Note
Managing Credit Risk
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"This ability of structured finance to repackage risks and create "safe" assets from otherwise risky collateral led to a dramatic expansion in the issuance of structured securities, most of which were viewed by investors to be virtually risk-free and certified as such by the rating agencies. At the core of the recent financial market crisis has been the discovery that these securities are actually far riskier than originally advertised.[1]"

- *Joshua Caval , Jakub Jurek, Erick Stafford.*

Introduction

Credit risk arises from the possibility of default by counterparty. Credit risk lay at the heart of the sub prime crisis. The most important point to note about credit risk is that it is more difficult to model and measure compared to market risk. Unlike market risk, where a lot of data is available in the public domain, data is scanty and sometimes non existent in case of credit risk. Moreover, credit risk is far more contextual, i.e., firm specific compared to market risk. Despite these challenges, there has been significant progress in credit risk modeling in recent years. In this chapter, we will examine the three building blocks of credit risk management – *probability of default, exposure at default* and *recovery rate*. We will also discuss briefly some of the commonly used credit risk modeling techniques. These techniques can help us to estimate the potential loss in a portfolio of credit exposures over a given time horizon at a specified confidence level. The aim of this chapter is to provide a high level understanding of credit risk management.

Pre-settlement and Settlement risk

Credit risk can be defined as the likelihood of a counterparty failing to discharge its obligations. Any credit transaction typically involves two stages: pre settlement and settlement.

Pre-settlement risk refers to the probability of failure of the counterparty to discharge its obligation during the life of the transaction. This includes the possibility of defaulting on bond interest or principal repayment or not making margin payment in case of a derivative transaction.

Settlement risk arises at the time of maturity. Suppose a bank fulfils its obligation at the time of expiry of a contract. Till the time the bank receives its dues from the counterparty, settlement risk exists. A good example of such risk is foreign currency payments made by two parties in different time zones.

To deal with settlement risk, banks have developed *real time gross settlement systems*. Such systems reduce the time interval between the point a stop payment instruction

[1] "The Economics of Structured Finance," Harvard Business School, Working Paper, 09-060, 2008.

can no longer be made and the point of receipt of dues from the counterparty. Another technique used is *netting*. Instead of paying the gross amounts to each other, only the net amount is paid by one of the counterparties. This reduces the exposure and contains the damage even if things go wrong.

Probability of default

The probability of default is a key concern in credit risk management. Two kinds of factors must be evaluated to arrive at the probability of default – borrower specific and market specific.

Borrower specific factors include:

- collateral
- leverage
- volatility of earnings/cash flows
- reputation.

Market specific factors include:

- the phase of the business cycle
- industry conditions
- interest rates
- exchange rates

Exhibit 6.1 A

S&P's Corporate Finance Cumulative Default Rates 1981-2014 (%)

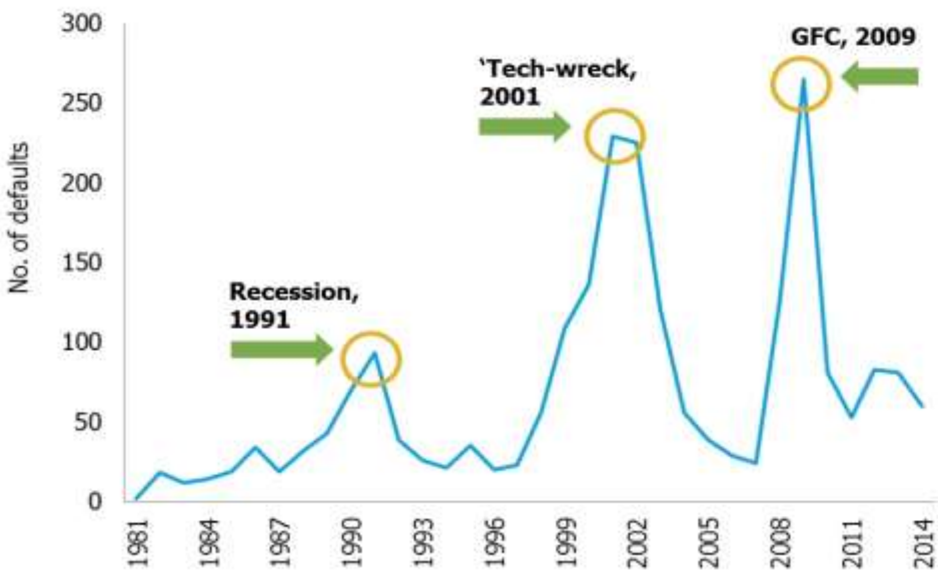
	S&P	1 year	2 years	3 years	4 years	5 years
	AAA	0.00	0.03	0.14	0.24	0.36
High grade	AA+	0.00	0.05	0.05	0.11	0.17
High grade	AA	0.02	0.03	0.09	0.23	0.38
High grade	AA-	0.03	0.10	0.20	0.28	0.37
Upper medium grade	A+	0.06	0.11	0.23	0.38	0.51
Upper medium grade	A	0.07	0.17	0.26	0.40	0.54
Upper medium grade	A-	0.08	0.20	0.32	0.46	0.66
Lower medium grade	BBB+	0.13	0.36	0.63	0.91	1.21
Lower medium grade	BBB	0.19	0.49	0.76	1.18	1.60
Lower medium grade	BBB-	0.30	0.91	1.63	2.47	3.29
	Investment grade	0.11	0.29	0.50	0.76	1.03
	Speculative grade	3.87	7.58	10.79	13.39	15.49
	All rated	1.50	2.95	4.23	5.31	6.20

Lowest investment grade rating

Source : S&P

Exhibit 6.1 B

S&P's Corporate Finance Number of Defaults, 1981-2014



Illustration

A portfolio consists of 5 bonds each with a probability of default of .01. What is the probability that there will be no default? What is the probability that there will be at least one default? What is the probability of exactly one default? What is the probability of exactly two defaults?

Probability of no default	=	$(.99)^5$	=	.951
Probability of at least one default	=	1 - .951	=	.049
Probability of exactly one default	=	$5C_1\,(.99)^4\,(.01)$ =	.0480	
Probability of exactly two default	=	$5C_2\,(.99)^3\,(.01)^2$	=	.00097

Illustration

The cumulative probability of default of an instrument over two years is 5%. The probability of default in the first year is 2%. What is the probability of default in the second year?

Probability of no default over the two years = 1 - 0.05 = 0.95

Probability of no default during the first year = 0.98

Let probability of default in the second year be p

In order that there is no default over the two years, there must be no default at in year 1 or year 2.

Then $(.98)(1-p) = .95$

$$\Rightarrow \quad p = 1-\frac{.95}{.98} = 0.0306$$

So probability of default: = 3.06%

Traditional methods

Default risk models can range in complexity from simple qualitative models to highly sophisticated quantitative models. Let us look first at some of the more simple and traditional ways of estimating the probability of default. These typically use financial statement data. Then we will examine some of the more sophisticated models.

Altman's Z Score

Altman's[2] Z score is a good example of a credit scoring tool based on data available in financial statements. It is based on multiple discriminant analysis. The Z score is calculated as:

$$Z = 1.2x_1 + 1.4x_2 + 3.3x_3 + 0.6x_4 + .999x_5$$

x_1 = Working capital / Total assets

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[2]. E.I Altman, "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *Journal of Finance*, September 1968, pp. 589-609

x_2 = Retained earnings / Total assets
x_3 = Earnings before interest and taxes / Total assets
x_4 = Market value of equity / Book value of total liabilities
x_5 = Sales / Total assets

Once Z is calculated, the credit risk is assessed as follows:

$Z > 3.0$ means low probability of default (Safe zone)
$2.7 < Z < 3.0$ means an alert signal (Grey zone)
$1.8 < Z < 2.7$ means a good chance of default (Grey zone)
$Z < 1.8$ means a high probability of default (Distress zone)

A variant of the Altman score has been used in the case of mortgage loans in the US. This is called the FICO score. FICO scores are tabulated by independent credit bureaus using a model created by Fair Issac Corporation (FICO). A lower FICO score denotes a higher risk of default and vice versa. In mid-2007, the average FICO scores were 725, 739, 712 and 628 for agency[3], jumbo, Alt-A and sub prime mortgages.

Estimating probability of default from market prices

The problem with financial statements is that they tend to be backward looking. A simple but forward looking way to measure the probability of default is to examine the market prices of bonds which are traded. Suppose the one year T Bill yields 2% while a one year corporate bond yields 3%. Assume that no recovery is possible in case of a default, what is the probability of default?

We can invest in either the T Bill or the risky instrument. Let us say we make an investment of $1 for exactly one year.

If we assume the probability of default is *p*, the following equation must hold good:

$$1.02 = 1.03\,(1-p)$$

If this equation does not hold, arbitrage is possible by going long in one of the instruments (which fetches higher return) and short in the other (which fetches lower return).

