PUBLIC VERSION

Credit Portfolio Management Instruments

Determination of the Effectiveness of Utilising Credit Derivatives in Credit Portfolio Management

Nazia Habiboellah

September 2004

vrije Universiteit *Amsterdam*
Faculty of Exact Sciences
Business Mathematics & Informatics
De Boelelaan 1081a
1081 HV Amsterdam

Rabobank International
Control RI
Modelling & Research
Croeselaan 18
3521 CB Utrecht

Credit Portfolio Management Instruments♦

♦ This public version does not contain business confidential information. As a result certain parts have been removed from chapters five, six. and eight.

Credit Portfolio Management Instruments

Determination of the Effectiveness of Utilising Credit Derivatives in Credit Portfolio Management

Thesis

Preface

As part of the study Business Mathematics and Informatics (BMI) at the *vrije* Universiteit (VU) in Amsterdam, an external work placement is obliged. During this work placement theoretical knowledge has to be applied in practice. Special attention has to be paid to the integration of the three fields of expertise, namely Business Administration, Mathematics and Computer Science.

I carried out my internship at the Modelling & Research (M&R) department of Rabobank International in Utrecht. As part of the Risk Research & Development team, I performed a study on modelling the credit risk mitigation by utilisation of credit derivatives as a part of credit portfolio management. The past six months have been a valuable experience for me, both on a personal and a content level. Besides a busy and stressful period, it has also been a pleasant and memorable experience.

During my internship I received support from several people. First and foremost, I would like to thank my internal supervisors at Modelling & Research, Ir. drs. W.N. Foppen and drs. H. Sijtsma for their excellent guidance, valuable advice and support during my work placement. A word of thanks also goes to Martijn Derix, Gerben Hagedoorn, Adriaan Kukler, Mark Lauber and Macé Mesters for their help during my work placement.

Furthermore, I would like to thank my supervisors at the VU, Prof. dr. H.R.M. Kersten (first supervisor) and dr. H. van Zanten (second supervisor) for their guidance during my exploration of Credit Portfolio Management.

Last but not least, I would like to express my gratitude to my family for being there for me at all times, during my education and beyond. I want to thank my parents for giving me the opportunity to continue my study and for their love and support, my grandmother for her care and especially her patience with me during the last nine years, and my siblings for just being there. Although I never say it: I do love you! I want to thank my elder sister, Reshma, in particular for her guidance, support and valuable advice during my education. I have given you several grey hairs, I'm sorry about that!

Purmerend, September 2004

Nazia Habiboellah

Management Summary

With the introduction of the BIS II regulations, new rules will apply for measuring credit risk. In contrast to BIS I, the size of the required capital buffer depends on the creditworthiness of the assets and the diversification within the credit portfolio. The more diversified the portfolio, the lower the required capital buffer will be. Since banks generally develop expertise in particular markets, they do not always have the ability to originate a fully diversified mix of assets. The resulting concentrations leave many banks overexposed to particular economic sectors, like the Food & Agriculture sector for instance.

As BIS II prescribes general rules for determining the diversification in the portfolio and the required capital buffer, banks also tend to develop their own Economic Capital framework. This internal framework enables banks to measure the true economic risks of their credit portfolio, taking into account the existing name and sector concentrations.

The reduction of these risk concentrations, and the possible fulfilment of arbitrage opportunities can be realised by means of credit instruments, like secondary sales, securitisation, insurance and credit derivatives. Based on the liquidity and risk characteristics of the assets, the client bank relationship and the purpose of the transaction, one of these instruments can be selected.

This thesis focuses on the utilisation of credit derivatives as a tool for portfolio management, for they enable partial regulatory and economic capital relief, without actually having to sell the assets. The objective has been defined as:

'Gaining insight in the main credit derivatives that can be applied in credit portfolio management, and taking a first step in developing a framework for measuring the credit risk reduction, when Credit Default Swaps or Collateralised Debt Obligations are applied to the RI Portfolio.'

Credit derivatives are specialised financial contracts that allow participants to increase or decrease their credit exposure to a particular name or basket of names, for a particular period of time. The payoff of a credit derivative is linked to the creditworthiness of a given company or sovereign entity. Two types of credit derivatives can be distinguished, being derivatives that offer protection against defaults and bankruptcies, and derivatives that offer protection for increasing yield spread or changes in credit rating. In this thesis only derivatives of the first type are discussed, for from a portfolio management perspective, a loss is suffered only then when a default has occurred.

According to estimates of the British Bankers' Association the Credit Default Swap (CDS) and the Collateralised Loan Obligation (CLO) will be the main credit derivatives in the global market in 2004. A CDS enables the risk transfer on one single asset, whereas a CLO involves the risk transfer on a pool of assets. The distinctive characteristic of a CLO is that the credit risk on a pool of assets is tranched in securities with different levels of subordination. The investors in the most subordinated tranche suffer the first losses in the portfolio, while the investors in the more senior tranches only suffer a loss when the most subordinated tranches are exhausted.

The cost-benefit analysis of a CDS or CDO transaction depends on the risk costs when the assets are retained in the portfolio, and the potential costs associated with mitigating the credit risk involved, being transaction costs, premium costs and risk costs. An important part of the internship focused on assessing the risk costs of the hedged asset, for the utilisation of credit derivatives is not completely risk free. When the risk cost reduction is greater than the premium and transaction costs, it is profitable to conclude the transaction.

The risks after applying a CDS are identified as double default risk, replacement risk and basis risk. To determine the effectiveness of a CDS transaction, the anticipated risk cost reduction is considered against the premium costs made to transfer the risk. Only the spread (premium costs) is included in the cost-benefit assessment, for the transaction costs are negligible compared to the spread payment.
It turned out that CDS transactions are not always profitable for the Rabobank. Furthermore, the timing of buying the CDS is an important factor in determining the effectiveness of the transaction. Further study should relax the model assumptions and sharpen the conclusions that have been made.

As for CDO's a foundation for a framework has been laid down, that enables the future cost-benefit analysis for real-life transactions. For now, only the risk costs before and after the deal are modelled for a fully funded synthetic CDO. The remaining risk for RI involves the credit risk of the tranches that are retained. However, nothing can be said about the effectiveness of the deal yet, because the transaction costs, the premium payments, and the interest payments on the tranches still have to be assessed.

List of Figures

List of Tables

List of Acronyms

ABS	Asset Backed Securities
Bps	Basis points
BBA	British Bankers' Association
BIS	Bank of International Settlements
CBO	Collateralised Bond Obligation
CDO	Collateralised Debt Obligation
CDS	Credit Default Swap
CLO	Collateralised Loan Obligation
CLN	Credit Linked Note
CM	Capital Multiplier
CMBS	Commercial Mortgage Backed Securities
CoC	Cost of Capital
EAD	Exposure At Default
EC	Economic Capital
EL	Expected Loss
EVA	Economic Value Added
FX	Foreign Exchange
ISDA	International Swaps and Derivatives Association
LIBOR	London Inter-Bank Offered Rate
LGD	Loss Given Default / Severity
MBS	Mortgage Backed Securities
MTM	Mark-To-Market
OECD	Organisation for Economic Co-operation and Development
OTC	Over-The-Counter
OWC	Oliver, Wyman & Company
PD	Probability of Default
RAROC	Risk-Adjusted Return On Capital
RI	Rabobank International
RMBS	Residential Mortgage Backed Securities
SPV	Special Purpose Vehicle
TRS	Total Return Swap
TRORS	Total Rate Of Return Swap
UL	Unexpected Loss

Table of Contents

Appendices

Introduction

I. Background

The banking industry is a heavily regulated sector with respect to capital requirements. The objective of the capital regulation has always been to reduce the number of bank failures. Therefore, sufficient capital must be reserved as a buffer to absorb losses that would otherwise cause banks to fail [Ong, 1999].
The regulations that determine the size of the capital buffer are developed by the Bank of International Settlement[1] (BIS). Besides the regulatory capital, which is based on *general* capital requirements prescribed to all banks, banks also reserve Economic Capital. The Economic Capital buffer is determined by the *internal* capital requirements specified by the bank and considers the 'actual' risk of the bank.

The first Capital Accord, also referred to as BIS I, dates of 1988. As a consequence of the innovations and increased complexity in financial intermediation these regulations have become obsolete. Therefore, a new regulatory framework (BIS II) has been developed, which will come into force in 2007. However, the new rules are to be implemented by banks before the beginning of 2006.
BIS II outlines minimal capital requirements for three types of risk, being market risk, operational risk and credit risk. The latter is considered to be the most important risk type in banking. Besides aforementioned risk types, banks are supposed to consider all other major risks when determining the Economic Capital buffer.

The main objectives of the new capital adequacy regulations are [Ghosh, 2003]:
- to make capital allocation of banks more risk sensitive;
- to distinguish between capital charges for credit risk and operational risk;
- to ensure that regulatory capital requirements are more in line with the Economic Capital requirements; and
- to encourage banks to use their internal systems for arriving at levels of regulatory capital.

[1] The Bank of International Settlements, located in Basle, Switzerland, was founded in 1930 and is an important forum for banking supervisors and central banks of the major industrialised nations to discuss and co-ordinate risk policies [Ong, 1999].

II. Rabobank International

The Rabobank Group is the largest mortgage bank of the Netherlands, with approximately 328 member banks across the country. Rabobank International (RI) is the internationally orientated Corporate Finance and Investment Banking activity of the Rabobank Group, which has built a worldwide reputation as specialist in the area of Food & Agribusiness. To provide optimal service to her clients, RI has approximately 90 offices spread over 33 countries. Among the clients of RI are large (international) companies in the Food & Agribusiness as well as first class financial institutes, like pension funds, insurers and banks.

Control RI is the central control department of Rabobank International. Within Control RI, the Modelling and Research (M&R) section is responsible for the development, validation and maintenance of innovative (mostly quantitative) risk management techniques. The M&R section is currently contributing to the efforts of the bank to become compliant with BIS II regulations and the implementation of an adequate Economic Capital framework.

III. Objective and Scope

Partly due to the new capital regulations, banks are now recognising the importance of credit portfolio management. In November 2003 a pilot portfolio management project has been initiated within Global Credit Risk Management (GCRM), with the aim to investigate possibilities as to mitigate the credit risk exposure of the RI portfolio.
Currently, the RI portfolio is concentrated on the whole value chain of the Food & Agribusiness sector. It is easier to withstand a setback in a certain sector, when the portfolio concerned is diverse, i.e. focussed on a number of sectors. Therefore, GCRM is looking into methods to reduce the credit risk of the portfolio. To this end, several portfolio management instruments are available.

This thesis is focused on gaining insight in the types of portfolio management instruments and their effect on the risk-return ratios. The main instruments of interest are credit derivatives. As determined by the Modelling & Research division of Control RI, the credit derivatives within the scope of this thesis are Credit Default Swaps (CDS's) and

Collateralised Debt Obligations (CDO's), where the CDS's are limited to standardised products for which ISDA[2] documentation is available.

The objective of this thesis is twofold, and can be defined as:

> ***'Gaining insight in the main credit derivatives that can be applied in credit portfolio management, and taking a first step in developing a framework for measuring the credit risk reduction, when Credit Default Swaps or Collateralised Debt Obligations are applied to the RI Portfolio.'***

The current internal credit risk framework of RI measures the credit risk of the RI portfolio and is used to determine the Economic Capital requirements. By applying the above-mentioned credit derivatives the credit risk exposure will be reduced. After the credit risk reduction is determined, it is compared to the costs associated with the credit derivative involved, in order to balance the benefits and costs against each other.

The following questions can be derived from aforementioned objective:

1. What kinds of portfolio management instruments can be distinguished, and how do these instruments work?
2. Which are the main credit derivatives used in the market today, and how do these products work?
3. How can the Rabobank credit risk framework be applied to CDS's, and how can this be modelled?
4. How can the Rabobank credit risk framework be applied to CDO's, and how can this be modelled?

---

[2] ISDA is the International Swaps and Derivatives Association, a global trade association representing participants in the privately negotiated derivatives industry. The ISDA's 'Master Agreement' has become the industry standard for derivatives contract documentation.

IV. Report structure

This paper is divided into three parts, which can be read separately:
PART I : Credit Portfolio Management
PART II : Risk Management Instruments - Credit Derivatives
PART III : The Credit Risk Framework - Modelling CDS's and CDO's

Part I of this thesis encompasses an introduction to credit portfolio management and consists of two chapters. The first chapter discusses credit risk and the portfolio management process. The second chapter outlines the available portfolio management instruments and describes their use (question one).
Part II gives an introduction to several types of credit derivatives (question two), and their use in managing the credit risk exposure in a portfolio. This part consists of two chapters. In the first chapter, chapter three, the most popular derivatives are discussed. In the second chapter, chapter four, special attention is paid to the CDO structure. While CDO's are often categorised under credit derivatives, it actually is a form of securitisation, which can be used in combination with credit derivatives. Several aspects which determine the type of CDO are treated.
Part III is meant for those who are already familiar with credit derivatives, and are merely interested in the modelling process. This part consists of three chapters. The first chapter, chapter five, discusses the credit risk framework of Rabobank International. Chapter six discusses the modelling of the risk reduction by utilisation of a CDS (question three) and in chapter seven the process of modelling the cost reduction associated with a CDO is treated (question four).
Finally, chapter eight summarises the conclusions of the investigation, and furthermore some points for further research are stated.

The structure of this thesis is depicted in Figure 0.1. The arrows reflect the dependencies between the chapters.

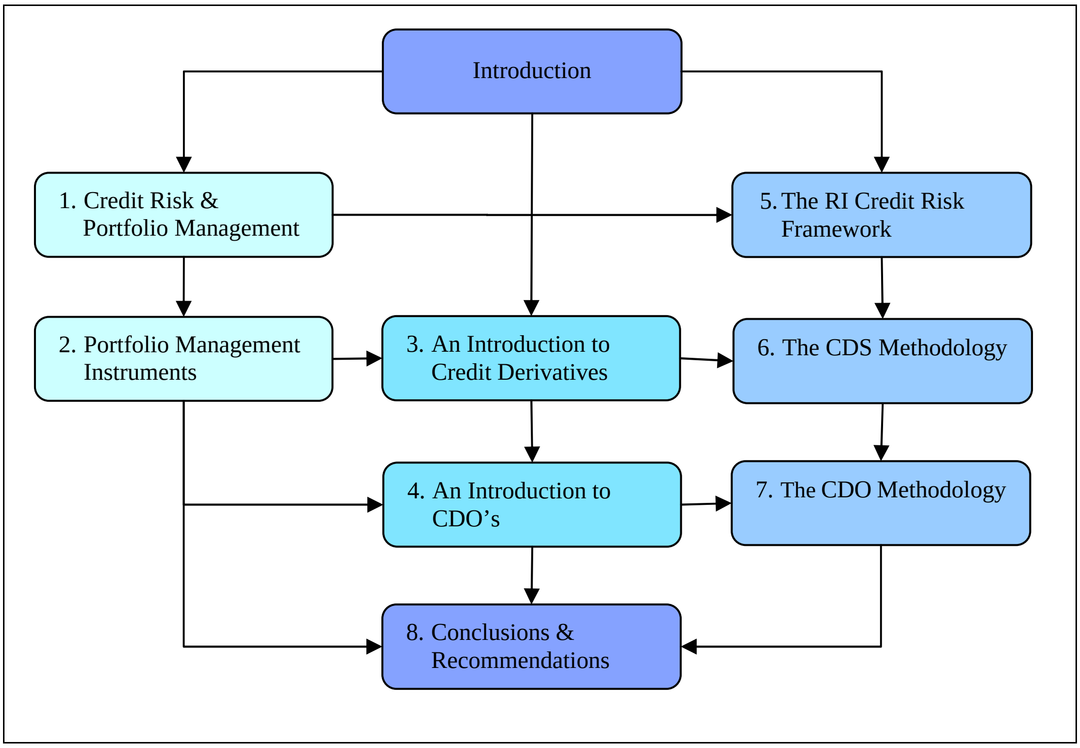


Figure 0.1: Report Structure

PART I: Credit Portfolio Management

1. Credit Risk and Portfolio Management

1.1 Introduction

Recently, many large banks have begun to analyse their loan books quantitatively, with the goal of optimising the risk-return profile of the entire portfolio. Generally, most loan books do not represent an optimal portfolio because of industry, geographic, or credit quality concentrations. These concentrations leave many banks overexposed to particular sectors. In case of a setback in one of those sectors, the bank could suffer significant losses. Therefore, it is important for banks to measure and manage their risk exposures carefully.

But, what is risk? From a banking point of view, risk is the financial uncertainty that the actual return on an investment will be different from the expected return [Datek]. In many risky situations the possible outcome can be classified either as a loss or a gain. However, generally only the 'downside' possibility of loss is considered to be risky, not the upside 'potential' for gain.

In this chapter the focus lies on credit risk management, which can be performed on a transaction and a portfolio level. In paragraph 1.2 an overview of the risks in banking is given, followed by a discussion of the risk management process is in paragraph 1.3. Subsequently, the importance of credit risk management is discussed in paragraph 1.4. Thereupon an overview is given of the sources of credit risk in banking and the indicators for assessing the level of credit risk in paragraph 1.5. The measurement of credit risk is treated in paragraph 1.6, and finally, portfolio management is discussed in paragraph 1.7, including the basic portfolio model of Markowitz and some alternative risk-return measures.

1.2 Risks in Banking

Various risks are involved with financial intermediation. An overview of some of these risks is given in Table 1.1. Credit risk, however, is considered to be the most important risk type in banking, for the losses suffered from credit risk can by far exceed the losses suffered from the other risk types.

