing in a tranche of CDS indices known as CDX.NA.HY.

7 Pricing Sources

Bloomberg and Markit are the most widely used sources for data related to pricing of CDSs. We compared the results from our package with results from Bloomberg and Markit. Interestingly, the results from Markit and Bloomberg were not always identical.

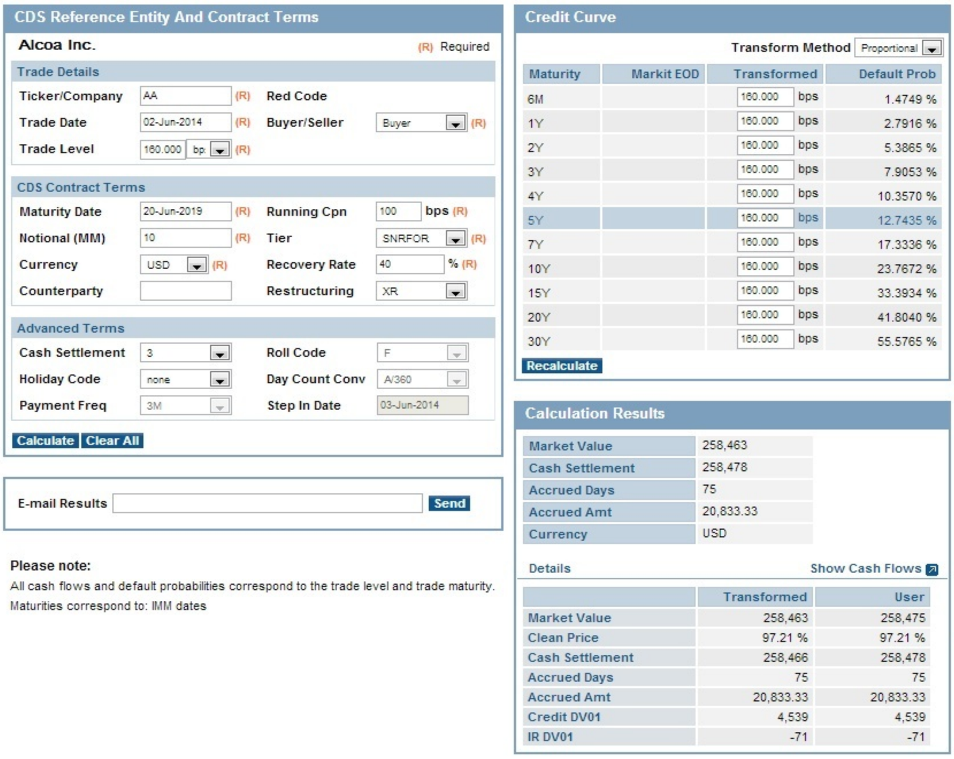


Figure 8: CDS figures from Markit.com

Figure 9: CDS figures from Bloomberg

The interest rate results were identical, at least until the fourth decimal place.

Yield Curve

Date 01-Jun-2014

Snap 1600 TimeZone: New York

Recalculate

Period	Type	Rate
1M	Deposit	0.1510 %
2M	Deposit	0.1908 %
3M	Deposit	0.2274 %
6M	Deposit	0.3219 %
1Y	Deposit	0.5344 %
2Y	Swap	0.5105 %
3Y	Swap	0.9095 %
4Y	Swap	1.2895 %
5Y	Swap	1.6175 %
6Y	Swap	1.8915 %
7Y	Swap	2.1165 %
8Y	Swap	2.2995 %
9Y	Swap	2.4525 %
10Y	Swap	2.5810 %
12Y	Swap	2.7885 %
15Y	Swap	2.9970 %
20Y	Swap	3.1825 %
25Y	Swap	3.2670 %
30Y	Swap	3.3055 %

Interest Rate Conventions

Spot Date: 04-Jun-2014	Swap DCC: 30/360
MM DCC: A/360	Swap Interval: 6M
Floating DCC: A/360	Holidays: none
Floating Interval: 3M	Bad Day Conv: MF

Figure 10: Interest Rate figures from Markit.com

Benchmark S260 (USD ISDA Standard Curve - Mid)
Date 06/02/2014

Term	Rate	Term	Rate
1 Month	0.1510	12 Year	2.7885
2 Month	0.1908	15 Year	2.9970
3 Month	0.2274	20 Year	3.1825
6 Month	0.3219	25 Year	3.2670
12 Month	0.5344	30 Year	3.3055
2 Year	0.5105		
3 Year	0.9095		
4 Year	1.2895		
5 Year	1.6175		
6 Year	1.8915		
7 Year	2.1165		
8 Year	2.2995		
9 Year	2.4525		
10 Year	2.5810		

Figure 11: Interest Rate figures from Bloomberg

8 Using the CDS package

The International Swaps and Derivatives Association (ISDA) has created the "Standard Model", which 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.

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 = "Alcoa Inc.",
+             RED = "49EB20",
+             TDate = "2014-04-15",
+             tenor = "5Y",
+             notional = 1e7,
+             coupon = 100,
+             parSpread = 50)
```

Here the user enters the CDS contract with "Alcoa Inc." 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 Reference Entity or the RED Code. She does not have to know that information to use the **CDS** package. As shown below, as long as she inputs the same `Trade Date`, `parSpread`, and `maturity` information, the valuation of the contract will be the same.

Besides `parSpread`, a market paricipant can choose to specify either `ptsUpfront` or `upfront` to construct a `CDS` class object.[5] `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.

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 before. 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 'Using the CDS package', a `CDS` class object called `cds1` has been constructed. Its maturity is five years. Its spread is set at 50 bps and its coupon at 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:             Alcoa Inc.   RED:                       49EB20
Currency:                       USD   End Date:              2019-06-20
Spread:                          50   Coupon:                       100
```

[5]See Section 4.2 for definitions on both terms.

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

```
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". `Trade Date` refers to the trade date and is April 15, 2014. Reference Entity (called `entityName` in the package) refers to the entity name of the CDS contract and is "Alcoa Inc.". 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 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.

The remaining three items from the `summary` output are `Spread DV01`, `IR DV01`, and `Rec Risk (1 pct)`. 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: five 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,"

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

  - 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.

8.1 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 and points 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:              Alcoa Inc.   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", "Reference Name" (called Entity Name in the package), "RED", "Trade Date", 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`.

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.

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"
```

9 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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