Solving we get: $p = 1 - \frac{(1.02)}{(1.03)}$ = .0097

= .97%

Suppose in the earlier illustration, the recovery in the case of default has been estimated as 50%. This means that in the case of default, 50% of the exposure can be recovered. Then we can rewrite the equation as follows:

$$1.02 = (1.03)(1-p) + (1.03)(p)(.5)$$

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[3]. Agency mortgages are backed by Fannie Mac/Fraddic Mac. Jumbo mortgages as the name suggests are large loans. Limited documentation is the key feature of Alt-A loans. Subprime mortgages have the highest probability of default. For more details, see Chapter 3.

$$= \quad 1.03 - 1.03p + .515\,p$$
$$.515\,p = .01$$
$$p = .0194$$
$$= 1.94\%$$

More generally, let i be the yield of the risky bond, r that of the risk free instrument. Let p be the probability of default and f the recovery rate, i.e., fraction of the amount which can be collected from the debtor in case of a default. Then for a loan of value, 1, to prevent arbitrage, the following condition must hold:

$$1+r = (1+i)(1-p) + (1+i)\,pf$$

or $$1+r = 1 + i - p - pi + pf + ipf$$

or $$i - r = p + pi - pf - ipf.$$

Ignoring pi, ipf, as these will be small quantities, we get:

$$i - r = p\,(1-f).$$

Since f is the recovery rate, (1-f) is nothing but the loss given default. $(i - r)$ is the credit spread. *Thus the spread or risk premium equals the product of the default probability and the loss given default.* There is nothing surprising about the result. Since we have assumed the loan value to be 1, the left side of the equation is the excess amount received by investors for the risky loan in comparison to a risk free loan and the right side is the expected loss on the risky loan. In other words, the left side represents the risk compensation to the investor and the right side, the expected loss. To prevent arbitrage, the risk compensation must equal the expected loss.

Exhibit 6.2

Credit Suisse counterparty ratings

Ratings	PD bands (%)	Definition	S&P	Fitch	Moody's	Details
AAA	0.000–0.021	Substantially risk free	AAA	AAA	Aaa	Extremely low risk, very high long-term stability, still solvent under extreme conditions
AA+ AA AA-	0.021–0.027 0.027–0.034 0.034–0.044	Minimal risk	AA+ AA AA-	AA+ AA AA-	Aa1 Aa2 Aa3	Very low risk, long-term stability, repayment sources sufficient under lasting adverse conditions, extremely high medium-term stability
A+ A A-	0.044–0.056 0.056–0.068 0.068–0.097	Modest risk	A+ A A-	A+ A A-	A1 A2 A3	Low risk, short- and medium-term stability, small adverse developments can be absorbed long term, short- and medium-term solvency preserved in the event of serious difficulties
BBB+ BBB BBB-	0.097–0.167 0.167–0.285 0.285–0.487	Average risk	BBB+ BBB BBB-	BBB+ BBB BBB-	Baa1 Baa2 Baa3	Medium to low risk, high short-term stability, adequate substance for medium-term survival, very stable short term
BB+ BB BB-	0.487–0.839 0.839–1.442 1.442–2.478	Acceptable risk	BB+ BB BB-	BB+ BB BB-	Ba1 Ba2 Ba3	Medium risk, only short-term stability, only capable of absorbing minor adverse developments in the medium term, stable in the short term, no increased credit risks expected within the year
B+ B B-	2.478–4.259 4.259–7.311 7.311–12.550	High risk	B+ B B-	B+ B B-	B1 B2 B3	Increasing risk, limited capability to absorb further unexpected negative developments
CCC+ CCC CCC- CC	12.550–21.543 21.543–100.00 21.543–100.00 21.543–100.00	Very high risk	CCC+ CCC CCC- CC	CCC+ CCC CCC- CC	Caa1 Caa2 Caa3 Ca	High risk, very limited capability to absorb further unexpected negative developments
C D1 D2	100 Risk of default has materialized	Imminent or actual loss	C D	C D	C	Substantial credit risk has materialized, i.e., counterparty is distressed and/or non-performing. Adequate specific provisions must be made as further adverse developments will result directly in credit losses.

Transactions rated C are potential problem loans; those rated D1 are non-performing assets and those rated D2 are non-interest earning.

Source: Credit Suisse Annual Report - 2015

Illustration

Calculate the implied probability of default if the one year T Bill yield is 9% and a one year zero coupon corporate bond is fetching 15.5%. Assume recovery in the event of default is zero.

Let the probability of default be p

Expected returns from corporate bond = 1.155 (1-p) + (0) (p)

Expected returns from treasury = 1.09

or 1.155 (1-p) = 1.09

p = 1 - 1.09/1.155 = .0563

= 5.63%

Illustration

In the earlier problem, if the recovery is 80% in the case of a default, what is the default probability?

1.155 (1-p) + (.80) (1.155) (p) = 1.09

or .231 p = 0.065

or p = 0.2814

= 28.14%

A brief note on Credit Rating Agencies[4]

Rating agencies specialize in evaluating the creditworthiness of debt securities and also the general credit worthiness of issuers. The rating given by the agencies are a good indication of the likelihood of all interest payment and principal repayments being made on time. Where capital markets have replaced banks as the major source of debt capital, rating agencies have a particularly important role to play. Basle II refers to the credit rating agencies as external credit assessment institutions. The three main rating agencies in the US are Moody's Standard and Poor's and Fitch.

The origin of rating agencies in the US goes back to 1909 when John Moody initiated bond ratings for the rail roads. In 1962, Dun and Bradstreet acquired Moody's After flourishing till the 1930s, rating agencies began to struggle as the bond markets were reasonably safe, dominated by government debt and investment grade corporates. But in the 1970s, the debt markets became more volatile, a landmark event being the bankruptcy of Penn Central in 1970.

[4] John B Caouette, Edward I Altman, Paul Narayanan and Robert W J Nimmo, "Managing Credit Risk – The great challenge for global financial markets," John Wiley & Sons, 2008.

In the 1970s, the rating agencies also revamped their revenue model, moving away from subscription paying investors to fee paying issuers. The agencies also widened the scope of coverage to include asset backed securities, commercial paper, municipal bonds, insurance companies, etc.

As credit quality can change over time, rating agencies publish updates on issuers at periodic intervals. While issuing ratings, the agencies can indicate whether the outlook is positive, i.e., it may be raised, negative, i.e., it may be lowered or stable, meaning neutral.

The revenue model of rating agencies remains a source of concern. The independence of rating agencies and their role during the sub prime crisis has been questioned. The International organization of Securities Commissions (IOSCO) published a code of conduct for the rating agencies in December 2005.

While rating bonds, the rating agencies consider various factors. S&P for example looks at the following while rating bonds:

- Business risk
- Industry characteristics
- Competitive positioning
- Management
- Financial risk
- Financial characteristics
- Financial policies
- Profitability
- Capitalization
- Cash flow protection
- Financial flexibility

The agencies compute a number of financial ratios and track them over time. The agencies typically study a range of public and non public documents related to the issuer and the specific debt issue. They review the accounting practices. Meetings are usually held with the management to seek clarifications regarding key operating and financial plans and policies. Some amount of subjectivity in the rating process, however, cannot be avoided.

Following the sub prime crisis, the rating agencies have been revisiting the default and loss assumptions, in their models and the assumptions made about correlations across asset classes. The agencies maintain that their approach is transparent and also swear by their independence. But they have also acknowledged the need to go beyond ability to pay, to include other factors such as liquidity.

Exposure at default

Now that we have covered probability of default, it is time to move on to the second building block of credit risk management – credit exposure. At the time of default, the amount of exposure determines the extent of losses. The larger the exposure, more the losses. So along with the probability of default, we must also determine the amount of exposure. The amount of credit exposure at the time of default is called exposure at default (EAD). In traditional banking, the exposure is usually the face value of the loan. But when derivatives and structured products are involved, the face value is not the relevant parameter. Determining the exposure is a more involved process. Guarantees and commitments further complicate the problem.

In case of derivative contracts, three situations may arise. The contract may be a liability to the bank, an asset to the bank or either of the two.

- Where the derivative position is a liability, there is no credit exposure.
- When the derivative position is an asset, there is credit exposure.
- In the third case, the position can be an asset or a liability depending on the market fluctuation. So there is a possibility of loss when the position is an asset and no loss when the position is a liability.

Credit exposure can be broken down into two components – current exposure and potential exposure.

- Current exposure is the exposure which exists today.
- Potential exposure is the likely exposure in case the credit deteriorates.
- Adjusted exposure takes into account both current and potential exposure.

Credit exposure can be managed proactively in various ways. By marking to market, any variations in the position can be settled daily, through a margin account, instead of allowing an accumulation over the life of the contract. Collateral also helps a company to protect itself against current and potential exposure. The collateral will typically exceed the funds owed, by an amount called *haircut*. Downgrade triggers can also be used to modify exposure. A clause can be inserted stating that if the credit rating of the counterparty falls below a certain level, the bank has the option to close out the derivatives contract at its market value.