Risk Type	Description
Business Risk	The risk of a loss due to changes in the competitive environment or the adaptability of the company. Business risk is a two-fold risk type: both the external environment and the internal flexibility need to be assessed. [RAROC, 2004]
Country Risk	The risk that a country won't be able to honour its financial commitments. When a country defaults it can harm the performance of all other financial instruments in that country as well as other countries it has relations with. This type of risk is most often seen in emerging markets or countries that have a severe deficit. [Investopedia.com]
Credit risk	The risk that a company or individual will be unable to pay the contractual interest or principal on its debt obligations. [RAROC, 2004]
Foreign Exchange Risk	Foreign exchange risk applies to all financial instruments that are in a currency other than your domestic currency. When investing in foreign countries you must consider the fact that currency exchange rates can change the price of the asset as well. [Cornett, 2002]
Insurance Risk	The risk of loss due to an unforeseen increase in non-catastrophe claims such as car accidents, fires and so forth. [RAROC, 2004]
Interest Rate Risk	The risk of (market) value changes that can be lost due to unexpected rate changes, compared to the expected future value. [RAROC, 2004]
Market Risk	The risk of adverse movements in market factors (such as asset prices, foreign exchange rates, interest rates) that cause volatility in P&L. [RAROC, 2004]
Operational Risk	The risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. [RAROC, 2004]
Political Risk	This represents the financial risk that a country's government will suddenly change its policies. This is a major reason that second and third world countries lack foreign investment. [Investopedia.com]
Transfer Risk	The risk due to the possibility that funds in foreign currencies cannot be transferred out of a country. [RAROC, 2004]

Table 1.1: Definitions of Risks

To be able to absorb the losses due to the various risks, banks are obliged to reserve capital. A distinction can be made between two types of capital, being regulatory capital and Economic Capital. The regulatory capital is determined by general rules prescribed to all banks by the Basle committee. In the new capital accord (BIS II) minimal capital requirements are stipulated for market risk, operational risk and credit risk (Pillar I). The Economic Capital buffer is determined by the banks' internal rules for solvency. These rules are stricter and include more risk types. In the EC framework of the Rabobank for instance, capital is reserved for credit risk, market risk, operational risk, interest rate risk, transfer risk, business risk and insurance risk [RAROC, 2004].

Furthermore, risk can be said to be systematic or unsystematic. A s*ystematic risk* influences the whole market, like for instance political events. It is virtually impossible to protect yourself against this type of risk. *Unsystematic risk*, also called (firm) specific risk affects a very small number of assets. For instance, the news of a sudden strike by employees, will only affect a specific stock. The means to protect oneself against this type of risk will be discussed in paragraph 1.3.

1.3 The Risk Management Process

The risk management process provides a framework for identifying risks and deciding what to do about them. The process consists of five phases [Bodie, 2000]:

PHASE I: Risk Identification

In the first phase the most important risk exposures are determined for the unit under analysis. This can for instance be a company, or a stock or loan portfolio.

PHASE II: Risk Assessment

In the second phase, the costs associated with the risks that have been identified in the first phase are quantified.

PHASE III: Selection of Risk Management Techniques

After the identification and quantification of the risk exposure, steps can be taken to reduce the risk. Four basic techniques for reducing risk are outlined below.

1. *Risk avoidance*

   Risk avoidance means that a conscious choice is made not to be exposed to a particular risk. This means that the choice can be made not to close a deal with a certain party, because of the risks involved.

2. *Loss prevention*

   With loss prevention specific actions are taken to reduce the likelihood or the severity of losses. The severity of a loss can be reduced with a netting agreement or additional collateral. When two parties enter into a netting agreement, it means that their mutual debt obligations are netted. When one of the parties defaults, the actual loss incurred is equal to the loss amount minus the debt obligations towards the defaulted party.

3. *Risk retention*

   Risk retention means that the risks are absorbed by covering the losses with own resources.

4. *Risk transfer*

   This means that risks are transferred to a third party. There are three basic methods of accomplishing the transfer of risk:

   - <u>Hedging</u>

     Hedging means to protect oneself from losing money in one transaction by engaging in a counterbalancing transaction. In hedging, the action taken to reduce the exposure to a loss eliminates the possibility of a gain.

   - <u>Insuring</u>

     Insuring means paying a premium to avoid a loss. By buying insurance, a sure loss (the premium paid for the policy) is substituted for the possibility of a larger loss in case of no insurance. In contrast to hedging, the premium is paid to eliminate the risk of loss, without giving up the potential for gain.

   - <u>Diversifying</u>

     In order to limit the risk exposure to any single asset, it is possible to diversify investments. This means that instead of concentrating all investments in only one risky asset, a similar amount of many risky assets is held. So, when one of the risky assets fails to perform it is still possible to profit from the investments in the other risky assets.

     The diversification principle states that by diversifying across risky assets it is sometimes possible to achieve a reduction in the overall risk exposure with no reduction in the expected return. The part of the portfolio volatility that can be eliminated by adding more stocks is the diversifiable risk (unsystematic risk), and the part that remains, no matter how many stocks are traded, is the non-diversifiable risk (systematic risk).

PHASE VI: Implementation

In this phase the selected techniques are implemented, with the restriction that the implementation costs have to be minimised.

PHASE V: Review

As time passes and circumstances change it will be necessary to review and revise the decisions made. This is done in the final phase.

1.4 Credit Risk Management

The goal of credit risk management is to maximise a bank's risk-adjusted rate of return (RAROC) by maintaining the credit risk exposure within acceptable parameters. Over the last years several new approaches have been developed to measure credit risk. Allen and Saunders distinguish seven reasons for this development [Allen, 2002]:

1. *The Structural Increase in Bankruptcies*

   There has been a permanent or structural increase in bankruptcies worldwide, which possibly is caused by the increased global competition. Therefore accurate credit risk analysis becomes even more important today than in the past.
2. *Disintermediation*

   Since the capital markets have become accessible to small and medium-size firms, the intermediation position of banks and other financial institutions is compromised. The loans which were previously made by banks can now be financed directly by the investors. As a result, the borrowers that are left to raise funds through financial intermediation are likely to be smaller and have a weaker credit rating.
3. *More Competitive Margins*

   In spite of the declined credit quality of loans, the margins on the loans have become tighter. An important factor for this is the increasing competition for the lower quality borrowers.
4. *Declining and Volatile Values of Collateral*

   Property and real estate values are hard to predict and realise through liquidation. The lower and more uncertain the collateral values are, the riskier the lending is likely to be.
5. *The Growth of Off-Balance Sheet Derivatives*

   The growth of the derivatives market has lead to great off balance sheet credit risk exposures. Therefore the need arose for credit risk analysis beyond the loan book.
6. *Technology*

   Because of the technological developments it is possible for banks and other financial institutions to collect and analyse huge amounts of default data.
7. *The BIS Risk-Based Capital Requirements*

   Probably the most important reason for the development of new measurement approaches is the new Capital Accord. Under the BIS II regulations the capital allocated to the loan is based on the credit rating of the counterparty. Furthermore, the new regulations permit lower capital requirements in case of greater diversification in the loan portfolio.

1.5 Credit Risk in Banking

Credit risk leads to volatility of the bank's earnings and interest income due to the inability of borrowers and counterparties to meet their payment commitments. In Figure 1.1 an illustration is given of the various sources of credit risk in banking.

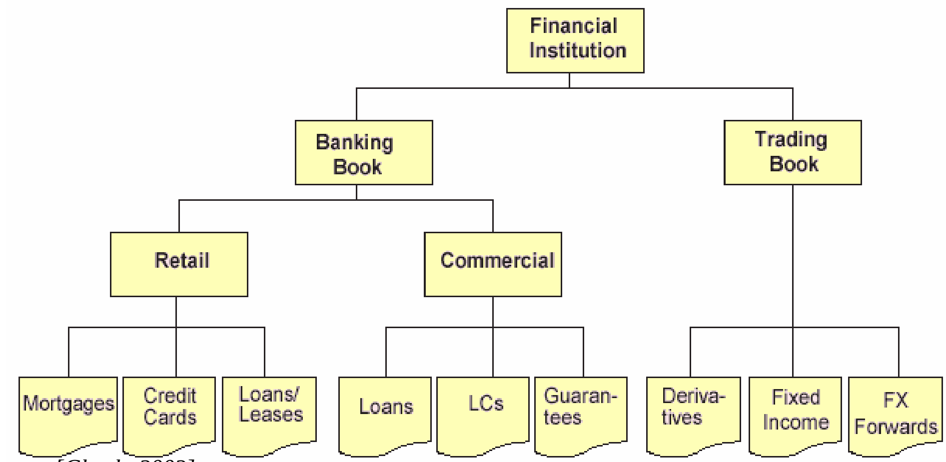


Figure 1.1: Sources of credit risk

When a counterparty cannot make its payment commitments, that party is considered to be in default. Generally speaking, the default process is not an abrupt one. A default does not occur out of the blue. Often there is a gradual deterioration of a firm's financial position and asset quality, for instance a degradation of its creditworthiness, which could potentially end in a default.

There are two important indicators for the level of credit risk of a borrower, namely the credit spread and the credit rating. The credit spread of a security is the compensation investors receive for bearing credit risk, and can be seen as the market's assessment of its credit risk.

A credit rating is a subjective assessment of the borrower's credit risk, measured on an alphanumeric scale. There are three credit rating agencies that are recognised worldwide, namely Standard & Poor's (S&P's), Moody's Investor Service and Fitch IPCA Ratings. Each of them have a universal rating scale and assign domestic and external ratings at the borrower's request. An overview of the credit ratings for each rating agency is given in

Table 1.2 [*Source*: WRL Ratings]. The first four major rating classes are collectively called investment grade and the remaining ratings are called speculative grade.

Fitch IPCA Ratings		Moody's Investors Service		Standard & Poor's	
AAA	Exceptionally Strong	Aaa	Exceptional	AAA	Extremely Strong
AA+	Very Strong	Aa1	Excellent	AA+	Very Strong
AA	Very Strong	Aa2	Excellent	AA	Very Strong
AA-	Very Strong	Aa3	Excellent	AA-	Very Strong
A+	Strong	A1	Good	A+	Strong
A	Strong	A2	Good	A	Strong
A-	Strong	A3	Good	A-	Strong
BBB+	Good	Baa1	Adequate	BBB+	Good
BBB	Good	Baa2	Adequate	BBB	Good
BBB-	Good	Baa3	Adequate	BBB-	Good
BB+	Moderately Weak	Ba1	Questionable	BB+	Marginal
BB	Moderately Weak	Ba2	Questionable	BB	Marginal
BB-	Moderately Weak	Ba3	Questionable	BB-	Marginal
B+	Weak	B1	Poor	B+	Weak
B	Weak	B2	Poor	B	Weak
B-	Weak	B3	Poor	B-	Weak
CCC	Very Weak	Caa1	Very Poor	CCC	Very Weak
CC	Very Weak	Caa2	Very Poor	CCC-	Very Weak
C	Very Weak	Caa3	Very Poor	CC	Extremely Weak
DDD	Distressed	Ca	Extremely Poor	R	Regulatory Supervision
DD	Distressed	C	Lowest	NR	Not Rated
D	Distressed				

Table 1.2: Rating Scales

Fitch IPCA Ratings distinguishes twelve major rating classes, which are refined into minor ratings by adding a + or – sign to a rating to indicate the relative position of a credit within the rating category. The suffixes are not added to ratings in the AAA category or to ratings below the CCC category. The rating scale of Moody's Investor Service consists of nine major rating classes, which are refined by applying the postfixes 1 to 3 in each rating from Aa through Caa. S&P's distinguishes 9 major rating classes. The ratings from AA to CCC are refined by adding a + or a – sign to show the relative standing within the major rating categories.

Many financial institutions also assign internal credit ratings to their counterparties. Similarly, the Rabobank has developed its own rating scale. The master scale of the Rabobank, the Rabobank Risk Rating (RRR) consists of 21 performing classes R0 to R20 and four default classes D1 to D4 [KRM, 2004]. For a more detailed overview of the Rabobank Risk Rating master scale refer to Appendix A.

1.6 Credit Risk Measurement

According to Ong banks need to measure the credit risk of the entire portfolio as well as the credit risk of individual transactions [Ong, 1999]. He distinguishes three factors that determine the credit risk of a single transaction, namely:

- *The Default Probability*
  This is the probability that the obligor or counterparty will default on its contractual obligations to repay its debt.
- *The Recovery Rate*
  This is the extent to which the face value of an obligation can be recovered once the obligor has defaulted.
- *Credit Migration*
  This is the extent to which the credit quality of the obligor or counterparty improves or deteriorates.

In practice a portfolio contains a number of loans and obligations. However, the credit risk of a loan portfolio is not equal to the sum of the credit risk of single transactions. This is caused by correlation between the loans. In general the correlation between loans is smaller than one, which means that when one loan defaults other loans in the portfolio could still perform well, offsetting the loss on the other loan. This leads to a smaller credit risk on the overall portfolio. So, in addition to the factors mentioned above Ong distinguishes the following elements:

- *The Default and Credit Quality Correlation*
  This is an indicator for the degree to which the default or credit quality of one obligor is related to the default or credit quality of another obligor.
  For example, when client A and client B trade in the same sector and country, the correlation between the default or credit quality will be higher than when both clients conduct business in different sectors or countries. Thus, the loss incurred in case of a setback in a sector will be higher when the correlation is high.
- *Risk Contribution and Credit Concentration*
  This is the extent to which an individual instrument or the presence of an obligor in the portfolio contributes to the totality of risk in the overall portfolio.
  When the correlation of an obligor with the remaining loans in the portfolio is high, the risk contribution of the obligor will be high too, for the loan does not diversify well with the remaining portfolio.

The advantages of the portfolio approach with respect to the single transaction approach are:

- *Concentration Risk can be Quantified.*
  Concentration risk is the risk that is added when there are a lot of outstanding debts in a certain category, like for instance in a certain country or sector. A setback in this category will cause a major loss in the whole portfolio. Concentration risk can be identified when the portfolio approach is applied.
- *The Diversification-effect of a Loan is Quantifiable.*
  The portfolio approach enables the quantification of the diversification effect of adding a loan to the portfolio. For instance, when a selection has to be made of two loans with the same return, the loan that increases the diversification-effect should be added to the portfolio.
- *The Marginal Contributions can be Quantified.*
  The marginal contribution of a loan gives the extent to which the individual loan contributes to the total risk of the portfolio. The marginal contribution is high in case of low diversification, and low in case of high diversification. The marginal contribution is a good indicator for determining whether or not a loan should be included in the portfolio. For instance, the loans could be selected on the basis of the expected return relative to the marginal contribution.

1.7 Portfolio Management

Portfolio theory is defined as quantitative analyses for optimal risk management. Applying portfolio theory consists of formulating and evaluating the trade offs between the benefits and costs of risk reduction in order to find an optimal course of action [Bodie, 2000]. Portfolio theory assumes that investors are basically risk averse, and that they want to maximise the returns from their investments for a given level of risk. In this paragraph several performance measures will be discussed.

1.7.1 Markowitz' Portfolio Model

Markowitz is the founder of modern portfolio theory. He derived the expected rate of return for a portfolio, and showed that the variance of the rate of return is a meaningful measure of portfolio risk[1]. The aim of the model was to minimize the risk of a portfolio of assets for a given level of expected return. A portfolio is said to be efficient if there is no portfolio with the same standard deviation and a greater expected return, and no portfolio

[1] For the set of assumptions made by Markowitz or a detailed discussion of his portfolio model refer to [Brown, 1997] or [Markowitz, 1991].

with the same return and a lesser standard deviation. The collection of all the efficient portfolios is called the efficient frontier.

1.7.2 Other Performance Measures

Over the years more sophisticated risk/return measures have been developed. In this paragraph the Sharpe Ratio, Economic Value Added and the Risk Adjusted Return On Capital will be discussed.

Sharpe Ratio

The Sharpe Ratio is a marginal measure that compares the return on an investment to the risk of the investment. It combines the two measures into one, and is defined as:

$$\text{Sharpe Ratio} = \frac{\text{Return on Investment - Risk Free Rate}}{\text{Standard Deviation of Returns}}\,.$$

Thus, the Sharpe Ratio represents the return on an investment per unit of risk. The higher the ratio will be, the better the investment.

Economic Value Added

The Economic Value Added (EVA) represents the annual contribution to shareholder value and is defined as:

$$\text{EVA} = \text{Adjusted Income} - \text{Cost of Capital},$$

where the adjusted income is given by the sum of the received spread and fees minus the expected loss and operational expenses. The cost of capital is determined by the hurdle rate multiplied by the Economic Capital. The hurdle rate reflects the bank’s cost of funds or the opportunity cost of stockholders in holding equity in the bank. So, in some models the hurdle rate is the banks stockholders’ Return On Equity (ROE), while in other models it is a measure of the risk weighted-average cost of capital (WACC) [Allen, 2002].

In contrast to the Sharpe Ratio, the risk concentration of the portfolio is included in the EVA. In the context of lending, the EVA requires the loan to be made only if it adds to the economic value of the bank from shareholders perspective. In other words, the EVA of a loan should be greater than zero.

Risk Adjusted Return On Capital

In contrast to EVA, the Risk Adjusted Return On Capital (RAROC) is a marginal risk measure and is defined as:

$$\text{RAROC} = \frac{\text{Adjusted Income}}{\text{Economic Capital}}$$

The RAROC is meant to be compared with the hurdle rate [Allen, 2002]. When the RAROC of a loan is greater than the hurdle rate, the loan is viewed as value adding.

2. Portfolio Management Instruments

2.1 Introduction

With active credit portfolio management, a group of portfolio managers is assigned responsibility for the buying, selling and hedging decisions with respect to the asset portfolio. The portfolio manager’s main concern is the reduction of the likelihood of a loss and optimising the risk/reward equation. To accomplish this, risk concentrations must be offloaded, and the portfolio has to be diversified.

There are various instruments to manage the credit risk exposure in a portfolio. The traditional methods for managing credit risk, like loan underwriting standards[1] and diversifying are necessary first steps for managing the credit risk exposure. However, their ability to reduce risk is limited, since the diversification opportunities are scarce [Neal, 1996]. Consequently, banks are searching for instruments to transfer the credit risk exposure to a third party.