Exhibit 6.3
Credit Suisse: Credit Exposures

Gross credit exposures by type

end of	2015	2014
Gross credit exposure (CHF million)		
Loans, deposits with banks and other assets [1]	376,594	361,177
Guarantees and commitments	69,432	61,297
Securities financing transactions	31,046	35,131
Derivatives	53,735	63,968
Total gross credit exposure	**530,807**	**521,573**
of which measured under the PD/LGD approach	503,065	502,229

[1] Includes interest bearing deposits with banks, banking book loans, available-for-sale debt securities and other receivables.

Gross credit exposure by asset class – portfolios measured under the PD/LGD approach

end of	2015	2014
Gross credit exposure (CHF million) [1]		
Sovereigns	88,206	77,037
Other institutions	1,752	2,381
Banks	35,579	38,062
Corporates	195,117	204,277
Total institutional	**320,654**	**321,757**
Residential mortgage	102,020	101,350
Qualifying revolving retail	876	672
Other retail	79,515	78,449
Total retail	**182,411**	**180,471**
Total gross credit exposure	**503,065**	**502,228**

[1] Gross credit exposures are shown post-substitution as, in certain circumstances, credit risk mitigation is reflected by shifting the counterparty exposure from the underlying obligor to the protection provider.

Source: Credit Suisse Annual Report, 2015

Loss given default

The third building block of credit risk management is the loss given default. In case of a default, it may be possible to recover part of the amount owed. The proportion of the amount which cannot be recovered is called *loss given default*.

The amount which can be recovered depends on various factors.

- The first factor is seniority. Senior claims have priority while settling claims. Thus secured bonds have priority over unsecured ones.
- The ease, with which assets can be sold to recover the amounts due, depends on the legal system and bankruptcy procedures.
- Collateralization i.e., the amount of collateral backing the loan, is another key factor in determining the recovery rate.
- Recovery rates are also more significantly negatively correlated with default rates. A bad year for defaults is also bad for recovery.

Before we take up a couple of simple illustrations, we need to define a few terms. A *commitment* represents the total amount the bank is prepared to lend to the borrower. On the other hand, *outstandings* refers to the actual amount loaned. Thus the commitment consists of two components – the outstanding and the unused portion of the commitment. The undrawn portion is nothing but a borrower's call option to draw on the full credit line in distress. During distress, the borrower will indeed draw on the remaining amount, fully or partly. The Adjusted exposure is nothing but the prior exposure adjusted for this drawdown. Adjusted exposure is calculated taking into account the bank's total commitment, undrawn amount and the likely draw down in the case of credit deterioration. Banks of course may put in place covenants that limit such drawdowns.

Exhibit 6.4
Credit Suisse: Loan Losses

Allowance for loan losses

end of	Swiss Universal Bank	International Wealth Management	Asia Pacific	Global Markets	Investment Banking & Capital Markets	Strategic Resolution Unit	Credit Suisse
2015 (CHF million)							
Allowance for loan losses at beginning of period [1]	**523**	**61**	**21**	**34**	**25**	**94**	**758**
Net movements recognized in statements of operations	111	51	34	(3)	2	100	295
Gross write-offs	(169)	(5)	(1)	(1)	(2)	(51)	(229)
Recoveries	16	2	1	3	3	3	28
Net write-offs	(153)	(3)	0	2	1	(48)	(201)
Provisions for interest	3	1	5	0	1	8	18
Foreign currency translation impact and other adjustments, net	(2)	(1)	1	0	0	(2)	(4)
Allowance for loan losses at end of period [1]	**482**	**109**	**61**	**33**	**29**	**152**	**866**
of which individually evaluated for impairment	349	77	49	21	7	147	650
of which collectively evaluated for impairment	133	32	12	12	22	5	216
2014 (CHF million)							
Allowance for loan losses at beginning of period [1]	**551**	**54**	**64**	**50**	**18**	**132**	**869**
Net movements recognized in statements of operations	100	12	9	(5)	1	28	145
Gross write-offs	(152)	(8)	(64)	(19)	(1)	(105)	(349)
Recoveries	15	1	0	3	2	20	41
Net write-offs	(137)	(7)	(64)	(16)	1	(85)	(308)
Provisions for interest	(3)	1	10	0	1	11	20
Foreign currency translation impact and other adjustments, net	12	1	2	5	4	8	32
Allowance for loan losses at end of period [1]	**523**	**61**	**21**	**34**	**25**	**94**	**758**
of which individually evaluated for impairment	388	32	7	20	1	92	540
of which collectively evaluated for impairment	135	29	14	14	24	2	218

[1] Allowance for loan losses are only based on loans which are not carried at fair value.

Source: Credit Suisse Annual Report, 2015

Expected and unexpected loss

- *Expected loss* is the average loss in value over a period of time for a given exposure. The expected loss is best handled by building it into the product price.
- The *unexpected loss* refers to the variability of potential loan loss around the average loss level.
- The unexpected loss can be viewed as some multiple of the standard deviation of the expected loss. *The essence of credit risk management is arriving at a good estimate of the unexpected loss*. The unexpected loss in turn can be divided into two components.

- The *statistical losses* can be measured using techniques such as VAR.
- *Losses in the tails* can be estimated by stress testing or by applying extreme value theory.

Capturing correlations: Structural and Reduced Form Models

So far we have considered simple situations. In reality, banks face multiple exposures. Correlations may exist among different exposures. For example, there tends to be higher default rates across all ratings grades during a recession. To capture correlations among different credit events, there are broadly two approaches: *Structural models* and *Reduced form models*.

Structural models try to establish a relationship between default risk and the value of the firm. For example, equity prices can be used to estimate the probability of default of the bond of a company whose shares are listed on the stock exchange. In structural models, debt and equity are viewed as contingent claims on firm value. The probability of default is calculated from the difference between the current value of the firm's assets and liabilities and the volatility of the assets. Structural models are difficult to apply if the capital structure is complicated or if the assets are not traded.

Structural models view a firm's equity as an option on the firm's assets with a strike price equal to the value of the firm's debt. Option pricing models, typically, Black-Scholes are used to identify the fair value of these claims. Two approaches are cited in the literature. The first was developed by the Nobel prize winning economist, Robert Merton. The second, called KMV is a modification of Merton's model by the credit rating company, Moody's. Let us briefly examine these two models.

Merton Model
The value of a firm, V equals the sum of the values of debt, D and equity, E. The Merton model attempts to measure the value of D and thus forecast the probability of default. The model frames the situation in such a way it reduces to an option pricing problem. The key assumption in the Merton model is that the firm has made a single issue of zero coupon debt that will be paid back in one shot, at a future point in time. Other assumptions include perfect financial markets, no bankruptcy costs and no costs to enforce contracts. All these assumptions can be suitably modified to extend the Merton Model.

Let us use the following notations:

V_O	=	Current value of the company's assets.
V_T	=	Value of the company's assets at time T.
E_O	=	Value of the company's equity today.
E_T	=	Value of the company's equity at time T.
D	=	Amount of zero coupon debt maturing at time T.
σ_V	=	Volatility of assets.
σ_E	=	Volatility of equity.
T	=	Time of maturity of the debt.

Two situations can arise.
If $V_T < D$, the company will default on its debt. Debt holders will receive V_T. Equity holders will not receive any thing, i.e., $E_T = 0$.

If $V_T > D$, debt holders will receive their full payment, D. Equity holders will receive V_T – D.

We can now combine the two possibilities into a more generalized equation:

$$E_T = \max (V_T - D, 0)$$

As the minimum value of equity is 0 and the maximum value is unlimited, the pay off profile is that of a call option with strike price = D. We can now apply the Black Scholes model to value the equity.

$$E_O = V_0 N(d_1) - De^{-rt} N(d_2)$$

$$d_1 = \frac{ln(V_0 / D) + (r + \sigma_v^2 / 2)T}{\sigma_v \sqrt{T}}$$

$$d_2 = d_1 - \sigma_v \sqrt{T}$$

N refers to the cumulative normal probability. The probability of default on the debt is N $(-d_2)$. To calculate d_2, we need to know the value of V_0 and σ_V. Both figures will in general not be readily available. So, assuming the company's shares are listed, we have to start with E_0. There is a relationship available based on Ito's lemma. (Derivation of this relationship is beyond the scope of this book.)

$$\sigma_E E_0 = \frac{dE}{dV} \sigma_V V_0$$

Using this relationship we can estimate V_0 and σ_V.

We could also approach the problem in a different way by stating that the amount received by the debt holders of the company is:

$$D - Max [(D-V_T), 0].$$

D is the pay off obtained by investing in a risk free zero coupon bond maturing at time T with a face value of D.

The second term, - Max $\{D-V_T, 0\}$ is the pay off from a short position in a put option on the firm's assets with strike price, D and maturity date, T.

By subtracting the value of the put from the risk free debt, we can value risky debt. The value of the put can be calculated by applying the Black-Scholes formula:

$$P = De^{-r(t)} N(-d_2) - V_0 N(-d_1)$$

Illustration

What is the value of a firm's equity if the total value of the firm is $600 million and the debt repayment is $100 million? What will be the value of equity if the total value of the firm drops to $75 million?

In the first case, value of equity = 600 – 100 = $500 million

In the second case, value of equity = 0 as the value of debt repayment exceeds the total firm value.

Illustration

The market value of a firm is $60 million and the value of the zero coupon bond to be redeemed in 3 years is $50 million. The annual interest rate is 5% while the volatility of the firm value is 10%. Using the Merton Model, calculate the value of the firm's equity.

Let us first calculate the curent firm value, S.

S = $60 \times N(d_1) - (50)e^{-(.05)(3)} \times N(d_2)$

$$d_1 = \frac{ln\frac{60}{50} + (.05 + \frac{.10^2}{2})(3)}{.10\sqrt{3}}$$

$$= \frac{.1823 + .165}{.17321}$$

= 2.005

d_2 = $d_1 - \sigma\sqrt{t} = 2.005 - (.1)(\sqrt{3}) = 2.005 - .17321$ = 1.8318

S = 60 N (2.005) – (50) (.8607) N (1.8318)

= 60 N (2.005) – (43.035) N (1.8318)

= (60) (.9775) – (43.035) (.9665)

= $17.057 million

We can now calculate the current value of the firm's debt.

D_t = $De^{-r(t)} - p_t$

= $50e^{-.05(3)} - p_t$

= $43.035 - p_t$

Based on put call parity

P_t = $C_t + Fe^{-r(t)} - V$

Or P_t = 17.057 + 43.035 – 60 = .092

D_t = 43.035 - .092 = $42.943 million

We can verify our calculation by adding up the market values of debt and equity and noting that we get the market value of the firm.

KMV Model

Moody's KMV approach adjusts for some of the limitations of the Merton model. The Merton Model assumes that all debt matures at the same time and the value of the firm follows a lognormal diffusion process. The KMV model assumes that there are only two debt issues. The first matures before the chosen horizon and the other matures after that horizon.

The KMV model uses a concept called *distance to default*. This is defined as the number of standard deviations by which the asset price must change in order for a default to happen in T years. The distance to default can be calculated as:

$$\frac{lnV_0 - lnD + (r - \sigma_v^2/2)T}{\sigma_v\sqrt{T}}$$

From the formula we can see that this is nothing but the value of d_2 in the Black Scholes formula. The distance to default is a proxy measure for the probability of default. As the distance to default decreases, the company becomes more likely to default. As the distance to default increases, the company becomes less likely to default. The KMV model, unlike the Merton Model does not use a normal distribution. Instead, it assumes a proprietary algorithm based on historical default rates.

Using the KMV model involves the following steps:

a) Identification of the default point, D.
b) Identification of the firm value V and volatility σ.
c) Identification of the number of standard deviation moves that would result in the firm value falling below D, thereby leading to default. This is the firm's distance to default, δ.
d) Reference to the KMV database to identify the proportion of firms with distance-to-default, δ who actually defaulted with a year. This is the expected default frequency. KMV takes D as the sum of the face value of the all short term liabilities (maturity < 1 year) and 50% of the face value of longer term liabilities.

Illustration
Consider the following figures for a company. What is the probability of default?

Book value of all liabilities	:	$2.4 billion
Estimated default point, D	:	$1.9 billion
Market value of equity	:	$11.3 billion
Market value of firm	:	$13.8 billion
Volatility of firm value:	20%	

We first calculate the distance to default.

Distance to default (in terms of value)	=	13.8 – 1.9	=	$11.9 billion
Standard deviation	=	(.20) (13.8)	=	$2.76 billion
Distance to default (in terms of standard deviation)	=	$\frac{11.9}{2.76}$	=	4.31

We now refer to the default database. If 3 out of 100 firms with distance to default of 4.31 actually defaulted, probability of default is .03

Illustration
Given the following figures, compute the distance to default:

Book value of liabilities	:	$5.95 billion
Estimated default point	:	$4.15 billion
Market value of equity	:	$ 12.4 billion
Market value of firm	:	$18.4 billion
Volatility of firm value:	24%	

Distance to default (in terms of value)	=	18.4 – 4.15	=	\$14.25 billion
Standard deviation	=	(.24) (18.4)	=	\$4.416 billion
Distance to default (in terms of standard deviation)		$\frac{14.25}{4.416}$	=	3.23

If in the default database, 2 out of 100 firms with a distance to default of 3.23 actually defaulted, the probability of default is .02.

Reduced form models

These models assume that default events occur unexpectedly due to one or more exogenous background factors which are independent of the firm's asset value. These factors may be observable such as GDP growth, interest rates, exchange rates, inflation or unobservable. Correlations arise because these background factors affect all the exposures. Reduced form models typically assume that default follows a Poisson distribution or similar hazard rate process. Using the Poisson distribution, we can determine the number of default events occurring during a specified period of time.

Credit Risk models

Credit risk models are used by banks to calculate the credit loss for a given time horizon. The output of these models is a portfolio loss distribution which describes the potential credit losses and their probabilities. A credit loss is nothing but a decrease in the value of a portfolio over a specified period of time. To estimate credit loss, we need to establish the portfolio value today and at the end of the time horizon.

There are two conceptual approaches to measuring credit loss. In the *default mode paradigm*, a credit loss occurs only when there is an actual default. The credit loss is nothing but the difference between the exposure-at-default and the recovery value. In the *mark-to-market paradigm* a credit loss occurs if the borrower defaults or if the borrower's credit quality deteriorates.

To measure the value of the obligations, two techniques are commonly used – *discounted contractual cash flow approach* and *risk neutral valuation approach*. In the first approach, the credit spreads are used to discount cash flows. Changes in the value of the loan are the result of changes in market spreads or changes in credit rating. In case of a default, the future value is determined by the recovery rate. In risk neutral valuation, we apply risk free rates and risk neutral probabilities.

Credit Risk Plus

The global bank, Credit Suisse[5] has developed a model for estimating default probability and Value at Risk. This model, called Credit Risk Plus, is based on actuarial, analytical techniques and does not use simulation. Credit risk is modeled on the basis of sudden events. Default rates are treated as continuous random variables.

[5] The subsidiary of Credit Suisse, Credit Suisse First Boston pioneered this model.

Suppose there are *N* counterparties of a type and the probability of default by each counterparty is *p*. If we consider that there are only two possibilities – default or no default and apply the binomial distribution, the mean number of defaults, μ, for the whole portfolio is Np. If *p* is small, the probability of *n* defaults is given by the Poisson distribution, i.e, the following equation:

$$p(n) = \frac{e^{-\mu}\mu^{n}}{n!}$$

The next step is to specify the recovery rate for each exposure. Then the distribution of losses in the portfolio can be estimated.

Credit Risk + allows only two outcomes – default and no default. In case of default, the loss is of a fixed size. The probability of default depends on credit rating, risk factors and the sensitivity of the counterparty to the risk factors. Once the probability of default is computed for all the counterparties, the distribution of the total number of defaults in the portfolio can be obtained. When the probability of default is multiplied successively by exposure at default and loss given default, we get the credit loss.

Through the use of sector analysis, Credit Risk Plus can measure the impact of concentration risks and the benefits which can be obtained through diversification.

Credit Metrics

Credit Metrics, another popular model, has been developed by J P Morgan. Unlike Credit Risk Plus, this model does not view credit risk as a binary situation. Instead, Credit Metrics tries to determine the probability of a company moving from one rating category to another during a certain period of time.

Credit Metrics first estimates the rating class for a debt claim. The rating may remain the same, improve or deteriorate, depending on the firm’s performance. A ratings transition matrix, usually provided by the rating agencies, gives us the probability of the credit migrating from one rating to another during one year.

Exhibit 6.5
Largest CRAs Global Structured Finance 1 Year Transition Rates

%	2007			2008		
	Downgrade	Upgrade	Stable	Downgrade	Upgrade	Stable
AAA	1.0	n/a	99.0	23.4	0.0	76.6
AA	4.4	3.5	92.1	34.9	1.8	63.3
A	11.3	4.2	83.9	36.9	2.1	61.0
BBB	20.2	2.9	77.0	40.2	1.0	58.1
BB	21.0	2.3	76.6	44.8	1.7	53.9
B	11.1	1.8	87.1	55.5	1.3	43.5
CCC	34.9	0.7	32.7	78.5	1.0	21.4

CCC figures for 2007 may not add to 100% because transitions to default are excluded.

Source: 1991-2006 & 2007 figures are average from Fitch Ratings, Moody's Investors Services and S&P, while the 2008 figures are for S&P only.

Ref: The Turner Review - A regulatory response to the global banking crisis, published by: UK Financial Services Authority, www.fsa.gov.uk/pubs/other/turner_review; March 2009.