In this chapter, an overview of the available risk transfer instruments will be given in paragraph 2.2. Subsequently, secondary sales and securitisation will be treated in paragraph 2.3 and 2.4 respectively. Thereafter, credit insurance and credit derivatives are discussed in paragraph 2.5 and 2.6 respectively. Finally, in paragraph 2.7 the differences between the instruments discussed will be summarised.

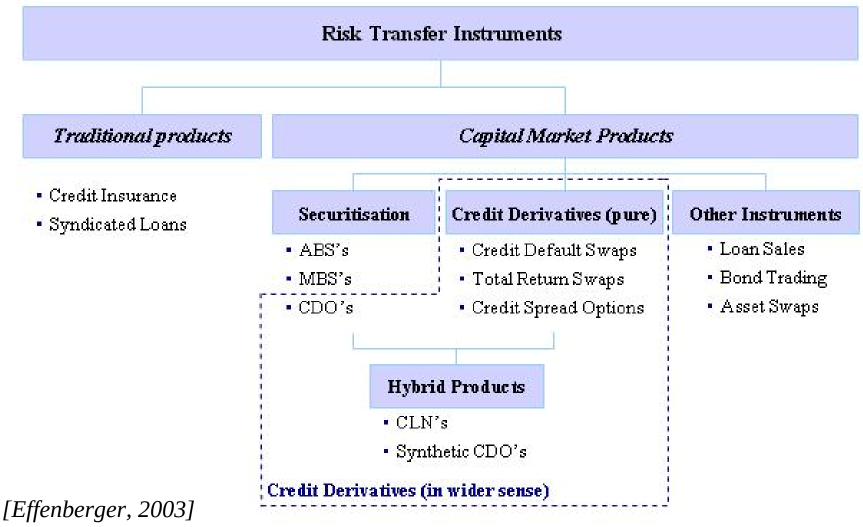
2.2 Risk Transfer Instruments

Effenberger distinguishes two major groups of instruments to transfer risk, being traditional instruments and capital market instruments [Effenberger, 2003]. An overview of the classification is given in Figure 2.1.
The traditional risk transfer instruments include loan syndication, which is the process of involving numerous different lenders in providing various portions of a loan. This instrument is mainly used in extremely large loan situations. Syndication allows a lender

---

[1] Underwriting Standards are an internal procedure document to assist the bank loan officers in the process of evaluating and analysing the creditworthiness of the borrower. The credit risk is managed by controlling the terms of the loan, like setting limits to the size of the loan and asking for collateral for instance.

to provide a large loan while maintaining a more manageable credit exposure because they are not the only creditor.



Source: [Effenberger, 2003]

Figure 2.1: Risk Transfer Instruments

The capital market instruments encompass securitisation, credit derivatives and other instruments that involve the trade of risk, like secondary sales and asset swaps. Effenberger distinguishes between pure credit derivatives and credit derivatives in a wider sense. The latter additionally encompasses derivatives that are closely related to securitisation products, which include collateralised debt obligations (CDO) and hybrid products.

2.3 Secondary Sales

With secondary sale a loan is sold in the secondary market[2]. After the loan that needs to be sold is identified, an indication of the price has to be obtained. Since the secondary market is an OTC market[3], each of the potential counterparties has to be approached individually to get the price quotes. After the quotes are received, the next step is to pick

[2] The secondary market is the market where an investor purchases an asset from another investor, rather than the issuing party. The market in which investors have the first opportunity to buy a newly issued security is called the primary market.

[3] An Over-The-Counter (OTC) market is a market where securities transactions are made via telephone and computer rather than on the floor of an exchange.

a buyer, agree on a price and properly document the loan transfer. This process could take several months.

The benefits of transferring loans to a third party are the regulatory and economic capital relief. By selling the loans the risk exposure of the bank will decrease, leading to lower capital requirements. By selling the loan cash is coming in sooner than when the loan would be held until maturity. This can be seen as advantage, for the generated cash can be used to grant new loans.

An important disadvantage of secondary sales is that the valuable client bank relation may be compromised. As part of so-called relationship banking, banks sometimes grant loans with a relative low margin to their regular clients in the hope of selling them other services with a higher margin. If the loan is sold, the bank is obliged[4] to notify the client, which could harm the relationship. For the client could interpret it as a signal that the bank does not value their relation [NIBE-SVV, 2003].

2.4 Securitisation

A broad description of asset securitisation is given by Ong [Ong, 1999]. He defines asset securitisation as the process where loans, receivables and other illiquid assets with similar characteristics in the balance sheet are packaged into interest-bearing securities that offer attractive investment opportunities.

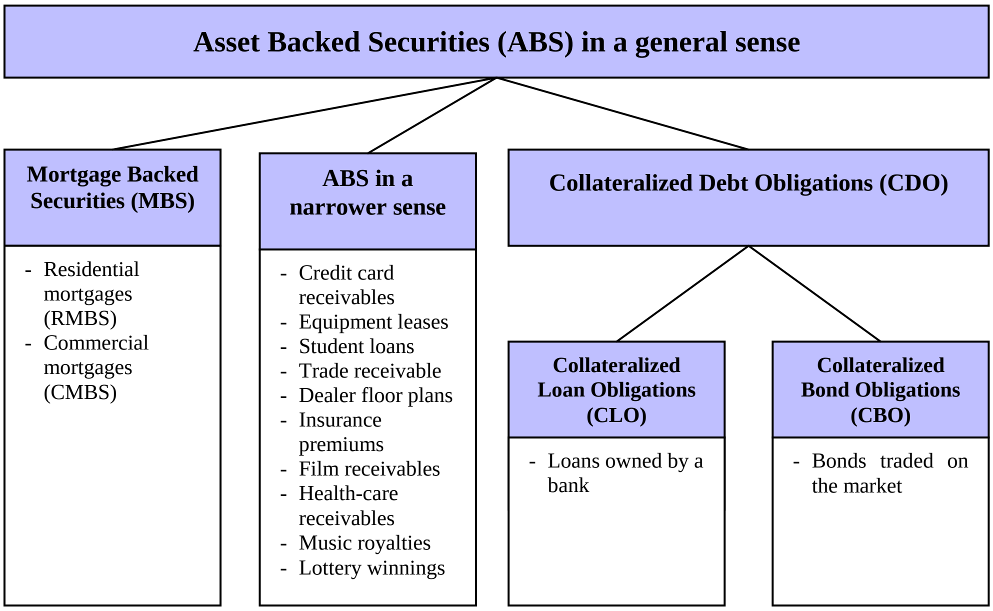
Jobst [Jobst, 2002] describes securitisation as the process that enables the transfer of asset risk to capital market investors in return for the cash flows generated from an asset portfolio (the reference portfolio). The risk on the reference portfolio is distributed over several tranches, where each tranche represents a group of investor with different risk appetites. The most junior tranche (the first loss position) bears any initial losses.

The generic term for the securitised assets is Asset Backed Securities (ABS's). Usually, the ABS's are backed by a portfolio of a large number of homogenous receivables [Jobst, 2002]. Figure 2.2 gives an overview of the various types of securitisation.

When the reference portfolio only consists of private and commercial mortgages the securitised assets are called mortgage backed securities (MBS's). In case only corporate or sovereign debt securities or bank loans are repackaged, the securitised assets are referred to as Collateralised Debt Obligations (CDO's).

[4] The bank is not obliged to notify the client in case the bank retains a servicing position. In this case all cash flows go through the bank. This will not be done often, for the costs involved are considerable.

Recently, also synthetic CDO structures are used to transfer the risk on debt securities. The aim of these structures is to transfer the risks to the SPV, without selling the reference assets. In chapter four the characteristics of the traditional and synthetic CDO structures will be discussed in more detail.



Source: [Jobst, 2001]

Figure 2.2: Types of Securitisation

Thus, with a traditional securitisation a substantial pool of assets is removed from the balance sheet and replaced by cash. Besides the fact that the cash flows can be used to generate new business, also economic and regulatory capital relief is obtained.

A disadvantage of traditional securitisation is the time required to complete the securitisation process. Besides the legal, tax and accounting issues, which make the transaction more complex, lots of administration and documentation is required [Lam, 2004]. Another disadvantage is that the valuable client bank relation is compensated for the traditional ABS's, given that the assets are sold to a third party.

These disadvantages can be prevented with synthetic securitisation structures. The reference assets do not have to be transferred to the counterparty, which leads to less legal and administrational issues. Furthermore, the client bank relation stays unharmed.

However, both types of securitisation are only applicable for loans that have standardised payment schedules and similar credit risk characteristics [Neal, 1996]. Furthermore, there are a lot of costs involved in a securitisation transaction, like for instance the fees to the rating agencies, structuring costs and marketing costs.

2.5 Insurance

By buying insurance, the protection buyer buys protection against possible future losses (credit risk). This can be done by means of a credit insurance policy or financial guarantee. By entering the contract the guarantor or insurer (the protection seller) agrees to compensate the protection buyer in case the borrower fails to make his payment commitments, in return for a premium payment. The terms and conditions under which the protection seller will compensate the insurance buyer are stated in the contract, which is tailor-made for each deal.

Thus, with insuring the assets stay on the balance sheet of the originator. The benefit is that the client-bank relation remains intact, for the client does not have to be notified when the insurance is bought. However, extra costs are made, as the insurance premium has to be paid. Another disadvantage of insurance is that no market place or standard documentation exists. The protection sellers have to be approached individually to obtain insurance, which is a time-consuming process.

2.6 Credit Derivatives

Credit derivatives are a more complex form of credit insurance. They enable the free trade of the credit risk on assets between financial institutions. With traditional insurance it was only possible to transfer the credit risk to a different agency such as governmental loan and deposit-insurance institutions. Another difference is that credit derivatives allow more flexible payoff patterns. The traditional instruments tend to only insure losses from defaults and bankruptcies, credit derivatives can also offer protection for increasing yield spread or changes in credit rating.

There is no universally accepted definition of credit derivatives. A credit derivative can be described as a specialised financial contract that allows participants to increase or decrease their credit exposure to a particular name, for a particular period of time.

Credit derivatives can be categorised based on various aspects, like for instance the underlying entity or the trigger/payout variable. The payout variable can be determined as the price/yield, credit rating or default status of the reference assets. In this thesis the same classification is adopted as outlined by Ammann [Ammann, 1999]. He distinguishes two types of credit derivatives, namely a default or bankruptcy-based class and a credit quality based class.

The first class encompasses default risk swaps, default options and the traditional credit insurance products. These derivatives compensate the creditor for losses suffered by a default. The maturity of such instruments usually corresponds to the maturity of the insured debt. Very popular derivatives of this type are Credit Default Swaps (CDS's), Total Return Swaps (TRS), and default put options. These products will be discussed in further detail in chapter three.

The payoff of the instruments in the second class is determined by changes in the credit quality of the underlying security instead of a default event. Examples are spread derivatives or rating-based derivatives. The payoff of these instruments is not contingent on a default but on rating or credit spread changes. Unlike instruments of the first type, these derivatives generally expire before their underlying assets mature.

The benefit of credit derivatives is that the credit risk of assets can be transferred without actually selling the asset. Thus, the regulatory and economic capital requirements can be lowered, while the client bank relation remains intact. In addition, the transactions are easy to execute and standardised ISDA documentation is available for most products.

The disadvantages of credit derivatives are the high prices for unknown names and the illiquidity of the market.

2.7 Overview

The instruments discussed each have their own benefits. With secondary sales and traditional securitisation the cash is acquired sooner than when the loan is held till maturity, however, with insurance and credit derivatives the client bank relation is preserved. In Table 2.1 the advantages and disadvantages of the various instruments are summarised. The portfolio manager has to decide which instrument should be used, taking into account the liquidity and risk characteristics of the assets and the client bank relationship.

An important factor for all portfolio management transactions is compliance. Account managers have close relations with clients and can have inside information. For portfolio managers can only trade based on publicly available information, this inside information cannot be used during trading. Thus, there has to be a distinct division between the two parties.

Instruments	**Secondary Sales**	**Securitisation**	**Insurance**	**Credit derivatives**
Advantages	- Full regulatory and economic capital relief - Cash is coming in earlier than when loan would be held till maturity - Relatively low execution costs	- Full or partial regulatory and economic capital relief[5] - Cash is coming in earlier with traditional securitisation than when the loan would be held till maturity	- Partial regulatory and economic capital relief - Client bank relation is not compromised	- Partial regulatory and economic capital relief - Client bank relation is not compromised - The transaction is easy to execute
Disadvantages	- Closing a deal can take months	- Client bank relation is compromised with traditional securitisation - Time- consuming process, for a lot of administration and documentation is required. - Legal, tax and accounting issues lead to increased complexity of setting up the deal - High costs	- No cash is coming in - High costs	- No cash is coming in - The prices are high for unknown names - The derivatives market is illiquid for unknown names.

Table 2.1: Differences between portfolio management instruments.

[5] Capital relief depends on whether or not the bank will retain a first loss position in the SPV and the type of securitisation.

PART II: Risk Management Instruments

Credit Derivatives

3. An Introduction to Credit Derivatives

3.1 Introduction

Credit derivatives are specialised financial contracts that allow participants to increase or decrease their credit exposure to a particular name or basket of names, for a particular period of time. The payoff of credit derivatives is linked to the creditworthiness of a given company or sovereign entity. The purpose of these instruments is to allow market participants to trade the credit risk associated with certain debt instruments. Credit derivatives that are widely used include Total Return Swaps (TRS), Credit Linked Notes (CLN), spread options, and Credit Default Swaps (CDS).

In this chapter the structure of the main credit derivates will be described. The focus lies on the credit default swap since this is the most common form of a credit derivative. Besides, credit default swaps are also used as building blocks for more complex derivatives, like synthetic CDO structures, which will be discussed in chapter four.

In paragraph 3.2 an overview of the credit derivatives market is given, followed by an explanation of the basic features of most credit derivatives in paragraph 3.3. Paragraph 3.4 outlines the basic structure of a vanilla CDS, which is the standard form of a CDS. Some variations on the vanilla CDS are discussed in paragraph 3.5. Finally, two other commonly used credit derivatives are discussed in paragraph 3.6 and 3.7, namely the Total Return Swap and the Credit Linked Note.

3.2 Market Overview

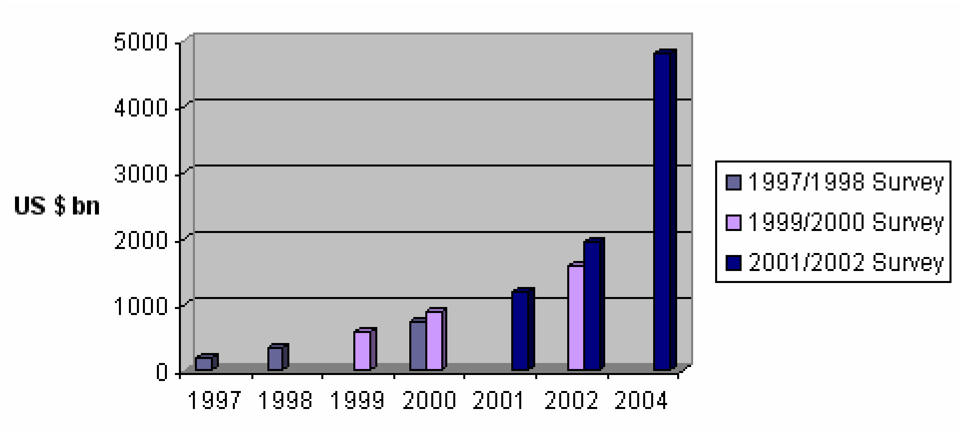
The credit derivatives market is growing fast, surpassing all expectations. In 2000 credit derivatives accounted for just 1 percent of the global derivatives market. Nowadays the credit derivatives market is larger then the equity derivatives market. The latter had a notional outstanding of $3.44 trillion at the end of 2003 [ISDA, 2004].

The British Bankers' Association[1] [BBA, 2002] reported that the global market size at the end of 2001 accounted for approximately $1189 billion (excluding asset swaps) and

---

[1] The British Bankers' Association (BBA) is the leading trade association in the banking and financial services industry representing banks and other financial services firms operating in the UK. The BBA (Continued on next page)

predicted that the market will nearly double to $1952 billion in 2002. The forecast for 2004 is that the global credit derivatives market will reach an outstanding of $4.8 trillion (excluding assets swaps). Figure 3.1 illustrates the growth of the global credit derivative market.



Source: [BBA, 2002]

Figure 3.1: Global Credit Derivatives Market (excluding asset swaps)

The growth in the credit derivatives market can be explained by several factors, including [BBA, 1999]:

- The increased interest by banks and non-banking institutions in credit derivatives for risk management purposes;
- The greater clarity of the regulatory environment, and the availability of standard ISDA documentation;
- The improved risk management techniques, along with improved valuation of credit derivatives;
- The higher return on capital provided by credit derivatives compared to more traditional investments;
- The utilisation of credit derivatives in securitisation programmes, to create synthetic exposures where only the credit risk on a pool of assets is transferred;
- The more advance IT systems that make it easier to process the transactions;

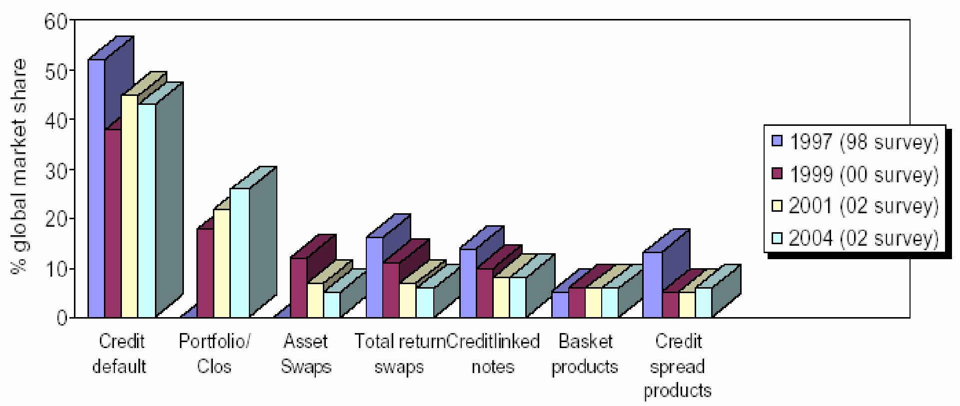
According to the British Bankers' Association [BBA, 2002] the single name credit default swap is the most popular type of credit derivative, representing 45 percent of the global

---

credit derivatives survey is widely considered the most comprehensive benchmark of market activity, expectations and sentiment [www.bba.org.uk].

credit derivatives market. In paragraph 3.4 this product is discussed in more detail. Another popular instrument is the Collateralised Loan Obligation with an estimated market share of 26 percent in 2004. In chapter four more information on this structure can be found. None of the other instruments have a market share larger than 8 percent. Figure 3.2 gives a complete overview of the market share per credit derivative product, based on surveys performed by the BBA.