Next, we construct the distribution of the value of the debt claim. We compute the value we expect the claim to have for each rating in one year. Based on the term structure of bond yields for each rating category, we can get today's price of a zero coupon bond for a forward contract to mature in one year. If the bond defaults, we assume a recovery rate. If the migration probabilities are independent, we can compute the probabilities for the transition of each bond independently and multiply them to obtain the joint probability. By computing the value of the portfolio for each possible outcome and the probability of each outcome, we can construct the distribution for the portfolio value. We can then find out the VAR at a given level of confidence.

But in general, while determining credit losses, the credit rating changes for different counterparties cannot be assumed to be independent. A *Gaussian Copula Model* comes in useful here. Gaussian Copula allows us to construct a joint probability distribution of rating changes. The Copula correlation between the ratings transitions for two companies is typically set equal to the correlation between their equity returns using a factor model. A brief explanation of the rationale behind this approach follows.

The historical record of rating migration can be used to estimate the different joint probabilities. However, this approach is often not enough. Credit Metrics proposes an approach based on stock returns. Using the rating transition matrix, we know the probability of the firm migrating to different credit ratings. We use the distribution of the company's stock returns to find out the ranges of returns that correspond to the various ratings. We can produce stock returns corresponding to the various rating outcomes for each firm represented in the portfolio. In short, the correlations between stock returns can be used to compute the probabilities of various rating outcomes for the credits. For example, if we have two stocks we can work out the probability that one stock will be in the A rating category and other in AAA category. When a large number of credits is involved, a factor model can be used.

Correlations and Gaussian Copula

A more detailed explanation of the Gaussian Copula is in order here. But before that, we need to delve into the world of correlations. In credit risk management, correlations are extremely important. During a crisis, default correlations across instruments tend to increase. This is essentially because the underlying factors are the same. In the same industry, many companies may default simultaneously. More generally, if a market participant has exposure to two different market variables, the total exposure will be very high when there is a strong positive correlation. The exposure will be far less when there is a zero correlation and would actually decrease if there is a negative correlation.

In credit risk management, correlations have to be monitored as closely and systematically as volatility in case of market risk management. The coefficient of correlation between two variables *x, y* can be written as: $\frac{\frac{1}{n}\sum xy - \bar{x}\bar{y}}{\sigma_x \sigma_y}$

The covariance between *x* and *y* can be written as: $\frac{1}{n}\sum xy - \bar{x}\bar{y}$. In other words, the correlation coefficient is nothing but the covariance divided by the product of the two standard deviations.

While the coefficient of correlation is a useful parameter, it does not tell us the full story. It measures only the linear dependence between two variables. We need other parameters to understand the non linear dependence. This is where copulas come in handy. We will come to copulas a little later.

Let us get back to covariance. How do we compute covariance? Let us define the covariance of daily returns per day between two variables, *x, y*. If x_i, y_i are the values of the two variables at the end of day *i* , the returns on day *i* are $\frac{x_i - x_{i-1}}{x_{i-1}}$ and $\frac{y_i - y_{i-1}}{y_{i-1}}$.

The covariance between *x, y* is $\frac{1}{n}\sum x_n y_n - \bar{x}_n \overline{y_n}$. If we assume the expected daily returns are zero, the same assumption we made while calculating volatility, $Cov_n = \frac{1}{n}\sum x_n y_n$. The variances of x_n and y_n are $\frac{1}{n}\sum x_n{}^2$ and $\frac{1}{n}\sum y_n{}^2$.

As in the case of volatility, we can use an exponentially weighted moving average model to get updated values of the covariance. $Cov_n = \lambda Cov_{n-1} + (1-\lambda)\, x_{n-1}\, y_{n-1}$.

We could also use a GARCH model to estimate the covariance. If we use a GARCH model, we could write: $Cov_n = \gamma + \alpha x_{n-1} y_{n-1} + \beta Cov_{n-1}$.
It is important that variances and covariances are calculated consistently. For example, if variances are calculated by giving equal weight to the last *m* data points, the same should be done for covariances. If we use an EWMA (Exponentially Weighted Moving Average) model, the same λ should be used for variances and covariances.

Now we are ready to discuss copulas. Let us say there are two variables V_1, V_2, which are not completely independent. The marginal distribution of V_1 is its distribution assuming we know nothing about V_2. The marginal distribution of V_2 is its distribution assuming we know nothing about V_1.

How do we establish the correlation structure between V_1 & V_2? If the two marginal distributions are normal, we can assume that the joint distribution of the two variables is also normal. But when the marginal distributions are not normal, we run into a problem. So we use the Gaussian Copula. We map V_1 into U_1 and V_2 into U_2 such that U_1 and U_2 are normal variables. To elaborate, the 1 percentile point of the V_1 distribution is mapped to the 1 percentile point of the U_1 distribution and so on. Similar mapping is done between V_2 and U_2. Thus copulas enable us to define a correlation structure between V_1 and V_2 indirectly. Copulas can also be used to establish the correlation structure between more than two variables. Lastly, instead of the Gaussian copula, we could also use the *t* Copula. As the name suggests, the variables U_1, U_2 are now assumed to have a bivariate *t* distribution.

Credit Risk Capital: Basle II framework

One of the key objectives of any risk measurement exercise is to understand how much capital must be set aside. Three different approaches are available to calculate the credit risk capital under Basel II norms. We shall cover this topic in more detail in a separate chapter. What follows here is a brief account.

Standardised approach

In the standardized approach, the risk weights are determined on the basis of ratings provided by an external credit rating agency. Fixed risk weights are used corresponding to the degree of risk in each asset category. Basel I had only five weights. Basle II is more granular with 13 categories of risk weights ranging from 20 to 150% depending on the type of counterparty and rating status. In such cases as low rated securitized assets, the weights can go up to 350%.

Internal Ratings Based approach

Here, banks can use their own estimates of credit risk. The exposures are categorized into six broad classes of assets – corporate, sovereign, bank, retail, equity and purchased receivables. Within the corporate asset class, five sub classes of specialized lending have been separately identified. Similarly in case of retail assets, there are three sub classes of exposures - exposures secured by residential properties, qualifying revolving retail exposures and all other retail exposures.

IRB is divided into two categories – *Foundation* and *Advanced*.

- Under the Foundation approach, banks estimate the probability of default and rely on supervisory estimates for other risk components.
- In the advanced method, banks provide their own estimates of probability of default, loss given default and exposure at default. To use the IRB approach, banks must meet various criteria laid down by the regulatory authorities.

Credit derivatives

On paper, banks manage their credit risk through diversification. But there are limits to diversification. For example, banks may not like to turn down customers with whom they have a valuable relationship even if the exposure has crossed prudent limits. Assignment of loans to another counterparty is also not that easy. Customers may not like their loans being sold off by the bank to another entity. Due to these reasons, the concentration of credit risk on the banking books is often much higher than desirable.

Credit derivatives have emerged to deal with such problems. *In simple terms, a credit derivative can be defined as an instrument that allows one party to transfer an asset's credit risk to another party without passing on the ownership of the asset.* The two parties in a credit derivative transaction are the *protection buyer* who pays a premium and *protection seller* who stands ready to provide compensation in case of a credit event. The instrument or group of instruments with respect to which the credit risk is being traded is called *referenced obligation*. The reference obligation is sometimes called reference asset or reference credit. Credit derivatives till now have been privately negotiated, over-the-counter (OTC) instruments. But now there are proposals from regulatory authorities in the US and Europe to establish central clearing arrangements for various OTC derivatives.

Thanks to credit derivatives, banks can continue to make loans and hedge the risks involved. At the same time, the counterparty which goes short on the credit derivative can gain access to an exposure which seems to make business sense. Indeed, credit derivatives can be used to create almost any desired risk profile. Say the bank is fine with the credit exposure to a specific client but is worried about a downturn in the industry. A suitable credit derivative can be structured. Credit derivatives also help in increasing the liquidity for banks. By limiting the bank's downside risk, banks will be more willing to lend more to many businesses. This will ensure healthy growth of credit, so vital to maintain economic growth.

From a systemic point of view, credit derivatives represent an efficient way of separating and trading credit risk by isolating it from other risks such as market risk and operational risk. Thanks to the International Swaps & Derivatives Association, ISDA, credit default agreements have become standardized. So buying and selling credit protection has become easy and straightforward.

Credit derivatives also have a useful signaling value. They provide an additional source of market based information about the company's financial health. There is an argument that Credit Default Swap (CDS) prices because they are market determined convey better information about the probability of default, than credit ratings which only reflect the views of an agency.

Credit derivatives support market completion by providing access to credit exposure in ways that would not have been possible otherwise. For example, a bank may not actually lend to a company but by going short on the CDS, it can assume an equivalent risk exposure. And even if a company's bonds are not traded, synthetic exposures can be created.

Credit derivatives have also helped in the integration of different segments of financial markets. For example, the dividing line between bonds and loans has become considerably thinner, thanks to CDS.

The rise and fall of credit derivatives

The origin of OTC credit derivatives can be traced back to bond insurance which involves compensation in the event of a default. Bond insurance has been around for several decades now, but credit derivatives have become popular only in the past 15 years or so. In 1993, transactions began to be structured which involved a periodic fee payment by the banks. Investors would pay compensation in case of a credit event. The first synthetic credit derivatives product was launched by J P Morgan in 1997. The outstanding notional value of credit derivatives grew from $180 million in 1997 to more than $1 trillion in 2001, reaching $5 trillion at the end of 2004. The credit derivatives market exploded in the build up to the sub prime crisis, reaching a notional value of $62 trillion at the peak. Since then due to netting and "trade compression," the value has come down. But even now the figure is significant.

Credit derivatives played an important role in the subprime crisis. AIG collapsed due to huge credit default swap positions it built on its books. Not surprisingly regulators and economists have expressed deep concerns about the indiscriminate use of credit derivatives. Rather than segregate and transfer credit risk, economists argue that these instruments seem to have added to the systemic risk. Let us understand the basis for these concerns.

Banks which lend to clients but offload their credit risk by purchasing credit derivatives, have little incentive to monitor their clients, even though they are the best equipped to do so in several respects. This has a negative impact on the way credit risk is managed at a system level. The protection seller in a CDS may have the motivation but is not as well equipped as the bank to monitor credit risk. The net effect is less monitoring oversight than what is desirable. It also leads to the moral hazard problem as far as borrowers are concerned. When they know that they are not being actively monitored, borrowers can afford to indulge in imprudent risk taking.

In the case of Enron, which went bankrupt in a spectacular way, JP Morgan Chase, Citigroup and other banks had lent billions of dollars. But they had simultaneously used credit derivatives to limit their credit exposure. According to one estimates, the banks used 800 swaps to lay off $8 billion of Enron risk.

Another perverse incentive which seems to have developed is that buyers of CDS on a company's bonds may be more keen on the company filing for bankruptcy rather than reviving it during a crisis. The CDS compensation is likely to be received immediately whereas restructuring initiatives are long drawn out, cumbersome and uncertain in terms of outcome. In other words, CDS buyers actually have a strong incentive to support value destruction. This phenomenon has by no means been uncommon in the aftermath of the sub prime crisis as many companies have run into trouble.

The CDS markets have also been heavily criticized for their opaqueness. The markets are of the OTC type and unregulated. So the quality of disclosure by the players involved is clearly not adequate. Moreover, a party can unwind its position by offloading it to another counterparty without informing the original counterparty. As Frank Partnoy & David Skeel mention[6], "If suppliers, bond holders or other stakeholders do not know whether the bank is hedged, the informational content of the bank's actions will be muddied. This uncertainty is itself an important cost of the credit default swap market."

Many investors place highly leveraged bets on CDS. So even a relatively small change in the market position can trigger a crisis. If there is a rush by market participants to unwind a vast array of interconnected contracts, there would be a serious liquidity crisis. Such concerns were serious when Bear Stearns and Lehman Brothers approached bankruptcy. That also probably explains why the US Treasury was desperate to save AIG.

Credit derivatives are relatively less liquid instruments compared to currency or interest rate derivatives. This is because of the unique nature of individual reference credits. Because of the lack of liquidity, the protection sellers can face problems if they try to hedge their derivative position. In many situations, the credit derivative may also be vulnerable to basis risk. There may be an imperfect correlation between the reference obligation and the underlying risk.

In case of Collateralised Debt Obligations (CDOs), there is another serious problem – the mispricing of credit. Similar assets should have similar values. If CDOs are able to create value by repackaging assets, it means there must be some inefficiencies in the corporate debt market. But this mispricing should logically be removed by the buying and selling

[6] "The promise and perils of credit derivatives," Working Paper, University of San Diego School of Law.

of bonds. Arbitraging opportunities rarely persist unless there is an information asymmetry or a regulatory issue. The investors in CDO tranches are usually sophisticated people. And there is no regulatory explanation that can be offered for synthetic CDOs.

What seems to be the case is that the complex arbitrary and opaque rating methodologies create arbitrage opportunities without actually adding any real value. In short the "value" may be the result of errors in rating the assets, errors in calculating the relationship between the assets and the tranche payouts or errors in rating the individual CDO tranches.

As Partnoy & Skeel mention[7], "Put another way, credit rating agencies are providing the markets with an opportunity to arbitrage the credit rating agencies' mistakes… The process of rating CDOs becomes a mathematical game that smart bankers know they can win. A person who understands the details of the model can tweak the inputs, assumptions and underlying assets to produce a CDO that appears to add value, even though in reality it does not." In other words, there is a very strong argument emerging that CDOs have been used to convert existing fixed income instruments that are priced correctly into new ones that are overvalued.

Types of credit derivatives

The term credit derivatives may have been coined in recent decades. But many traditional instruments have carried features of credit derivatives. For example, letters of credit guarantee payment in case of a default. But credit derivatives, as we know them today, differ significantly from these traditional instruments. Let us understand some of the key features of credit derivatives. In general, credit derivatives can be classified on the basis of:

- *Underlying credit* – single entity or a group of entities
- *Conditions of exercise* – default, rating downgrade, increase in credit spread.
- *Pay off function* – fixed amount, linear pay off, non linear pay off.

In a *single name CDS*, the contract is between a protection buyer and a protection seller. In a *basket CDS*, there is a portfolio of assets. In a *first to default CDS*, compensation is payable after the first default. The structure is terminated after the first event. In an *n^{th} to default CDS*, the pay off occurs only when the n^{th} default happens. In a *standard basket CDS*, compensation is payable for each and every default.

The key factor in determining the spread for a basket CDS is the default correlation of the reference entitles in the basket. If the default correlation between the reference entities is zero, the probability of multiple defaults will be very low. In other words, the value of a first-to-default CDS will be significantly higher than that of say a 10^{th}-to-

[7] "The promise and perils of credit derivatives," Working Paper, University of San Diego School of Law.

default CDS. On the other hand, if the default correlation among the reference entities is perfect, either all the reference entities will default or none will default. In such a case, a first-to-default and an 10^{th}-to-default CDS will have the same value.

The conditions of exercise depend on how the credit events are defined. Credit events can be default, bankruptcy, failure to pay, restructuring, widening of credit spread, etc.

The pay off is usually linked to the amount that cannot be recovered. This is often measured by par value – price of the bond after the credit event. Alternatively the protection buyer can hand over the reference asset to the protection seller and receive a cash payment equal to the par value. Finally, a credit derivative may also be structured with a binary payout. This means in case of a credit event, the payment is fixed and independent of the actual impairment.

Credit Default Swaps

We have already been referring to Credit Default Swaps (CDS) in this Chapter. Now, it is time to understand CDS in more detail. In many ways, the CDS is the simplest form of credit derivative. It is also by far the most popular credit derivative. In a CDS, one party sells protection against default on an underlying instrument to another party. Unlike insurance contracts, the two parties involved in a CDS may have nothing to do with the reference entity. In other words, the parties may be betting on the probability of default of an instrument issued by a third party. It is precisely because of this element of speculation, that the CDS market hit $62 trillion in notional value at its peak. (In the past 18 months, however, the market has shrunk significantly due to offsetting of contracts.)

The protection buyer pays a premium while the protection seller stands ready to compensate the buyer in case of a credit event. As mentioned earlier, the compensation may be fixed or variable. Variable compensation may be either in cash or payment of face value against the receipt of the underlying bond. Cash settlement is preferred when transfer of the ownership of the obligation is difficult. On the other hand, the protection seller may prefer physical settlement if this enables direct interaction with the bankrupt entity during post default negotiations. The protection buyer too may prefer this arrangement as the payment is transparent and not subject to any uncertainty or dispute about the exact recovery value of the underlying asset.

CDS is certainly a form of credit insurance. But it does not eliminate credit risk. All that happens is that exposure to the underlying credit is replaced by that to the protection seller. The effectiveness of CDS as a credit insurance mechanism implicitly assumes a low correlation between the default risk of the underlying credit and the protection seller.

Let us briefly understand the important terms used in the context of CDS:

- The premium amount paid by the protection buyer, as a percentage of the notional principal is called the *CDS spread*. The premium is often expressed as basis points. The premium can also be a lumpsum amount.
- The *reference entity* is defined as the entity on which the protection is bought and sold.
- A *credit event* is defined as the situation that will trigger the payment of compensation by the protection seller to the protection buyer.
- The three most important credit events are *bankruptcy*, *failure to pay* and *restructuring*.
- In case of a credit event, the purchaser of the CDS can sell a bond issued by the reference entity to the seller of the CDS and receive the par value. This bond is called the *reference obligation*.
- The par value of the reference obligation is termed as the swap's *notional principal*.
- Alternatively, *cash* compensation is possible. The protection seller can pay the difference between the reference obligation's par and market value.