A wide range of institutions participate in the credit derivatives market. The protection buyers market is mainly dominated by banks, security houses, and hedge funds. As for 2001, banks represented more than 50 percent of the demand. For 2004 this number is estimated to decrease to 47 percent. The share of hedge funds on the other hand is expected to grow to 13 percent in 2004.
On the protection-sellers side, banks and insurance companies dominate the market with respectively 39 and 33 percent of the market in 2001. However, the share of banks is estimated to decrease to 32 percent in 2004 while the share of insurance companies remains the same [BBA, 2002].



Source: [BBA, 2002]

Figure 3.2: Market Share of Credit Derivatives Products

3.3 Basic Features of a Credit Derivative

A credit derivative is a derivative security in which one party commits to pay the counterparty the loss on the specified reference assets in case of a credit event. If the credit event has occurred, the default payment has to be made by the insurer. In addition to the default payment a credit derivative can have further payoffs that are not default contingent.

A credit event is usually defined with respect to a reference entity and reference assets. The reference entity is the debtor whose default triggers the credit event, for example the issuer of the bonds. The reference assets are a pool of assets issued by the reference entity. They are needed for the determination of the credit event and for the calculation of the recovery rate. The latter is used to calculate the default payment. The reference assets can be defined as 'any financial obligation of the reference entity' or as a specific list of just a few bonds issued by the reference entity.
The International Swaps and Derivatives Association (ISDA) distinguishes six types of credit events. However, market participants generally view the following three to be the most important [Andelson, 2004]:

- *Bankruptcy;*
  This is the reference entity's insolvency or inability to repay its debt.
- *Failure to Pay;*
  This occurs when the reference entity, after a certain grace period, fails to make principal or interest payments.
- *Restructuring;*
  This refers to a change in the terms of debt obligations that are adverse to the creditors.

Of the aforementioned credit events, restructuring is the most problematic because 'adverse change' is an ambiguous concept. Currently, there are four options regarding restructuring, namely:

- *No Restructuring or Ex-Restructuring (XR);*
  Under this option restructuring is not included as credit event in the contract.
- *Full Restructuring or Cum-Restructuring (CR);*
  This is the old definition of restructuring and the broadest. It allows the protection buyer to deliver bonds of any maturity after restructuring of debt in any form has occurred.
- *Modified Restructuring (MR);*
  This option limits the deliverable obligations to bonds with a maturity of less than 30 months after a restructuring and is mostly used in the US.
- *Modified Modified Restructuring (MM);*
  This is an adapted version of the modified restructuring option, which allows deliverable obligations that may mature up to 60 months after a restructuring. This option is generally used in Europe.

For more information on the definitions of credit events refer to the 2003 ISDA credit derivatives definitions.

3.4 Credit Default Swap

A CDS is a bilateral financial contract in which one party, the protection buyer, agrees to pay a fixed periodic fee to the counterparty, the protection seller, in return for a reimbursement of his loss on the reference asset in case of a credit event.

The purpose of this form of credit derivative is to transfer the credit risk of financial assets from one party to another without actually transferring the ownership of the assets. As a result, the assets stay on the balance sheet of the protection buyer, and the debtors do not have to be involved. This way, the bank can mitigate its credit risk exposure, without affecting the valuable client bank relation.

With a vanilla CDS, the contract offers protection on a single reference entity, this is called a single name CDS. However, a CDS that offers protection on a portfolio of reference assets also exists, which is called a portfolio credit default swap. In this paragraph only the vanilla CDS will be discussed.

Since credit default swaps are OTC contracts, the maturity and size of CDS contracts are negotiable. Maturities vary from a few months to ten years or more. The most common maturities are 3, 5, and 10 years, with the five-year maturity being especially popular [Bomfin, 2001]. The size of CDS contracts ranges from a few million to more than a billion dollars. The average size lies in the range of \$25 to \$50 million [Longstaff, 2003].

The premium payments under the CDS are typically made quarterly until maturity of the contract or the occurrence of a credit event. This periodic fee, also called default swap spread is expressed in basis points on the notional amount. Figure 3.3 illustrates the payments under the CDS.

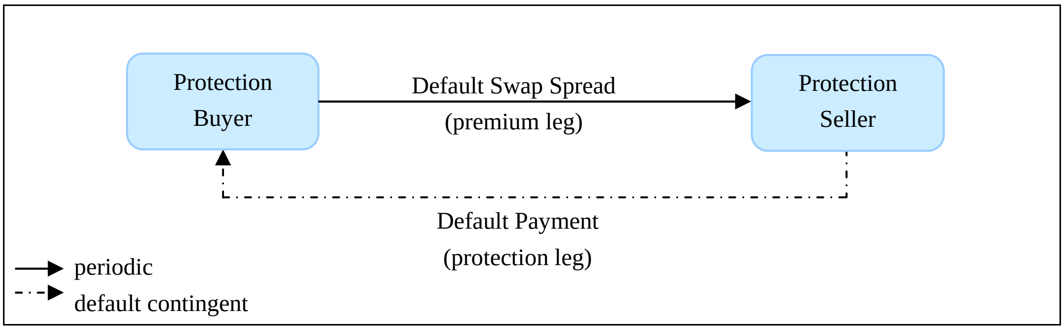


Figure 3.3: Payments under a Vanilla CDS

When a credit event has occurred, the CDS expires. The protection buyer pays the protection seller the accrued premium since the last payment. In return, the protection seller reimburses the protection buyer for his loss. This can be settled in two ways, namely by physical settlement, or cash settlement. The choice is made before entering the contract.

Physical Settlement

Physical settlement is the most common form of settlement in the CDS market, and normally takes place within 30 days after the credit event. In a physical settlement the protection buyer delivers an obligation of the reference entity that has experienced a credit event (the reference obligation) to the protection seller. The protection seller pays par for that asset, reimbursing the buyer for any default related loss that it would otherwise suffer. In Figure 3.4 an illustration is given of this type of settlement.

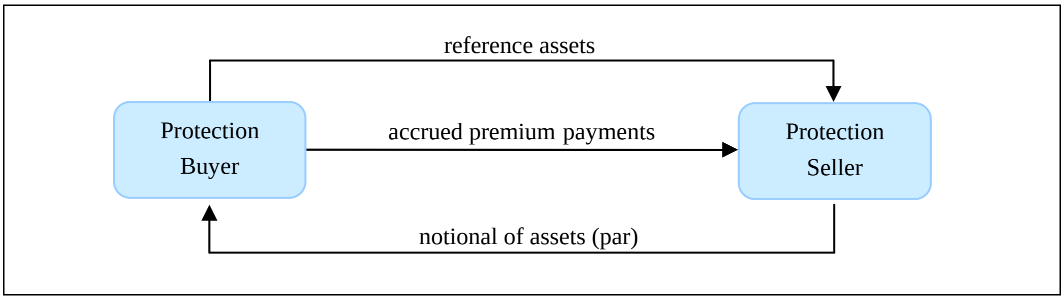


Figure 3.4: Physical Settlement of a CDS

Cash Settlement

In a cash settlement the protection buyer is not required to deliver the reference obligation. Instead, the default payment is determined as the difference between the notional of the CDS and the post default value of the reference obligation. The post default value, typically expressed as a percentage of par, is determined by polling dealers for a set period of time, usually up to three months, following the credit event. Cash settlement is less common because in general it is very difficult to obtain quotes for the distressed reference credit. An illustration of this type of settlement is given in Figure 3.5.

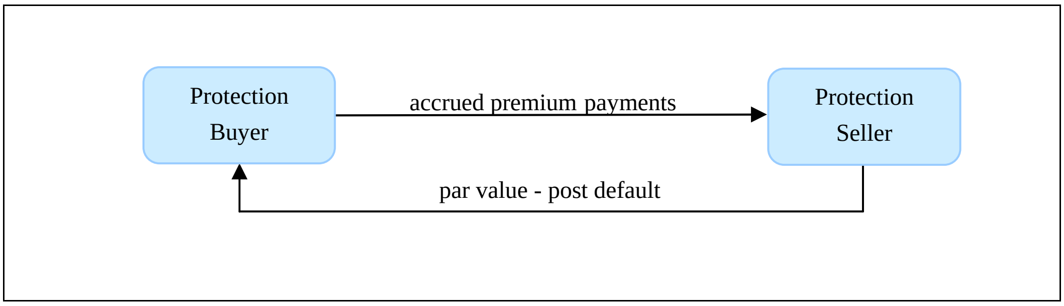


Figure 3.5: Cash Settlement of a CDS

3.5 Derived Products

In this paragraph five credit derivatives with a similar structure as a vanilla CDS will be discussed.

3.5.1 Digital Credit Default Swap

With a digital or binary credit default swap the payoff in case of a default is independent of the post default value of the reference asset. Instead, the contract specifies a specific dollar amount that is determined up front, when entering the contract.

3.5.2 Contingent Credit Default Swap

In case of a contingent credit default swap the payoff requires both a credit event and an additional trigger. The additional trigger might be a credit event with respect to another reference entity or a specified movement in some market variable.

3.5.3 Basket Default Swap

Under a basket default swap a 'basket' of reference entities is specified by the protection buyer. The losses in the basket are assigned to securities with different priorities, which are issued by the protection buyer. For instance, the first default in the pool of assets triggers a payment by the first-to-default (FTD) basket reimbursing the protection buyer for his loss. For the nth-to-default (NTD) basket the nth default in the pool triggers the payment to the protection buyer.
Thus, an nth-to-default basket is similar to a CDS, with the exception that the pay-out trigger is the nth credit event in a specified basket of reference entities.

3.5.4 Default Put Option

A default put option combines the recurring premium payments into a lump-sum payment. The payoff of the option is defined in the same way as the CDS payment in case of a credit event. Because a CDS requires premium payments only until a triggered default event occurs, the default option and the CDS are not identical instruments

3.5.5 Portfolio Default Swap

A portfolio default swap is often used as building block for synthetic CDO structures. Instead of specifying the pay-out trigger in terms of defaults by individual reference entities represented in the portfolio, the trigger is expressed in terms of the size of the default-related loss in the overall portfolio [Bomfin, 2001]. For instance, in a portfolio default swap with a first-loss tranche of 5 percent of the notional of the portfolio, the investors in that tranche are exposed to however many individual defaults are necessary to lead to a 5 percent loss in the overall portfolio. Second- and third-loss portfolio default swaps are defined similarly.

Other variations on the standard instruments are credit swaps or default options that do not insure the entire loss from a default. For example, a default put option may only have a payoff if the loss from default exceeds a predetermined threshold value, which serves as a strike recovery rate and can be interpreted as a deductible on the insurance.

3.6 Total Return Swap

Under a Total Return Swap (TRS), also known as a Total Rate Of Return Swap (TRORS), a synthetic exchange of assets is realized. All the proceeds of a risky asset are swapped against a contracted prefixed return (risk free). The protection buyer, the party that physically owns the reference asset, is the originator of the contract and is also referred to as the risk seller or the total return payer. The protection seller has a synthetic exposure on the reference asset and is referred to as the risk buyer or the total return receiver.

The amount paid by the risk seller to the risk buyer consists of the interest income on the reference asset and all positive changes in the market price. In return the risk buyer pays the risk seller LIBOR[2] ± spread, as compensation for using their balance sheet, all negative market price changes and the loss when a default has occurred [Dufey, 2000]. Figure 3.6 illustrates the structure of a TRS.

The TRS is an attractive instrument for investors who normally cannot get access to the loan market, because it is primarily dominated by banks. By means of the TRS investors can profit from the economical benefits of the reference assets, without putting it on their balance sheet.

The fundamental difference between a credit default swap and a total return swap is that the credit default swap provides protection against specific credit events, while the total return swap provides protection against loss of value irrespective of cause.

[2] The London Inter-Bank Offered Rate (LIBOR) is a key rate in international bank lending. LIBOR is the rate at which major bank is London are willing to lend Eurodollars to each other, and is used to determine the interest rate charged to creditworthy borrowers.

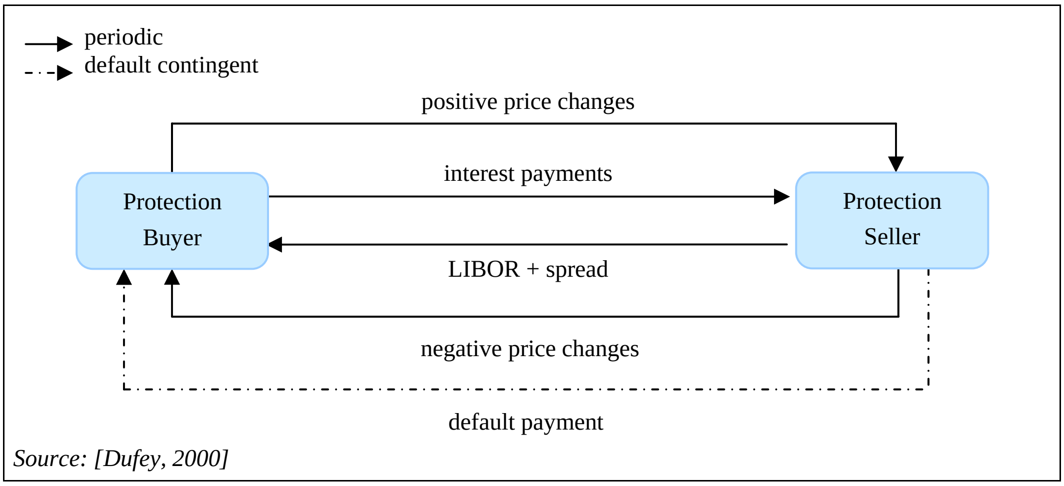


Figure 3.6: Structure of a TRS

3.7 Credit Linked Note

A credit linked note (CLN) is a securitised form of a credit derivative. This implies that the CLN's are funded and that the proceeds of the notes are used to buy government bonds. For more information on securitisation refer to section 2.4 or chapter four.

The CLN is a perfect solution for investors that normally cannot participate in the derivatives market, because they are for example constrained by internal investment policies [Bomfin, 2001]. By means of a CLN they are able to profit from the advantages of single and multi-name derivatives.

Under a CLN structure the protection buyer issues notes with as underlying assets a pool of credit derivatives. With the proceeds of the notes the CLN issuer buys investment grade bonds that serve as collateral for the claim of the credit derivatives. This structure is illustrated in Figure 3.7. The encircled represents the securitised part of the structure. In this illustration the underlying asset of the CLN's is a CDS. Thus, by buying the CLN the investor has a synthetic exposure on the reference assets of the CDS.

In case of a credit event the CLN expires [Bomfim, 2001]. The collateral is sold and the protection buyer is reimbursed for his loss. With the remaining amount the CLN investors are paid off. Thus the CLN investors only receive the recovery value of the reference assets in case of a default, absorbing the loss on the reference assets. Figure 3.8 depicts the payment structure. In case no default occurs, the contract will expire at maturity and the investors will receive their principal back.