A CDS can be unwound in three ways.

- The counterparties can exchange the current market-to-market value. All the future cash flow streams are cancelled. The ongoing legal risk is eliminated.

- The second way to unwind a CDS is to replace the current investor by a new counterparty. Assignment will be subject to the protection buyer agreeing to take on the counterparty risk of the protection seller.

- The third way to unwind a CDS is through an offsetting transaction. An offsetting long or short protection can be entered into with another counterparty. But such an unwinding involves signing of further documentation and adds to legal risk. Where the position is illiquid and assignment is not possible, this kind of unwinding may make sense. Intuitively, the mark-to-market value of a CDS is equal to the cost of entering into an offsetting transaction.

Other variations of CDS

An *asset default swap* is essentially a single name CDS where the underlying reference is an asset backed security.

In an *equity default, swap,* compensation is payable if the stock value falls below a pre specified level.

A *callable default swap* is a CDS that can be terminated by the protection buyer at some strike spread at a future date. Thus it is nothing but a CDS with an embedded short receiver option. Effectively, this means the protection buyer has the right to "sell back" to the protection seller. The protection buyer will be motivated to do so if there is sufficient spread tightening. This way, the protection buyer can avoid paying what looks like a high premium, going by the current market scenario. In return for this facility, the callable default swap spread tends to be higher.

A *total rate of return swap* (TRORS) is another way of transferring credit risk. One party passes on the total return on a security, in exchange for a fixed return calculated as LIBOR plus some spread. The cash flows are exchanged on specific payment dates. At the end of the swap, the accumulated gain or loss in the value of the security is exchanged. The different elements of a TRORS are *reference asset*, *total return payer* and *total return receiver*. If the underlying asset is a portfolio of bonds owned by the total return payer, the payer transfers the credit risk of the portfolio to the total return receiver. If the credit quality of the portfolio deteriorates, and there are capital losses, the receiver will bear the loss.

The reference asset may be a bond, index or basket of assets. Usually, it is a widely quoted and traded bond. The total return payer is the legal owner of the reference asset. The payer pays the total income from the reference asset in return for a floating rate of interest. The total return receiver derives the economic benefit of owning the reference asset without actually holding the asset on the balance sheet. The total return includes interest/dividends, gains/losses due to market movements and credit losses. There is no exchange of the notional principal of the swap. But if the reference asset is amortised over the life of the swap, the notional principal is reduced accordingly. TRORS are sometimes collateralized and marked-to-market daily. The cash flows may be exchanged periodically or at maturity.

Any increase or decrease in the value of the asset leads to cash flows. If the asset has increased in value, the total return payer must pass on the increase in value to the total return receiver. If the asset has decreased in value, the total return receiver must compensate the total return payer. In case of a default, the TRORS terminates and the total return receiver must pay compensation.

Special purpose vehicles and CDOs

Collateralised Debt Obligation (CDO) is the general term for an asset backed security that issues securities and pays principal and interest from an underlying pool of debt instruments. If the underlying pool consists entirely of bonds, it called a Collateralised Bond Obligation (CBO). If it consists only of loans, it is called Collateralized Loan Obligation (CLO).

CDOs are used to repackage securities to create structured products with a completely different risk complexion, compared to the underlying debt instruments. CDOs are divided into tranches with different degrees of certainty regarding payments and consequently different credit ratings. The tranche with the lowest credit rating is called the *equity tranche*. The highest credit rated tranche is referred to as *senior or super senior*. In between there are *mezzanine tranches*. Usually, the originator of the CDO retains the equity tranche.

In a *balance sheet CDO*, the main motivation is to remove selected assets from the balance sheet to manage credit risk, improve liquidity, etc. *Arbitrage CDOs* focus on creating structured products that take advantage of the spread between assets in the pool and the promised payments to security holders. Whereas balance sheet CDOs tend to be “static,” arbitrage CDOs are managed actively. *Cash flow arbitrage CDOs* depend primarily on cash flows from the underlying pool of assets to discharge the obligations towards investors. *Market value arbitrage CDOs* sell securities in the pool from time to time to meet the obligations towards investors. The degree of active management has an impact on the legal and accounting aspects of the CDO.

Many structured credit products can be created through securitization. A special purpose vehicle (SPV) often substitutes the investment bank. The SPV is a legal trust that purchases and holds the notes as collateral and simultaneously enters into a CDS as a protection seller. The SPV issues securities to investors.

In a synthetic CDO, the money collected is invested in risk free instruments. At the same time, a portfolio of CDS is sold to third parties. In the absence of a credit event, the SPV makes the coupon payment as well as the premium on CDS to investors. After a credit event is triggered, the SPV liquidates the notes. First the CDS protection buyers are taken care of. Then the remainder is distributed to the shareholders.

In a synthetic CDO, unlike cash CDO, assets are retained by the sponsoring organization. They are not transferred to the SPV. The performance of a synthetic CDO is not linked to an underlying revenue stream but to a reference portfolio of assets. Referencing a portfolio can be done through a CDS, total return of rate swap or credit linked note. Unless stated specifically, a synthetic CDO normally uses CDS to transfer risk.

Essentially, in a synthetic CDO, CDS and government bonds are combined to substitute corporate loans as the assets in the SPV. The premium from the CDS and the interest earned on risk free securities are paid to investors in a way that reflects the risk they are bearing. When the CDS is triggered, the asset value is reduced. The pay off for the lower tranches depends on the amortizing rate of the assets, which is determined by the number of CDSs triggered.

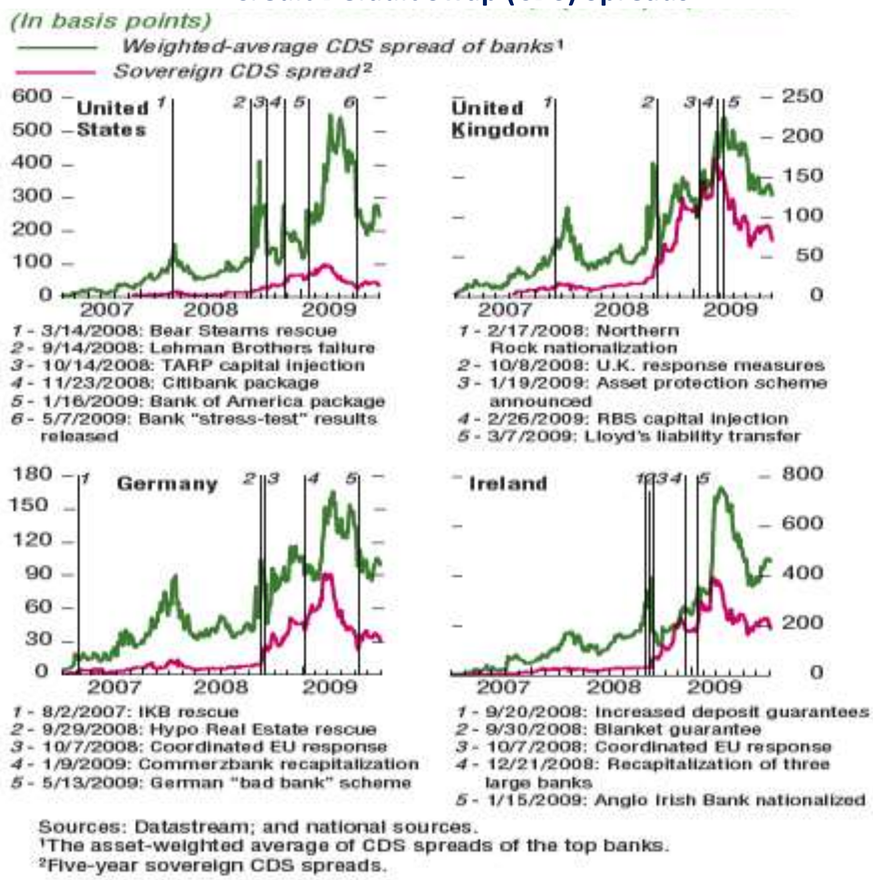
The market has standard definitions of CDO tranches. So individual tranche trading is also possible. A Single Tranche CDO, (STCDO) is a contract between two parties on a particular tranche of a synthetic CDO on a standalone basis. In a single tranche, one side sells protection against losses on a tranche and the other side agrees to buy the protection. If the correlation between the CDO assets is low, the equity tranche will be very risky. But the senior tranches will be relatively safe. On the other hand when the correlation is perfect, all the tranches will be equally risky. It is clear that during the sub prime crisis, correlations turned out to be higher than expected. Banks such as UBS got into big trouble with their super senior tranches.

We need to differentiate between corporate CDS and ABS (Asset Backed Securities) CDS. In the corporate market, the focus is on the corporate entity. Less emphasis is placed on the credit's individual obligations. In the ABS market, the focus is on a specific instrument typically a particular tranche from a particular securitization of a particular originator.