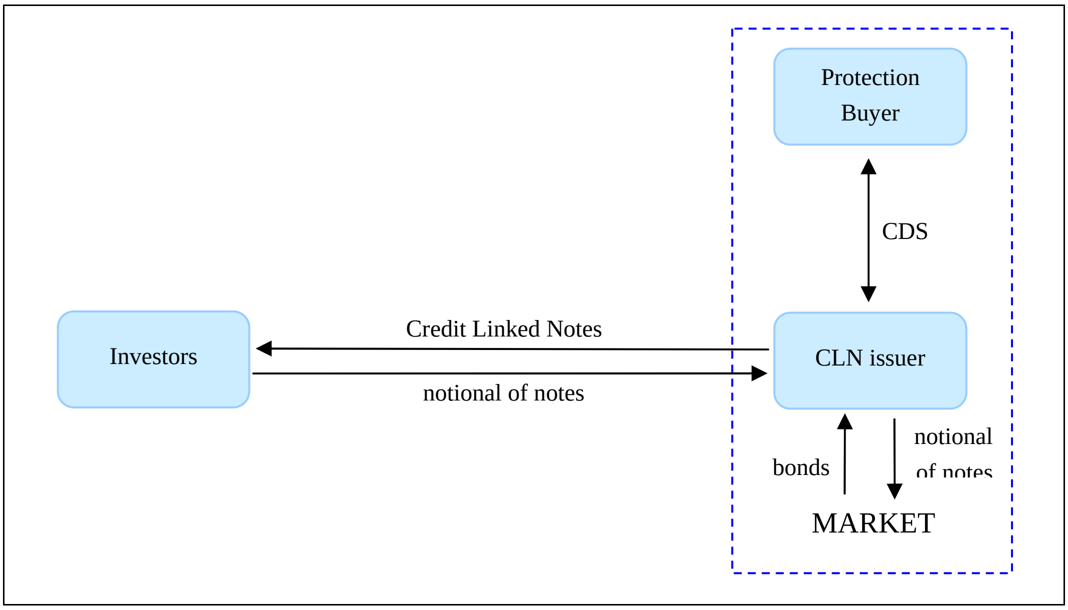


Figure 3.7: Establishment of a CLN structure

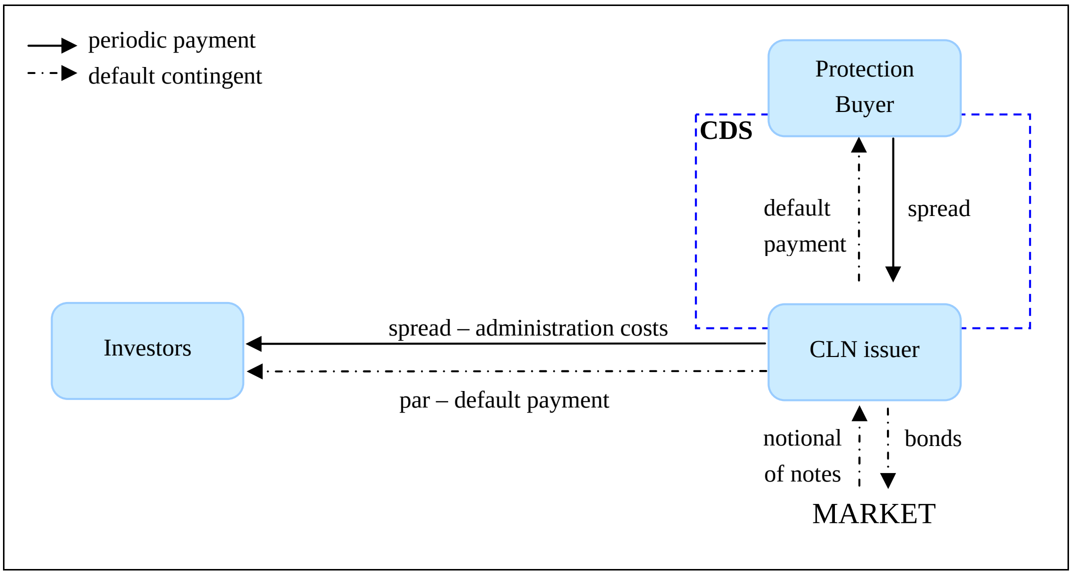


Figure 3.8: Cash flow structure of a CLN

4. An Introduction to Collateralised Debt Obligations

4.1 Introduction

Asset securitisation is a general term that refers to the process where loans, receivables and other illiquid assets with similar characteristics in the balance sheet are packaged into interest-bearing securities that offer attractive investment opportunities. Various forms of securitisation can be distinguished, as depicted in Figure 2.2.

The term Collateralised Debt Obligation (CDO) is an umbrella term encompassing various forms of asset securitisation. These forms can be described by the following aspects:

1. the asset portfolio;
2. the purpose;
3. the tranche structure;
4. the credit structure; and
5. the way exposure is gained on the assets;

In this chapter the characteristics of CDO structures will be discussed. Paragraph 4.2 explains the basic structure of a CDO. Subsequently, the underlying assets of a CDO are discussed in 4.3, followed by a discussion of the purpose of a CDO in paragraph 4.4. Thereafter the tranche and credit structure are treated in paragraph 4.5 and 4.6 respectively. The way exposure is gained on the assets is discussed in 4.7 and in paragraph 4.8 an overview is given of the most used CDO's and the CDO market. Finally, section 4.9 will further elaborate on synthetic balance sheet cash flow CLO's, for that is the instrument most relevant for this study.

4.2 Basic CDO Structure

Under a CDO a special purpose vehicle (SPV) is established by a sponsoring organisation. The SPV is a legal entity, with its own assets, liabilities and management, whose operations are limited to the acquisition and financing of specific assets. The sponsoring organisation can be a bank or other financial institution, or an investment manager. Often, the sponsoring organisation acts as the manager of the SPV.

The assets, which are generally bought from the sponsoring organisation, serve as collateral for the securities that the SPV issued. The SPV funds these assets with the cash proceeds of the securities, which are sold in the capital market. The basic structure of a CDO is illustrated in Figure 4.1.

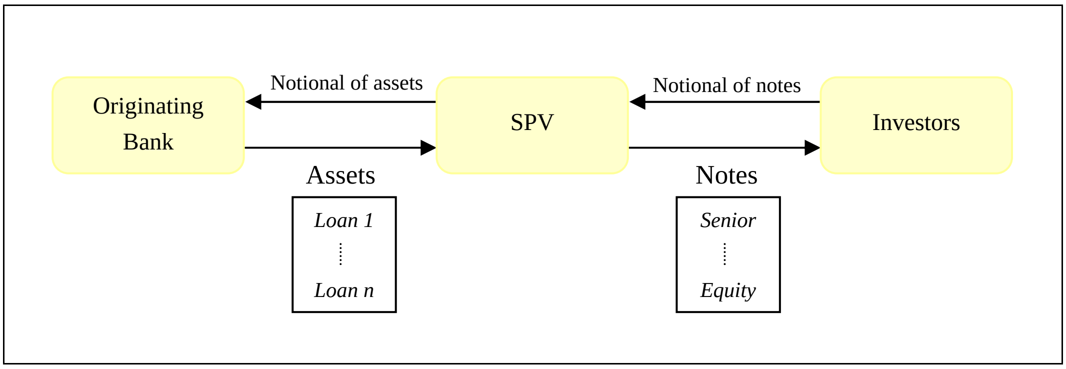


Figure 4.1: Establishment of a (Cash) CDO

From the interest and principal proceeds of the SPV's assets periodic payments are made to the investors. The expenses associated with running the SPV (operational costs) are subtracted from the cash flows to the investors. In Figure 4.2 an overview of the cash flows within the SPV are given.

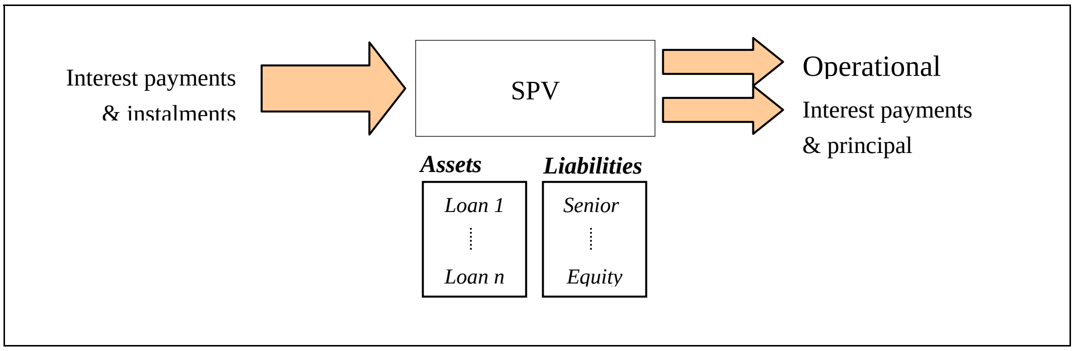
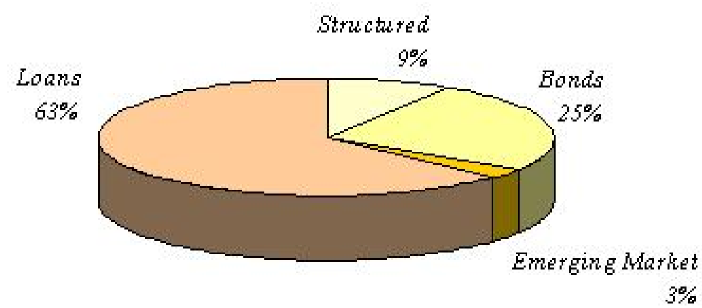


Figure 4.2: Periodic cash flows in a (Cash) CDO

4.3 Asset Portfolio

Typically, the SPV's assets consist of a diversified portfolio of illiquid and credit-risky assets. In the beginning (in the late 1980's and early 1990's) the underlying assets of CDO's were restricted to bank loans and bonds. Soon the market extended to emerging market debt, subordinated Asset Backed Securities (ABS), Residential Mortgage Backed Securities (RMBS) and Commercial Mortgage Backed Securities (CMBS). Even tranches of CDO's have been re-securitised into CDO's of CDO's [Lucas, 2001].

Loans and bonds still make up for the major part of the underlying assets of CDO's. From 1987 to 2000 loans and bonds comprised 63 percent and 25 percent respectively of the underlying assets. The share of ABS, RMBS and CMBS increased and accounted for 9 percent of the CDO's assets. The remaining 3 percent consists of emerging market debt [Lucas, 2001]. An overview of the underlying assets in a CDO is given in Figure 4.3.



Source: [Lucas, 2001]

Figure 4.3: Underlying Assets of a CDO 1987 - 2000

A CDO that only has high yield bonds as underlying assets is referred to as a Collateralised Bond Obligation (CBO). When the underlying assets are solely bank loans, the CDO is referred to as a Collateralised Loan Obligation (CLO).

Besides by the type of reference assets, the reference portfolio can be characterized by being either static or managed. With a static CDO the collateral portfolio is fixed through the term of the CDO. In case of a managed CDO, a portfolio manager is appointed that actively manages the asset portfolio of the CDO. Nowadays, most deals are managed.

4.4 Purpose

Depending on the motivation behind the securitisation and the source of the underlying assets CDO's can be classified as either balance sheet or arbitrage CDO's. The purpose of balance sheet CDO's can be to shrink the balance sheet, reduce required regulatory capital, or reduce economic capital [Lucas, 2001]. In this case, the originator of the CDO is a holder of securitizable assets and desires to sell the assets or synthetically transfer the risk of the assets (refer to paragraph 4.7 for synthetic structures). By removing the lower yielding assets that take too much regulatory capital from the balance sheet, capital relief is realised[1]. This relief reduces funding costs or increases return on equity.

[1] This only applies for the BIS I regulations, for BIS II takes the credit rating of the counterparty into account.

An arbitrage CDO, however, is set-up to make money from the difference between the cost of acquiring the collateral portfolio and the issuance of the notes. In contrast to a balance sheet CDO, the underlying assets are purchased from various sources in the open market.

The two parties that can profit from this structure are the equity tranche investors and the asset manager. The equity tranche investors hope to achieve a leveraged return between the after-default yield on assets, and the financing cost of the debt tranches. The asset manager gains a management fee from monitoring and trading the CDO’s assets [Lucas, 2001].

Arbitrage transactions make up for 74 percent of the CDO transactions. However, the size of balance sheet transactions is in general larger then an arbitrage transaction, as the transaction must have an impact on the return on equity. Due to this the division of the market is almost 50-50 percent by volume [Lucas, 2001].

4.5 Tranche Structure

The SPV issues multiple classes of equity and debt notes that are tranched with respect to seniority in bankruptcy and timing of repayment [Lucas, 2001]. This structure is also known as the ‘waterfall’. The subordinated tranches protect more senior tranches against credit losses and receive a higher yield for taking on greater credit risk.

The tranches are sized to minimise funding costs, taking into account the requirements of the investors. In general, the most senior tranche provides the majority of the SPV’s financing. Other debt tranches are sized around 5 to 15 percent. The equity tranche is usually around 2 to 15 percent of the notional of the reference assets, depending on the credit quality and diversity of the assets [Lucas, 2001]. In Figure 4.4 an illustration is given of a tranche structure. The losses are absorbed bottom up, and the interest and principal payments are done top down.

Suppose that a loss has occurred of 7 percent of the notional of the reference portfolio. In this case the equity tranche will be completely consumed. The first mezzanine tranche will have to absorb the remaining loss. Thus the first mezzanine tranche will lose 20 percent of his notional.

When a loss has occurred, the future interest payments are made on the remaining notional of the tranche.

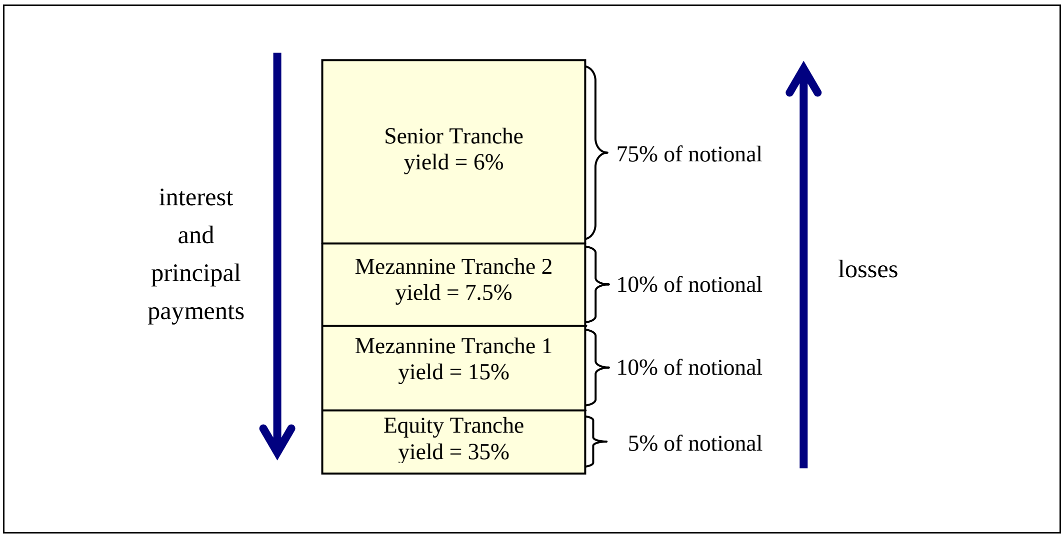


Figure 4.4: CDO Tranche Structure

4.5.1 *Equity tranche*

The equity or junior tranche, also referred to as preferred stock or income notes, is the most subordinate tranche in the CDO’s capital structure. It is also called the “first loss” position, because it is exposed to the first dollar of loss in the portfolio. The equity tranche bears the risk of payment delays and credit losses first, in order to make the more senior debt tranches less credit-risky. Equity holders receive whatever cash flows are left after the satisfaction of debt tranche claims. In return, the equity holders get a relatively high yield.

4.5.2 *Mezzanine notes*

A CDO consists of one or more mezzanine tranches. The holders of mezzanine notes carry less risk than equity holders, and more risk than senior note holders. Consequently, they receive a lower yield than the equity holders, and a higher yield than the senior note holders.

This tranche is typically rated B to BBB. A loss will only occur when the total loss exceeds the notional of the equity tranche.

4.5.3 *Senior notes*

The holders of senior notes bear the lowest risk, for they are protected by the subordinated. A loss will only occur when all other tranches are exhausted, therefore the premium is lower than the premium of the other notes. Typically, the senior tranche is rated A to AAA.

4.6 Credit Structure

A CDO can have either a market value or a cash flow credit structure, depending on the way the CDO protects debt tranches from credit losses. In the cash flow structure the cash flows of the collateral are used to pay the interest and principal to the investors. When the cash flow is insufficient to cover all tranches or the CDO is in violation of certain tests[2], the tranches with the highest seniority are paid first.

With the market value structure, interest and principal payments to investors come from both, the cash flows of collateral, as well as the sale of collateral. In this case, the payments to tranches are contingent on the market value of the collateral, rather than on the cash flows. When the market value of the collateral drops below a certain level, payments are suspended to the equity tranche. If it falls even further, more senior tranches will be affected.

With the market value structure the asset manager of the SPV has more freedom of action, since he is not constrained by the need to match the cash flows of collateral to those of the various tranches. The investors are, however, exposed to an additional risk. As the collateral portfolio of a market value CDO is frequently marked-to-market, the investors are also exposed to the risk of poor performance of the asset manager.

Note: A cash flow CDO does not by definition have a static pool of assets. So called ‘master trust structures’ enable the originator to add and remove loans to the pool on a regular basis, without having to do all of the time-consuming paperwork.

4.7 Exposure on Assets

There are two ways a CDO can gain exposure to assets, which is either by cash purchase, (cash CDO) or synthetically (synthetic CDO). Cash CDO’s are the most traditional structure where the underlying assets are physically transferred to the SPV. This structure is already discussed in section 4.2 above. In a nutshell, the SPV purchases a pool of assets from the originating bank. The SPV pays the bank with the proceeds of the notes it has issued.

With a synthetic CDO, the reference assets stay on the balance sheet of the originating bank. Instead, the SPV writes a CDS with the originating bank and issues Credit Linked

[2] Refer to Appendix B for more information on the collateral tests.

Notes (CLN) to the investors. With the proceeds of the CLN's, the SPV invests in AAA rated securities to ensure that the repayment of principal to the investors is secured.
In case of a default event the bank will seek a payment from the SPV. As long as no default event takes place, investors get returns equal to the return from the AAA-rated investments and the default swap premium.

The advantages of synthetic transactions versus cash transactions are [Picone, 2002]:

- Synthetic transactions require less resources;
  One of the main advantages of a synthetic CDO is that they do not have to be fully funded. Partly funded and unfunded structures can also be applied. With a partially funded structure notes are issued for part of the reference portfolio. The remaining piece is called the super senior tranche. It is generally less expensive to sell the super senior tranche as a CDS than it would be to fund that tranche.
- It takes less time to complete synthetic transactions;
  With cash deals the assets are actually transferred into the SPV. The process of transferring loans to the SPV requires significant work up front. For every single loan it is required to check if it complies with the securitisation programme, and to verify that there are no special purpose clauses attached to any loan limiting its transfer.
- Sensitive client relationship issues arising from loan transfer notification, assignment provisions and other restrictions can be avoided with a synthetic transaction.
- The client confidentiality can be maintained in synthetic transactions.

4.8 The Life-Cycle of a CDO

According to Picone [Picone] and [RMF, 2002] the life cycle of a CDO can be divided in three phases, namely the ramp-up period, the reinvestment period and the wind up period.

The Ramp-up Period
The first three to six months after the CDO has closed. During this period the initial collateral is bought. This phase is often associated with arbitrage CDO's rather than balance sheet CDO's [Lucas, 2001].

The Reinvestment Period
This period is also referred to as the revolver period and lasts three to five years. This period only concerns a managed CDO, for with a managed CDO the principal proceeds of the collateral are used to reinvest in additional eligible CDO assets so long as collateral coverage tests are met. Whereas with a static CDO all principal proceeds are used to retire the CDO's liabilities according to their priorities.

The Wind-up Period
This period of one to four years is also called the amortisation period. During this period new collateral purchases are not allowed. Instead the principal of the maturing collateral assets is used to repay the most senior tranche liabilities. Once the most senior tranche has been repaid, the following tranche starts to amortise followed by the subordinated tranches and finally leading to the equity tranche.

Lucas [Lucas, 2001] distinguishes an additional period: the warehousing period. This period starts several months before the CDO is closed. During this phase part of the initial collateral is bought. This period can be associated with arbitrage as well as balance sheet CDO’s.

4.9 Typical Structures

Leaving out the type of underlying assets and the tranche structure, combining the above discussed characteristics leads to 16 types of CDO’s (= 2^4, see Table 4.1). However, with balance sheet transactions trading is not allowed or limited to replacement of amortised assets.
Since there is no active trading, balance sheet transactions are said to be static, and thus by definition cash flow deals.

Characteristic	**Types**
Underlying Assets	Loans, Bonds, etc.
Purpose	Arbitrage, Balance Sheet
Tranche Structure	Several
Credit Structure	Cash flow, Market Value
Asset Portfolio	Static, Managed
Exposure on Assets	Cash, Synthetic

Table 4.1: Overview of CDO characteristics

According to Lucas [Lucas, 2001] market value transactions have not yet been done with synthetic assets, because of their illiquidity. He also states that there is a negative correlation between market value credit structure and balance sheet purposes. Taking all this into account leaves us with the five CDO structures. In Figure 4.5 an overview is given.

The underlying assets in the scope of this study are corporate loans and the purpose is to reduce economic capital without compromising the client-bank relationship. The product of interest is therefore a synthetic balance sheet CLO. This product will be discussed further in paragraph 4.10.

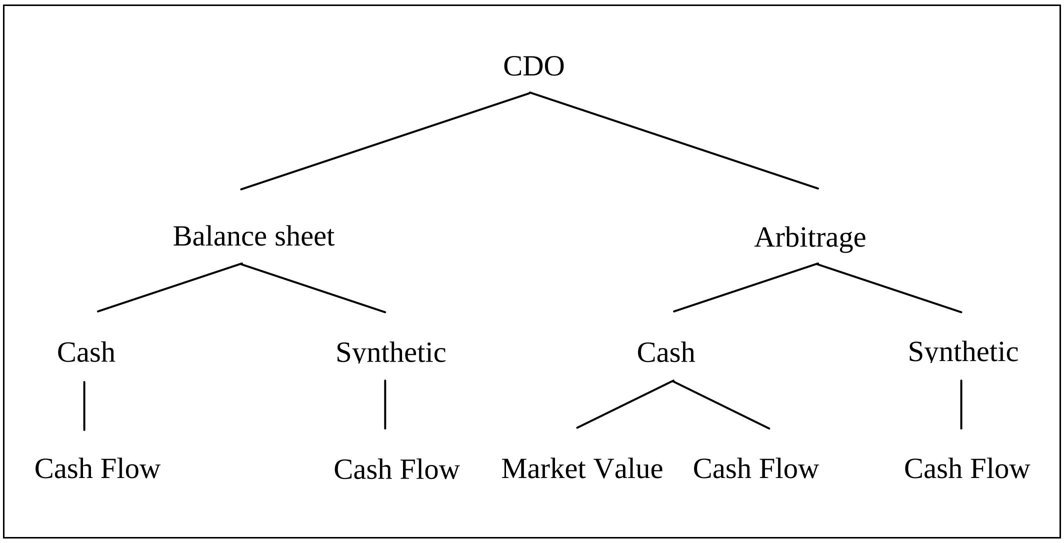


Figure 4.5: Typical CDO Structures

4.10 Synthetic Balance Sheet CLO

As mentioned above, active trading is not allowed in balance sheet CDO's, thus the underlying portfolio is static. Therefore it can be said that balance sheet CDO's are cash flow transactions. The purpose of the synthetic balance sheet CLO is to achieve risk transfer and therefore economic capital relief without compromising the client bank relation. One of the main advantages of a synthetic CDO is that they do not have to be fully funded. In paragraph 4.10.1 the most traditional fully funded structure will be discussed, followed by the partly funded structure in 4.10.2.

4.10.1 Fully Funded Synthetic Structures

The fully funded synthetic structures were the first to be used as an alternative to cash CDO's. Under this structure the SPV issues notes for approximately 100 percent of the reference portfolio. Unlike with cash CDO's the proceeds of the note issuance are used to buy high-quality collateral. The originator of the SPV enters into a Credit Default Swap (refer to chapter four for a explanation of this product) with either the same SPV (see Figure 4.6) or an OECD[3] bank (see Figure 4.7) to hedge his credit risk exposure on the reference portfolio.

[3] The OECD, Organisation for Economic Co-operation and Development, is a forum with 30 member countries world-wide that discusses, develops and refines economic and social policies (www.oecd.org).

The CDS premiums are added to the interest income from the high quality collateral and are allocated to the prioritised tranches.

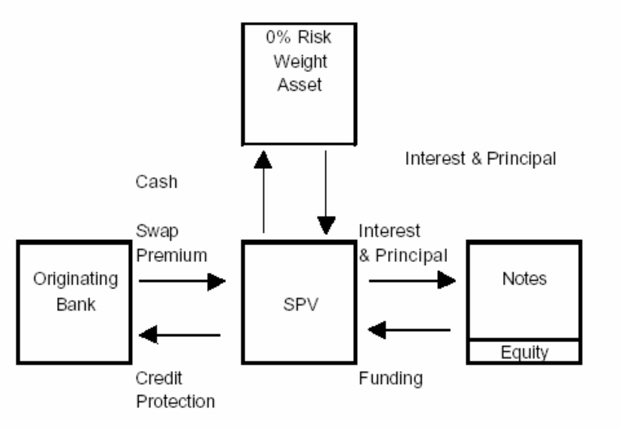


Figure 4.6: Fully Funded Synthetic CDO Structure

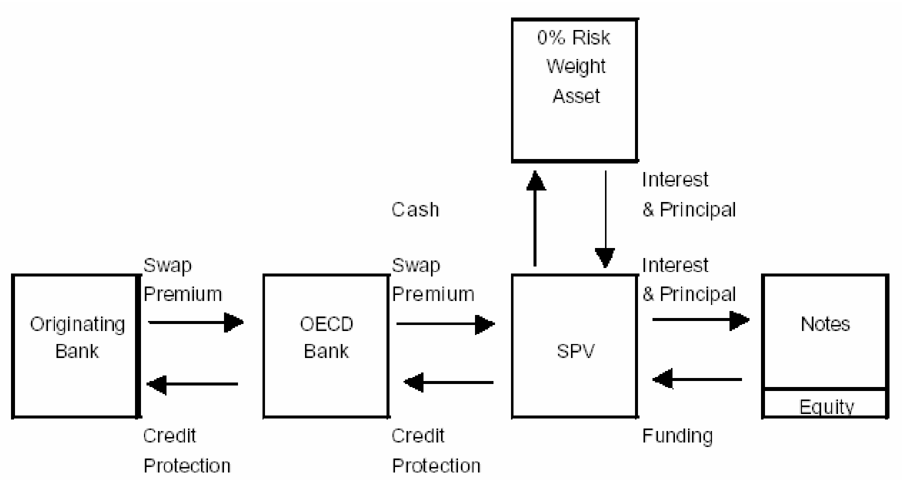


Figure 4.7: Fully Funded Synthetic CDO Structure with Intermediation

4.10.2 Partially funded synthetic structures

The partially funded synthetic structure is similar to a fully funded structure. The originator does buy credit protection directly from the SPV (Figure 4.8) or an OECD bank (Figure 4.9), however, the SPV issues a lower amount of notes because it guarantees a lower amount of collateral. The unfunded piece is called the super senior tranche. This is a very high quality financial paper, with a probability close to zero of being exposed to a credit loss. The originator enters in a CDS with an OECD bank for the amount of the super senior tranche; this is also referred to as a super senior CDS.

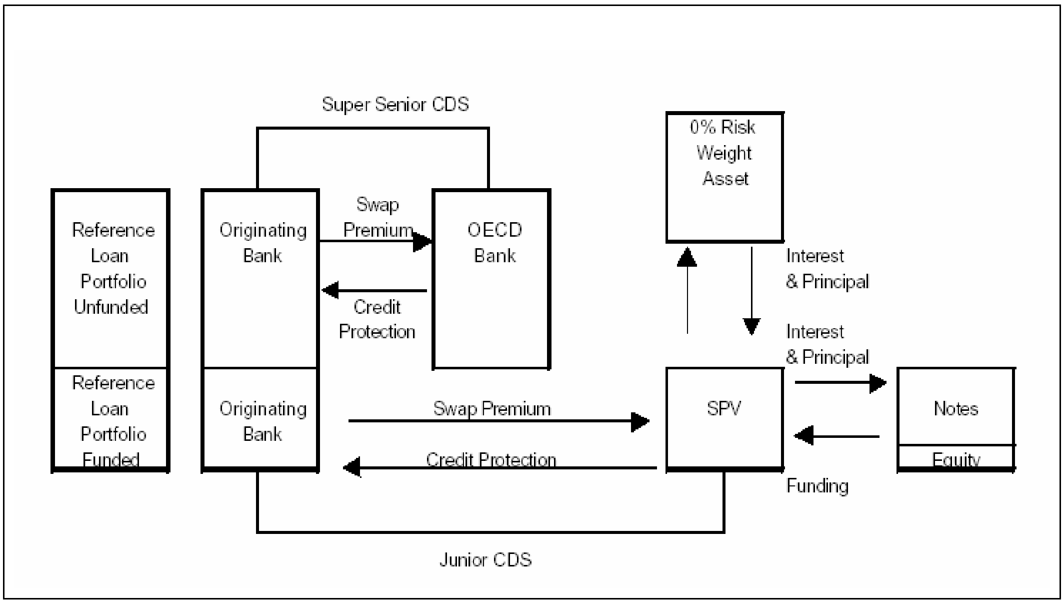


Figure 4.8: Partially Funded Synthetic CDO Structure

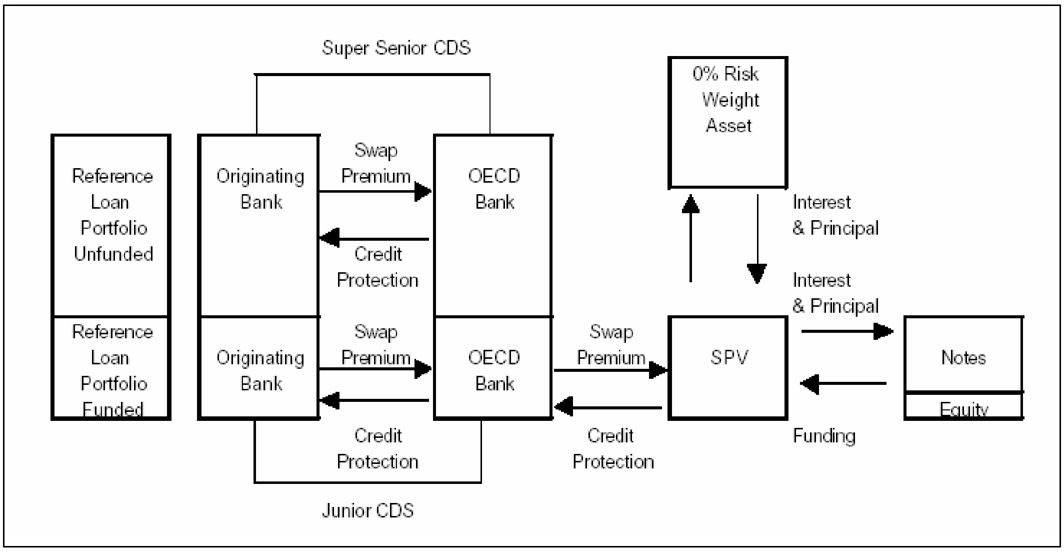


Figure 4.9: Partially Funded Synthetic CDO Structure with Intermediation

For example, to cover your credit exposure of € 200 million of corporate loans with a partially funded synthetic deal, just € 20 million of high quality collateral could support the exposure. The entire reference portfolio is still tranched, but only the lower rated tranches are funded. In this example, the super senior tranche would be the most senior tranche of € 180 million.

PART III: The Credit Risk Framework

Modelling CDS's and CDO's

5. The RI Credit Risk Framework*

5.1 Introduction

Banks are obliged to maintain a capital buffer to cover the risks they bear. A distinction can be made between the regulatory capital and the Economic Capital. The size of the regulatory capital buffer is determined by the BIS II regulations, which prescribes the same rules for all banks regarding market risk, credit risk and operational risk.
The size of the Economic Capital buffer, however, is determined by the bank itself and depends on the bank specific portfolio. In addition to the abovementioned risks, the Rabobank reserves Economic Capital for interest rate risk, transfer risk, business risk and insurance risk [RAROC, 2004].

In this chapter the methodology behind the internal credit risk framework of Rabobank International will be discussed. This framework is used to determine the size of the Economic Capital buffer to cover the credit risk exposure of the portfolio. The framework has a time frame of one year, and measures the credit risk in terms of Expected Loss (EL) and Unexpected Loss (UL).

The internal credit risk framework of Rabobank International depends on three factors, which will be discussed in paragraph 5.2. Subsequently the methodology to determine the credit risk on a single loan and a portfolio of loans will be outlined in paragraph 5.3 and 5.4 respectively. Thereafter, the allocation of Economic Capital will be discussed in paragraph 5.5, followed by a discussion of the Risk Diversification Factor for the RI portfolio in paragraph 5.6. In the final paragraph the assessment whether or not credit derivatives are cost effective is explained.

5.2 The Basic Factors

[…]

* Since this is the public version of a confidential report business confidential information has been removed from certain paragraphs in this chapter.

5.3 The Single Loan Framework

[…]

5.4 The Multi-Loan Framework

[…]

5.5 Economic Capital Allocation

[…]

5.6 The Interim Correlation Solution

[…]

5.7 Modelling the Credit Risk Reduction

The credit risk on a single loan or a pool of loans can be mitigated by utilisation of a CDS or a CDO. However, there are costs associated with the utilisation of these derivatives, like premium payments for instance. To be able to assess the 'profitability' of the deal, the risk reduction has to be considered against the costs of utilisation of the credit derivative. The cost trade-off is depicted in Figure 5.1.

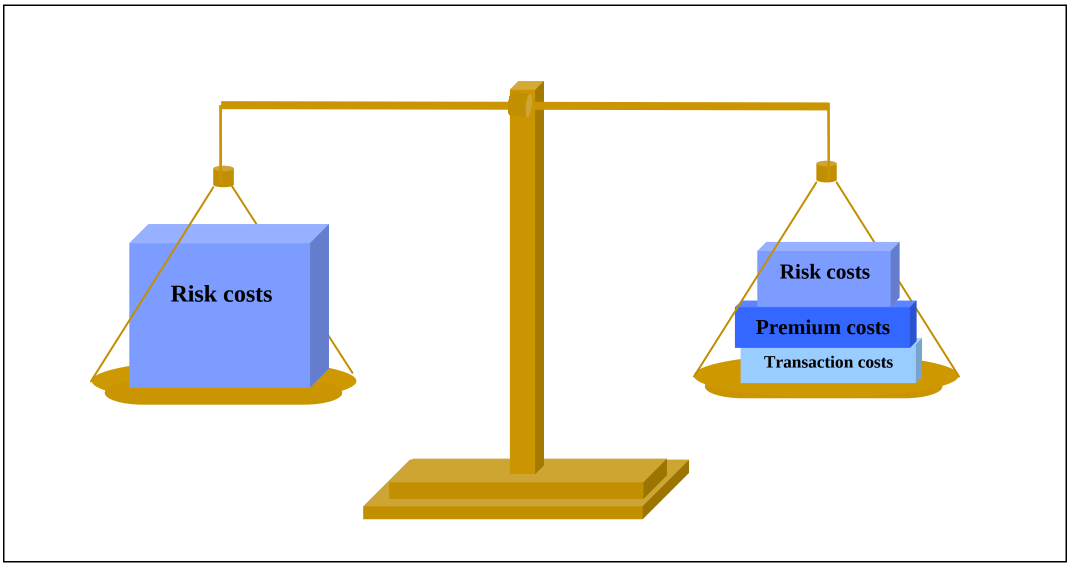


Figure 5.1: The cost trade-off

The risk costs are the costs made to cover risks and can be determined as:

$$\text{Risk Costs} = \text{Expected Loss} + \text{Cost Of Capital} \cdot \text{Economic Capital},$$

where the cost of capital (CoC) is the rate of return required by investors on the capital provided by them. Within the Rabobank this is assumed to be 12.5 percent.

The risk costs before the deal are determined by the credit risk on the reference loan, which can be derived from the current credit risk framework. By utilisation of a credit derivative, the exposure on the underlying assets is substituted by a risk exposure on the credit derivative. To be able to determine the risk costs after the transaction, the associated risks have to be identified and modelled. A methodology to determine the risk costs associated with utilisation of a credit derivative will be proposed in chapter six and seven for a CDS and CDO respectively.

6. The CDS Methodology

6.1 Introduction

The credit default swap is the most common form of credit derivative, which is often used as building block for more complex derivatives. A CDS is a bilateral contract that offers credit protection against a loss on the specified assets in case of a default. In this chapter a first step is taken in modelling the credit risk reduction by utilisation of a single name CDS. The central question is: "Does the risk cost reduction outweigh the costs associated with the CDS?"

In this chapter, paragraph 6.2 briefly outlines the approach taken. The basic structure of a vanilla CDS as well as the general assumptions made are treated in paragraph 6.3, and the risk substitution by applying a CDS is handled in paragraph 6.4. Thereupon, a simple model covering a CDS on a bilateral loan granted by the bank, and a more advanced model where the CDS covers a tradable bond issued by the same entity, are the subjects of sections 6.5 and 6.6 respectively. Subsequently, the effect on the risk-return ratios is handled in paragraph 6.7 and finally, four examples are discussed in paragraph 6.8.