In case of corporate CDS, the usual practice is for all obligations of a seniority to be reference obligations. In the corporate CDS market, it does not much matter which senior unsecured obligation is tendered for physical settlement or marked to market for cash settlement. In the case of ABS CDO, each tranche has a distinct credit quality and a distinct credit rating. ABS CDS focus on the specific tranche.

The credit problem in case of a corporate CDS is clearly defined. Credit events are easily discernable. On the other hand, credit problems in ABS securitization are not that clearly defined. The flexibility of an ABS tranche's cash flows means that the existence or extent of a credit problem is ambiguous. Problems may resolve themselves. They will usually not rise to the same level of distress as a defined credit event in a corporate CDS. Many ABS tranches stipulate deferment of interest payments if collateral cash flow is insufficient due to delinquencies and defaults. Later, if cash flow recovers, deferred interest can be made up.

Exhibit 6.6
Impact of Financial Sector Stabilization Measures on Credit Default Swap (CDS) Spreads



Ref: IMF Global Financial Stability Report, October 2009, www.imf.org

Credit spread Forward

The protection buyer and protection seller agree to a credit spread. The buyer receives the difference between the credit spread at maturity and an agreed – upon spread, if positive. On the other hand, if the difference is negative, a payment is made. If i is the prevailing spread and r is the agreed upon spread and the modified duration is D, then the compensation payable to the buyer is given by:

Compensation = (i - r) (D) (Notional amount).

Credit spread options

Credit-spread options are options on asset swaps. They are used to hedge against the risk of changes in credit spreads. A reference asset is selected and a strike spread and maturity are set. The pay off depends on whether the actual spot spread on the exercise date is above or below the spread on the reference security. The credit spread can be relative to a risk free instrument or any other bond. Credit spread options may be of the European or American type.

The buyer of a call option has the right to buy the spread at a pre specified strike price. Such an option has value if the spread at exercise is greater than the specified strike spread. The buyer of a credit spread put option has the right to sell the spread at a pre specified strike price on the exercise date. The option has value if the spread at exercise is less than the strike spread.

Credit Swaptions

A credit swaption involves payment streams that are contingent on the occurrence of a credit event. A swaption is nothing but an option on a swap. The holder of a swaption can enter into a swap with a pre specified fixed payment stream over a specified period of time.

A credit swaption can be an option to buy or sell credit protection at a pre specified CDS strike spread. The underlying is the forward CDS spread from the option expiry date to the maturity date of the CDS. A swaption can be European, American or Bermudan. In a *payer default swaption*, there is a right to buy the protection. The option holder benefits if the spread widens sufficiently enough by the maturity date. The *receiver default swaption* confers the right to sell protection. The option holder benefits if the spread tightens sufficiently enough by the maturity date. A credit default swaption can also be structured with a provision for a knockout. If there is a credit event between the trade date and the expiry date, the knock out provision cancels the default swaption with immediate effect. The payer default swaption buyer will have the right to buy the protection at the strike spread. In case of a receiver default swaption, the reference spread would widen and the option would not be exercised after a credit event. So a knock out provision is not needed.

Credit default swaptions may be structured such that the underlying asset is a credit index. This may be preferred if the investor wants to take a macro view as opposed to a view on a specific credit. Portfolio volatility also tends to be lower.

Credit linked note

A credit linked note (CLN) is a funded credit derivative. Features of the derivative are embedded in a generic cash instrument. Typically, a CLN combines a credit derivative with a regular bond. The credit risk is transferred through the issue of bonds either directly by the protection buyer or by a Special Purpose Vehicle (SPV).The investor is the credit protection seller while the issuer of the note is the protection buyer. The investor/protection seller pays up front the par value of the bond and receives interest payments at LIBOR plus a spread. In case of a credit event, the investor will receive the recovery value of the underlying asset in the CDS and lose claim over the principal. Or to put it differently, the investor will receive the principal less the amount that cannot be recovered.

A true credit derivative CLN has a third party as reference name. The settlement process is similar to that of CDS. The protection buyer, in case of a cash settlement, will pay the recovery value to the protection seller. In case of physical settlement, the note is terminated. The reference security is handed over to the protection seller.

Some CLNs may be issued by a party which is also the reference name. The occurrence of a credit event implies immediate termination of the bond. No settlement process is needed because the protection seller is already holding the bond.

A standard CLN is issued with reference to a specific bond. A CLN that is referenced to more than one credit is called *basket credit linked note*. A variant of the basket CLN is the *first-to-default CLN*, in which the investor is selling protection on the first credit-to-default. The return on the CLN is a multiple of the average spread of the basket. In a physical settlement, the defaulted asset is delivered to the bond holder. In cash settlement, the CLN issuer pays redemption proceeds to the bond holder. This is nothing but the difference between the principal and recovery value.

Synthetic CLN can be issued by a SPV that holds collateral securities financed by the issue. The SPV uses the issue proceeds to purchase the collateral and then sells credit protection to a counterparty. The SPV also provides interest on the collateral against the SPV's future performance under the CDS. The SPV may also enter into an interest rate swap to modify cash flows suitably. For example, the cash flows on the collateral may be fixed rate but the CLN cash flows may be required in floating rate form.

The CLN coupon is the sum of the returns on the collateral and the CDS premium. Investors in the CLN receive their coupon and principal at the time of redemption in the absence of any credit event. If a credit event happens during the life of the CLN, the collateral is sold to form the par payment made by the SPV to the CDS counterparty. The CLN is redeemed by the issuer at zero percent. Accrued interest payments from the collateral/CDS premium form an accrued CLN coupon which the investor receives.

The CDS counterparty is only eligible for 100% of the notional amount. Excess value of the collateral belongs to the investors. If the collateral has lower than market value, the CDS counterparty receives the compensation. The counterparty reduces the amount of defaultable obligations it delivers. When the market value of the collateral falls sharply, the investor loses the entire notional value of the CLN. The CDS counterparty will also suffer a loss.

The collateral provides a base return to the investors and acts as a collateral for the CDS counterparty. So the collateral must be acceptable to both the parties. The collateral should be chosen such that the probability of things going wrong with the reference entity and collateral, simultaneously is minimized.

In general, the CLN investors are exposed to three kinds of risk:

- Credit risk of the reference entity
- Credit risk associated with the securities making up the collateral

- Counterparty risk associated with the protection buyer.

If the collateral is highly rated and the CDS counterparty is highly rated, the focus shifts to the credit risk of the reference entity. When the SPV uses interest rate swaps to modify the cash flows, there is an additional source of risk.

Effectively, CLNs give investors an opportunity to exploit anomalies in pricing between the cash and credit protection markets. CLNs enable investors to customize their exposure with respect to currencies, maturities and coupon structures. CLNs can be traded in the same way as bonds. But CLNs lack liquidity, when compared to bonds. Moreover, there are fixed costs associated with the creation of the SPV and the various aspects of the CLN. So CLNs may make more sense for medium term rather than short term investors.

A good example of CLN use is Citigroup which had considerable exposure to Enron in 2000. Though Enron at that time was flying high, Citigroup decided to hedge the exposure using securities which resembled credit linked notes. Citi created a trust which issued the securities in the form of five year notes with interest payments. The proceeds were invested in high quality debt. If Enron did not go bankrupt, investors would receive the principal after 5 years. In the event of bankruptcy, Citi could swap the loan it had made to Enron, for the securities in the trust.

Conclusion

Credit risk management is more complex compared to market risk management with regard to data availability and modeling. Credit risk is also firm specific unlike market risk. Is this chapter, we have tried to understand the basic principles of measuring credit risk. We have also seen how credit risk can be managed using credit derivatives. As financial instruments become more and more complex and specialized, the distinction between market and credit risk is becoming increasingly blurred. We shall examine this theme in more detail in a later chapter.

References:

- E.I Altman, "Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy," *Journal of Finance,* September 1968, pp. 589-609
- Robert C Merton, "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," Journal of Finance, 29, 1974, pp. 449-470.
- Edward. I. Altman, "Credit risk measurement and management: The ironic challenge in the next decade," New York University Stern School of Business, Working Paper, February 1998, FIN-98-003.
- Rangarajan K Sundaram, "The Merton/KMV Approach to Pricing Credit Risk," Working Paper, Stern School of Business, January 2, 2001.
- John C Hull, "Options, Futures and Other Derivatives," Prentice Hall, 2006
- John C Hull, "Risk Management and Financial Institutions," Pearson Education, 2007.
- Philippe Jorion, "Financial Risk Manager Handbook," John Wiley & Sons, 2007.
- John B Caouette, Edward I Altman, Paul Narayanan and Robert W J Nimmo, "Managing Credit Risk – The great challenge for global financial markets," John Wiley & Sons, 2008.
- UBS Annual Reports, 2007 & 2008.
- Frank Partnoy, David A Skeel, "The promise and perils of credit derivatives," Working Paper, University of San Diego School of Law.