6.2 Approach

The bank has two options to hedge the credit risk exposure on a loan with a CDS, namely purchasing a 'customised' CDS or purchasing a 'standardised' CDS. Since the CDS market is an OTC market, the contract specifications can be customised according to the wishes of the protection buyer. Thus, the bank has the ability to purchase a customised CDS, which exactly matches the loan. However, the process of formulating the contract specifications is time consuming and costly. Furthermore, the resulting contract is illiquid; the contract is hard to trade, and consequently it is more difficult to find a protection seller.

Alternatively, the bank could also purchase a 'standardised' CDS. A standardised CDS includes bonds of the reference entity as underlying assets. Moreover, ISDA-specified documentation is present as well. These CDS's are more tradable while regular quotes for these deals are available. However, there are negative aspects when buying a CDS on a bond. Although both deals are not risk-free, the latter has an additional exposure, for the standardised CDS could not fully cover the loss on the loan in case of a default.

To assess whether a CDS transaction is justified, the risk cost reduction has to be considered against the costs involved in applying a CDS, like transaction costs and premium payments. During modelling of the CDS only the premium payments are taken into account. Since the transaction costs are estimated to run up to 1 or 2 bps of the notional of the CDS, they are considered to be negligible compared to the premium costs.

To assess the risk costs associated with a CDS, the expected and unexpected loss on the CDS have to be determined. For this purpose the new risk exposure has to be identified and modelled. Since the 'models' are an expansion on the current internal credit risk framework of RI, as discussed in chapter three, the loss associated with the CDS will also be expressed in terms of the Probability of Default (PD), Exposure At Default (EAD) and the Loss Given Default (LGD). Furthermore, the choice of CDS's is narrowed down to one year CDS's.

The following steps were taken for both, a customised and a standardised CDS:

- Identifying the risks that are mitigated by utilisation of the CDS as well as the additional risks;
- Determining the expected and unexpected loss of a loan with a CDS;
- Determining the diversification factor of a loan with a CDS;
- Quantifying the costs reduction for a CDS.

6.3 Basic CDS Structure

A vanilla CDS is a bilateral financial contract in which a party, the protection seller, agrees to reimburse the counterparty, the protection buyer, for his loss following a credit event of a single asset. In return, the protection seller receives a periodic fee, typically paid quarterly, until the maturity of the CDS or the default of the reference entity. Following a credit event the CDS can be settled in cash or physically (refer to section 3.4 for an explanation). The form of settlement is decided before the contract is closed.

Three entities can be distinguished in a CDS deal, namely the protection buyer, the reference entity and the protection seller. By entering the CDS deal the protection buyer only has an exposure on the protection seller, which depends on the exposure on the reference assets.
The reference asset could either be a loan issued by the bank (referred to as a customised CDS), or bonds, which are traded in the market (referred to as a standardised CDS). Thus, during modelling the following variables can be defined:

Stochastic

$$D_i = \begin{cases} 1 & \text{when entity } i \text{ is in default,} \\ 0 & \text{otherwise.} \end{cases}$$

D_i ~ Bernoulli(PD_i), where PD_i = probability of default of entity i

Non stochastic

LGD_i Loss when entity i is in default

EAD_i Exposure when entity i is in default

With the following subscripts:
- L indicates the loan being hedged with a CDS.
- R indicates the reference bond of the CDS.
- C indicates the CDS provider.

During modelling it is assumed that:
- the full anticipated loss ($LGD_L \cdot EAD_L$) on the loan is hedged;
- the post-default market value of a loan (or bond) is equivalent to the recovery on the loan (or bond): $(1 - LGD_L) \cdot EAD_L$;
- the transaction costs involved in a CDS deal are negligible.

6.4 Risk Substitution

By buying a CDS the protection buyer has substituted the credit risk exposure on the reference entity by a smaller credit risk exposure on the CDS. In general, two sources of credit risk exposure can be distinguished in an OTC derivative, being the reference entity and the counterparty. This also applies for a CDS.

For a customised CDS the credit risk exposure is determined by the reference loan and the CDS counterparty. Consequently, four scenarios can be distinguished, as given in Table 6.1. Keep in mind that the protection buyer only has a claim on the protection seller, if the reference assets are in default.

Scenario			Description
	D_L	D_C	
1.	0	0	No default has occurred, therefore the CDS does not pay out.
2.	0	1	The protection is invalid, for the CDS counterparty is in default.
3.	1	0	The reference assets are in default, and the CDS reimburses the loss to the bank.
4.	1	1	Both parties are in default, therefore part of the claim on the CDS will be recovered.

Table 6.1: Scenarios for a loan with CDS

Both, the first and third scenario are risk free when a customised CDS has been bought. In the second scenario however, the protection buyer is exposed to replacement risk, which will be clarified in section 6.4.1. The fourth scenario leads to double default risk, which will be discussed in section 6.4.2.

In case of a standardised CDS the protection buyer has an additional exposure on the CDS, for he purchased a CDS with similar (however, not exactly the same) underlying assets as the loan to the reference entity. Therefore, the loss on the loan could differ from the settlement of the CDS (scenario three and four). This mismatch is called basis risk, and will be discussed in section 6.4.3.

6.4.1 Replacement Risk

When the protection seller defaults during the term of the CDS the bank has no ‘real’ loss, as the bank only has a claim on the protection seller when the reference entity is in default. However, the bank will be exposed to the credit risk of the reference entity again. To cover this exposure the bank could once more decide to buy protection. But the price of default protection could have risen since the original CDS was negotiated; this exposes the protection buyer to the risk of having to pay a higher protection fee. These extra costs are called replacement cost and are treated as a loss.
Thus, replacement risk is the risk that the price of default insurance on the assets might have raised since the original default swap was negotiated.

6.4.2 Double Default Risk

Double default risk is the risk of loss when both, the protection seller and the reference entity, are in default at the same time. The bank then suffers a credit loss. Such a joint event is far less likely to occur, than the default of the reference asset alone.

6.4.3 Basis Risk

By buying a standardised CDS the protection buyer has an additional risk exposure. As he purchased a CDS with similar underlying assets to the loan to the reference entity instead of on identical assets, there can be a difference between the loss on the loan and the compensation received from the protection seller. This mismatch is called basis risk and can be caused by a mismatch in default moments and a pay-out mismatch.

Mismatch in default moments

The pay-out of the CDS is contingent on the default moment of the reference assets. The pay-out moment of the CDS therefore depends on whether or not the reference assets are considered to be in default by the CDS contract. Another factor is the default time of the reference assets.

Whether or not the reference assets are considered in default depends on the definition of a credit event used in the CDS documentation. The market definition could differ from the definition used by the bank involved. This could lead to different moments of default, for the bank could consider the reference asset to be in default, while under the CDS documentation the reference asset is not.

The biggest issue here is whether or not restructuring events are included. Based on the ISDA 2003 standard there are four options for restructuring, namely no restructuring, full restructuring, modified restructuring and modified-modified restructuring.

The second factor is the difference in default timing between a bond and the loan to the reference entity. The loan could be in default while the bond is not. This would lead to great losses. On the other hand, when the bond is in default while the loan is not, there is a possibility of a profit.

The pay-out structure

During settlement there is the option for a cash or physical settlement. With a physical settlement the pay-out of the CDS is equal to the notional of the reference assets in exchange for the delivering the assets. With a cash settlement on the other hand the pay-out under the CDS is completely determined by the loss on the reference bond. For the protection seller pays the protection buyer the difference between the notional and the post-default value of the reference bond.

From a modelling point-of-view both options are similar. The main issue is the difference between the loss on the loan and the loss on the reference bonds. If both, the bonds and the loan are unsecured, with coinciding terms, and with the exact same legal entity as counterparty, the LGD estimates will be the same. However, this does not necessarily mean that the actual recoveries will correspond. Thus, although the expected LGD's are similar, the volatility around the estimated values has to be taken into account.

Thus, to minimise the basis risk associated with a standardised CDS it is important to take the following aspects into account before closing a deal:

- Does the default definition stated in the CDS documentation take restructuring into account?
- Does the credit rating of the reference bonds and the loan correspond?
- Which deliverable obligations are specified in case of a physical settlement; is the loan issued by the bank acceptable?
- If so, can the loan issued by the bank easily be transferred in case of a default? If the loan is not transferable cash settlement is preferred.

6.5 Modelling a Customised CDS

The reference asset of a customised CDS is the loan that the bank issued to the reference entity. Thus, the bank has an exposure on the protection seller equal to the notional of the loan. During modelling the following additional assumptions are made:

- It is possible to transfer the loan to the protection seller, in case of a default;
- When physical settlement is specified in the contract, the loan is transferred to the protection seller.

Under these assumptions there is no difference between the loss incurred with physical and cash settlement. However, the cash flow in both situations differs. In case of a physical settlement the bank will receive the full notional of the loan from the protection seller. In return, the loan has to be transferred. With a cash settlement only the loss on the reference assets is reimbursed by the protection seller. Thus, the bank first has to recover part of the loan from the reference entity himself.

Each settlement option involves different costs. With cash settlement, the protection buyer has to pay the work out costs[1] of the loan, while with physical settlement these costs are made by the protection seller. Instead, the protection buyer has the costs of transferring the loan to the protection seller.

In Table 6.1 four scenarios were distinguished for a loan with CDS. In case of a customised CDS, only the second and fourth scenario are considered to be risky. An overview of the risks for each scenario is given in Table 6.2, followed by an explanation of each scenario.

[1] Work out costs is a general term referring to the costs made to handle the default. It includes the internal administration cost, external legal fees etc.

Scenario			Risk type	Probability	Loss
	D_L	D_C			
1.	0	0	No risk	$P(D_L = 0 \wedge D_C = 0)$	None
2.	0	1	Replacement risk	$P(D_L = 0 \wedge D_C = 1)$	Replacement cost
3.	1	0	No risk	$P(D_L = 1 \wedge D_C = 0)$	None
4.	1	1	Double default risk	$P(D_L = 1 \wedge D_C = 1)$	Part of the notional of the loan

Table 6.2: Risks involved in a Customised CDS

Scenario 1: No Default

In case no default has occurred during the term of the CDS, the will CDS expire. The bank will not incur a loss in this situation, thus $\text{loss}_1 = 0$.

Scenario 2: Protection Seller in Default

When the protection seller defaults while the reference entity does not, the protection seller has no direct loss on the loan. Instead, the protection seller has the risk of 'losing' the replacement cost, assuming that the CDS will be replaced. So, in this scenario the protection seller bears replacement risk.

The replacement costs are the *extra* costs made to buy protection on the reference assets again for the remaining term of the CDS. Thus, the extra costs are the difference between the current price paid for protection and the new future price.

The price of the protection depends on the credit quality of the reference assets, and can be determined by the credit rating of the reference entity. However, the rating of the reference entity at time of default of the protection seller is unknown, for the assets of the reference entity could have deteriorated.

A way to model the loss is to determine the migration probabilities of the rating of the loan given the default of the protection seller, and the CDS spread under those circumstances. The replacement costs for a loan with rating i (RC_i) can be determined as:

$$RC_i = \sum_{j=R1}^{R20} P(i,j) \cdot (S_j - S)\,,$$

where:

i = rating of the reference asset $\quad i \in$ R1, …, R20

j = migrated rating of the reference asset $\quad j \in$ R1, …, R20

S = current spread paid

S_j = future spread for a CDS with underlying assets with rating j

P(i, j) = migration probability from i to j given the default of the protection seller.

However, it is hard to make assumptions about the market circumstances when the protection seller has defaulted. The protection seller, generally a large bank, has a higher credit rating than the reference entity, so the default of the bank is likely to influence the creditworthiness of the reference entity. This makes it difficult to estimate the migration probabilities.

The choice has been made to make a conservative estimation for the replacement cost. Given the default of the protection seller it is assumed that the reference entity has had a downgrade of two major S&P rating classes. Furthermore, the assumption is made that if the protection seller defaults it is halfway the year. The replacement cost can now be calculated as the extra spread cost for a one year CDS divided by two, since protection only has to be bought for the second part of the year. Thus, $loss_2 = RC$.
For now, these extra costs are regarded as an expected loss, and therefore no Economic Capital is retained to cover this loss. The expected replacement costs are only added to the EL.

Scenario 3: Reference Entity in Default
If the reference entity is in default while the protection seller is not, the protection buyer will be reimbursed by the protection seller for the loss on the loan. The protection seller bears no risk of loss in this case, thus $loss_3 = 0$. The 'cash flows' in this situation are illustrated in Figure 6.1 and Figure 6.2 for a cash and physical settlement respectively.

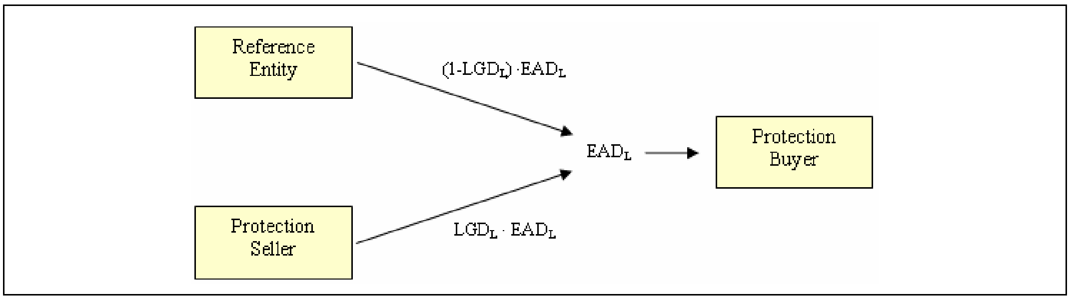


Figure 6.1: Cash Settlement in case of a single default

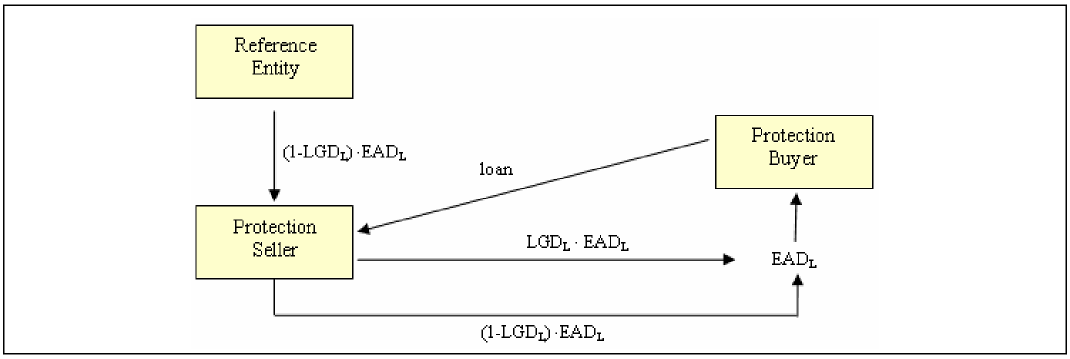


Figure 6.2: Physical Settlement in case of a single default

Scenario 4: Double Default

In case the reference entity and protection seller are in default at the same time, the protection seller has the risk of losing part of his claim on the protection seller, for the latter could not be able to compensate for the whole loss. In this case the protection buyer is exposed to double default risk. An illustration of the cash flows in case of a double-default event is given in Figure 6.3 and Figure 6.4 for a cash and physical settlement respectively. In both cases the protection buyer receives the full amount recovered on the loan and a part of the loss. Thus, the $loss_4 = LGD_L \cdot LGD_C \cdot EAD_L$, as can be derived from the figures below.

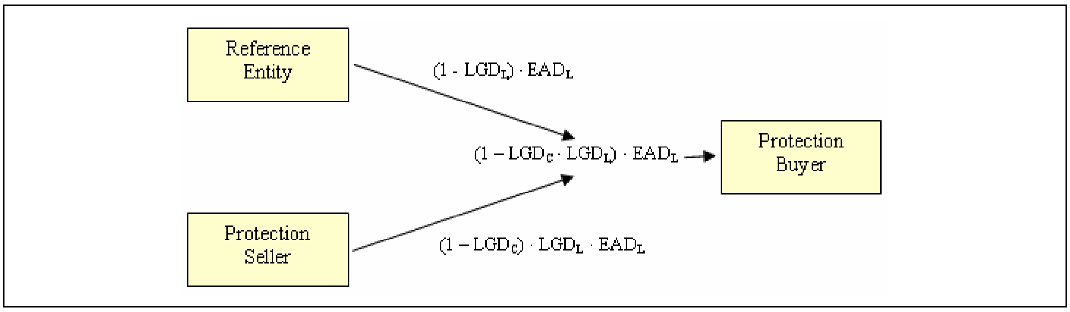


Figure 6.3: Cash Settlement in case of a joint default

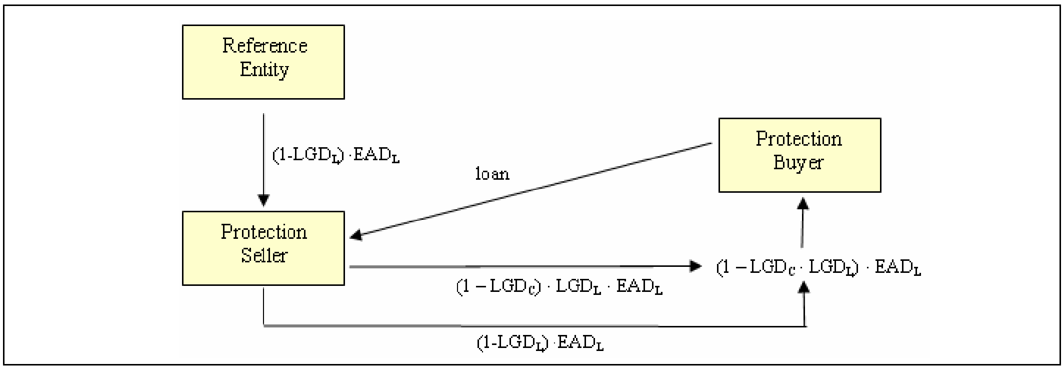


Figure 6.4: Physical Settlement in case of a joint default

Loss on the loan with CDS

The loss on a loan with a CDS ($loss_{CDS}$) can be determined by combining the losses in each scenario. Since a loss is only incurred in scenario two and four, $loss_{CDS}$ is given by:

$$loss_{CDS} = D_C \cdot D_L \cdot LGD_L \cdot LGD_C \cdot EAD_L + D_C \cdot (1 - D_L) \cdot RC$$

To calculate the expected loss (*EL*) and unexpected loss (*UL*) on the loan with a CDS, the expectation and the volatility of $loss_{CDS}$ have to be determined.

$$
\begin{aligned}
EL &= E(loss_{CDS}) \\
&= E\left(D_C \cdot D_L \cdot LGD_L \cdot LGD_C \cdot EAD_L + (1-D_L) \cdot D_C \cdot RC\right) \\
&= E(D_C \cdot D_L) \cdot LGD_L \cdot LGD_C \cdot EAD_L + E\left((1-D_L) \cdot D_C\right) \cdot RC \\
&= P(D_C = 1 \wedge D_L = 1) \cdot LGD_L \cdot LGD_C \cdot EAD_L + P(D_L = 0 \wedge D_C = 1) \cdot RC \\
&= PD_{C,L} \cdot LGD_L \cdot LGD_C \cdot EAD_L + (PD_C - PD_{C,L}) \cdot RC
\end{aligned}
$$

In the above, $PD_{C,L}$ stands for the joint default probability of the protection seller and the reference entity, and is calculated as:

$$PD_{C,L} = PD_L \cdot PD_C + \rho_{C,L} \cdot \sqrt{PD_L \cdot (1-PD_L) \cdot PD_C \cdot (1-PD_C)}\ .$$

This formula can be derived from equation 5-7. The $\rho_{C,L}$ stands for the default correlation between the protection seller and the reference entity.

Since the replacement costs are seen as an expected loss, no Economic Capital has to be reserved. Therefore, the replacement costs have to be excluded during the UL calculation.

$$
\begin{aligned}
UL &= \sqrt{Var(loss_{CDS} - (1-D_L) \cdot D_C \cdot RC)} \\
&= \sqrt{E((loss_{CDS} - (1-D_L) \cdot D_C \cdot RC) - E(loss_{CDS} - (1-D_L) \cdot D_C \cdot RC))^2} \\
&= \sqrt{LGD_L^2 \cdot LGD_C^2 \cdot EAD_L^2 \cdot PD_{C,L} - LGD_L^2 \cdot LGD_C^2 \cdot EAD_L^2 \cdot PD_{C,L}^2} \\
&= \sqrt{PD_{C,L} \cdot (1-PD_{C,L})} \cdot LGD_L \cdot LGD_C \cdot EAD_L
\end{aligned}
$$

6.6 Modelling a Standardised CDS

When a standardised CDS is bought, the underlying assets are bonds of the reference entity instead of the loan to the reference entity. In this case there is a mismatch between the reference bond and the loan, which leads to an additional risk exposure.
In addition to the previous section the following assumptions are made:

- The recovery on the reference bond is different from the recovery on the loan, thus the following applies: $LGD_R = LGD_L$.
- The market's definition of a default matches the default definition of the Rabobank and the bond defaults at the same time as the loan: $P(D_L = 1 \mid D_R = 1) = 1$.
- The difference between the recovery on the CDS (which is equivalent to the loss on the reference bonds) and the loss on the loan is stochastic. This difference equals the loss or profit due to basis risk: $LGD_L \cdot EAD_L - LGD_R \cdot EAD_R$.
- The expected loss (μ) and the volatility of the loss (σ) due to basis risk are known.

Under these assumptions the following associations can be made:

- The default probability of the reference asset is the same as the default probability of the loan: $PD_R = PD_L$.
- The protection is bought as such that the expectation of basis risk is nil. This gives the following relation: $EAD_R = (EAD_L \cdot LGD_L)/LGD_R$.

Given the abovementioned assumptions the model is still not affected by the type of settlement specified in the CDS contract. In comparison with the scenarios in the simple model, this model has an additional basis risk in the third and fourth scenario. An overview of the risks in each scenario is given in Table 6.3.

Scenario	D_L	D_R	D_C	Risk type	Probability	Loss
1.	0	0	0	No risk	$P(D_L = 0 \wedge D_C = 0)$	None
2.	0	0	1	Replacement risk	$P(D_L = 0 \wedge D_C = 1)$	Replacement costs
3.	1	1	0	Basis risk	$P(D_L = 1 \wedge D_C = 0)$	Part of the notional of the loan
4.	1	1	1	Double default and basis risk	$P(D_L = 1 \wedge D_C = 1)$	Part of the notional of the loan

Table 6.3: Risks involved in a Standardised CDS

Scenario 3: Reference Entity in Default

In this case, the protection buyer will be reimbursed by the protection seller for the loss on the reference asset. In Figure 6.5 and Figure 6.6 an illustration is given of the 'cash flows' in this situation, for a cash and physical settlement respectively.

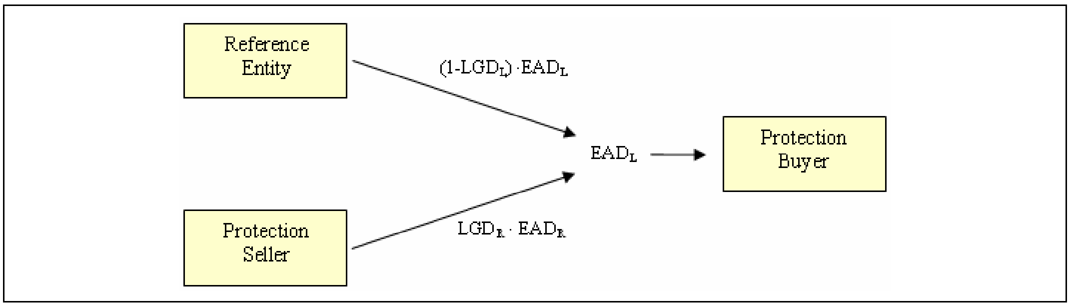


Figure 6.5: Cash Settlement in case of a single default

Because the reference assets are similar but not identical to the loan, the protection buyer bears basis risk, for the loss on the reference assets could differ from the loss on the loan. Before entering the CDS these amounts are attuned, based on estimated expected LGD's. In reality, the recovery on the loan and bond can differ from the expected value. This difference is given by:

$$loss_3 = LGD_L \cdot EAD_L \; - \; LGD_R \cdot EAD_R.$$

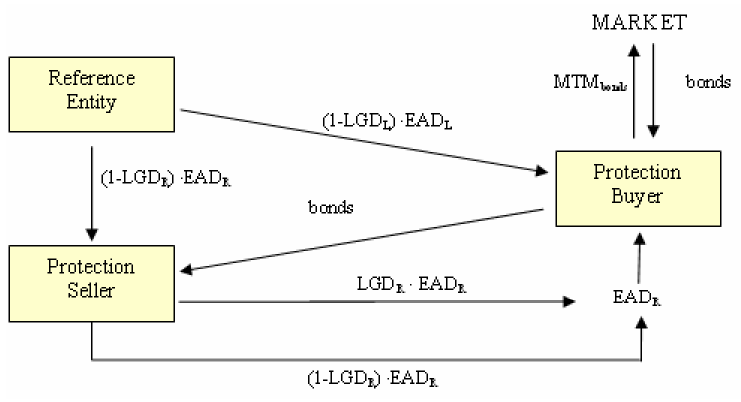


Figure 6.6: Physical Settlement in case of a single default

The loss due to basis risk is stochastic and will be expressed as a percentage of the EAD_L. This can be modelled as:

$$loss_3 = B \cdot EAD_L,$$

where B stands for basis, a random variable that represents the percentage loss on the loan due to basis risk. The expected basis is noted as μ_B and σ_B denoted the volatility of the loss due to basis risk. Since these data are sufficient to calculate the unexpected loss due to basis risk, no assumption has to be made regarding the distribution of B.

Since the CDS is attuned to fully cover the loss on the loan, the basis is expected to be zero. However, the size of the volatility of the basis is difficult to determine.

Scenario 4: Double Default

In addition to the double default risk quantified in the paragraph 6.5, the protection buyer also bears basis risk in this scenario. An illustration of the "cash flows" in case of a joint-default event is given in Figure 6.7 for a cash settlement and in Figure 6.8 for a physical settlement.

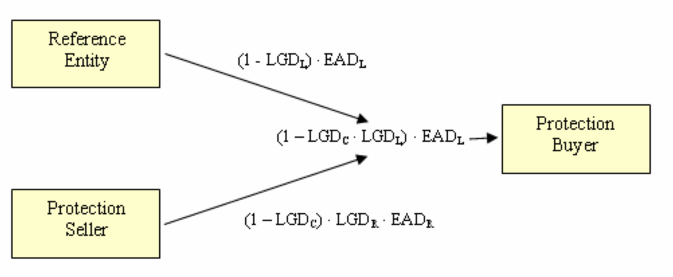


Figure 6.7: Cash Settlement in case of a joint default

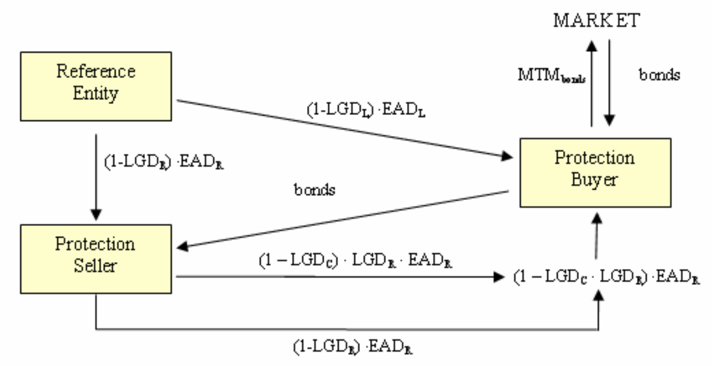


Figure 6.8: Physical Settlement in case of a joint default

In both cases, the protection buyer receives the full amount recovered on the reference assets and part of the loss, minus the deviation due to basis risk. Thus, the loss in this scenario is given by:

$$loss_4 = B \cdot EAD_L + LGD_R \cdot LGD_C \cdot EAD_R.$$

Loss on the loan with CDS

Again the loss on a loan with a standardised CDS can be determined by combining the losses in each scenario, and is given by:

$$loss_{CDS} = (1 - D_L) \cdot D_C \cdot loss_2 + (1 - D_C) \cdot D_L \cdot loss_3 + D_L \cdot D_C \cdot loss_4,$$

where:

$$loss_2 = RC$$
$$loss_3 = B \cdot EAD_L,$$
$$loss_4 = B \cdot EAD_L + LGD_R \cdot LGD_C \cdot EAD_R.$$

Based on these data the expected (EL) and unexpected loss (UL) of the loan with a CDS can be computed. The EL is given by:

$$\begin{aligned} EL &= E((1 - D_L) \cdot D_C) \cdot E(loss_2) + ((1 - D_C) \cdot D_L) \cdot E(loss_3) + E(D_L \cdot D_C) \cdot E(loss_4) \\ &= (PD_L - PD_{C,L}) \cdot RC + PD_{C,L} \cdot LGD_C \cdot LGD_L \cdot LGD_L \end{aligned}$$

Since the expectation of B is zero.

In determining the UL the loss in the second scenario is once again excluded, for no Economic Capital will be reserved to cover this loss. The UL is given by:

$$UL = \sqrt{PD_L \cdot \sigma_B^2 + PD_{C,L} \cdot (1 - PD_{C,L}) \cdot LGD_C^2 \cdot LGD_L^2} \cdot EAD_L \ .$$

For the derivation of the unexpected loss refer to Appendix C.

Now that the EL and UL are known, the only data required for calculating the Economic Capital is the risk diversification factor (RDF) of the loan with a CDS. To determine this, the correlation between a single loan and the loan with a CDS has to be calculated. For the computation of the correlation refer to Appendix D. The correlation between the loan with CDS and any other loan is given by:

$$cor(loss_{CDS}, loss_T) = \frac{\left(PD_{L,B,T} - PD_{L,B} \cdot PD_T\right) \cdot LGD_L \cdot LGD_B}{\sqrt{\left(PD_T - PD_T^2\right) \cdot \left(PD_L \cdot \sigma_{LB}^2 + PD_{L,B} \cdot \left(1 - PD_{L,B}\right) \cdot LGD_L^2 \cdot LGD_B^2\right)}},$$

where $loss_{CDS}$ stands for the loss on the loan with a CDS, and $loss_T$ stands for the loss of any other loan in the portfolio.

The RDF of a CDS in the RI portfolio can now be calculated as specified in chapter five.

6.7 Some Practical Examples

The model for the standardised CDS is implemented into an Excel spreadsheet. By specifying the characteristics of the loan, the reference bonds and the CDS counterparty the 'profitability' of a CDS transaction can be calculated. For a more elaborate explanation of the spreadsheet refer to Appendix E.

The spreadsheet is applied to four clients of RI. In Table 6.4 an overview is given of the characteristics of the facilities to these clients. Besides the internal credit rating (RRR), the estimated LGD, and the exposure at default of each facility, an overview is given of the special arrangements with the debtor. These special arrangements could for instance involve whether or not the facility has additional collateral, or covenants[2].

[2] A covenant is a promise in an indenture, or any other formal debt agreement, that certain activities will or will not be carried out. The purpose of a covenant is to monitor and possibly restrict the actions of the client. Covenants can cover everything from limited dividend payments to levels that must be maintained in working capital.

The facilities in Table 6.4 are hedged with standardised CDS's, meaning that the underlying assets of the CDS are bonds of the reference entity instead of the loan. The features of the CDS on the reference bonds are given in Table 6.5, including the spread of the CDS. The data in both represent the state of affairs on 5 July 2004.

It has to be noted that the market does not use the detailed S&P scale. Only the main rating classes are taken into account, which renders comparing more difficult. For example, the market gives the client a triple B rating. Mapping this to the master-scale employed within the bank, this could mean a R8, R9 or R10 rating, while the bank has rated the client as R9. This could lead to a rating mismatch, which is not accounted for in the CDS framework.

Another important difference is that there are bilateral arrangements between the reference entity and the bank (covenants) or the bank has some additional collateral. This results in a lower LGD estimate for the loan than for the bond. The LGD's of the loans and bonds are estimated with the LEA system. For the latter, some minor adjustments had to be made.

For each client, the risk costs before and after the CDS deal are determined. In Table 6.6 an overview is given of the risk cost reduction, the CDS spread, and the average spread for the corresponding rating class. These numbers are expressed in basis points of the notional of the loan.

Client	Rating	LGD	EAD	Remarks
Client A	R9	48,91%	€ 210.885.733	with covenants
Client B	R7	17,28%	€ 154.763.000	with covenants
Client C	R7	50,43%	€ 186.676.788	
Client D	R8	25,90%	€ 48.871.199	security present

Table 6.4: Four clients of RI

Client	Rating	LGD	Spread	Remarks
Client A	BBB+	50,00%	0,31%	no covenants
Client B	BBB+	18,00%	0,22%	no covenants
Client C	A+	50,43%	0,19%	
Client D	BBB	39,36%	0,30%	no security

Table 6.5: CDS on bonds

Client	Risk Cost Reduction	CDS Spread client	CDS spread rating
Client A	34	30	39
Client B	6	21	39
Client C	18	19	21
Client D	26	20	39

Table 6.6: The risk costs (in bps) compared

From Table 6.6 it can be derived that only the transaction with client A is profitable. For the other three transactions the risk cost-reduction is less than the premium costs.

Client A

In contrast to the other clients, the transaction is profitable for client A. The risk cost-reduction is approximately € 717 thousand (0.34 percent of € 210.855.733), whereas the premium costs are approximately € 639 thousand (0.3 percent of € 210.855.733). Because the outstanding to this client is high, a name concentration penalty is given. This means that additional solvency has to be met for the large size of the loan.
In this case the market and the bank assigned the client the same rating. The recovery on the bond however is lower than the recovery on the loan, for the bank has made special arrangements with the client.

Client B

The transaction turns out not to be profitable for client B. This can partially be explained by a rating mismatch. The market has assigned the bonds a lower rating than the bank (R8 by market, R7 by bank). Thus, the bank is more optimistic about the client and keeps less capital. Therefore, the risk cost reduction is less than the premium costs. The difference is significant for this deal, namely 16 bps.
The recovery on the bonds and the loan do not differ much, as the bank loan has an LGD of 17.28 percent, while the bonds have an LGD of 18 percent. This difference is caused by the covenants on the loan.

Client C

The market has rated the client as R6, while the bank has rated the same client as R7. Thus, the market is more optimistic about the client. The recovery on both loan and bonds is estimated to be the same. This would mean that the bank could buy the protection at a relatively low price. The risk cost reduction is slightly less than the CDS spread.
[…]

Client D

For client D the bank is more optimistic about the client than the market. The bank has rated the client R8, while the market assigned a R9 rating. Furthermore, the LGD of the loan is 25.90 percent while the LGD of the bonds is 39.36 percent. This is caused by the fact that the bank has security, which can be sold in case of a default. By entering the CDS the bank would pay more for the protection, than the risk cost reduction.

These examples again stress the importance of carefully selecting the CDS. Before entering the contract, the default definition stated in the contract has to be checked on whether or not the restructuring clause is included, as well as the rating and priority of the bonds. Furthermore, the timing in buying the CDS plays an important role. This is illustrated in Figure 6.9 and Figure 6.10 below. When the risk cost reduction, depicted as the orange line, lies above the blue line, the deal is considered to be profitable.
For instance, for client B the risk costs reduction is very low compared to the spread costs. This transaction was never profitable to execute before the second of august.

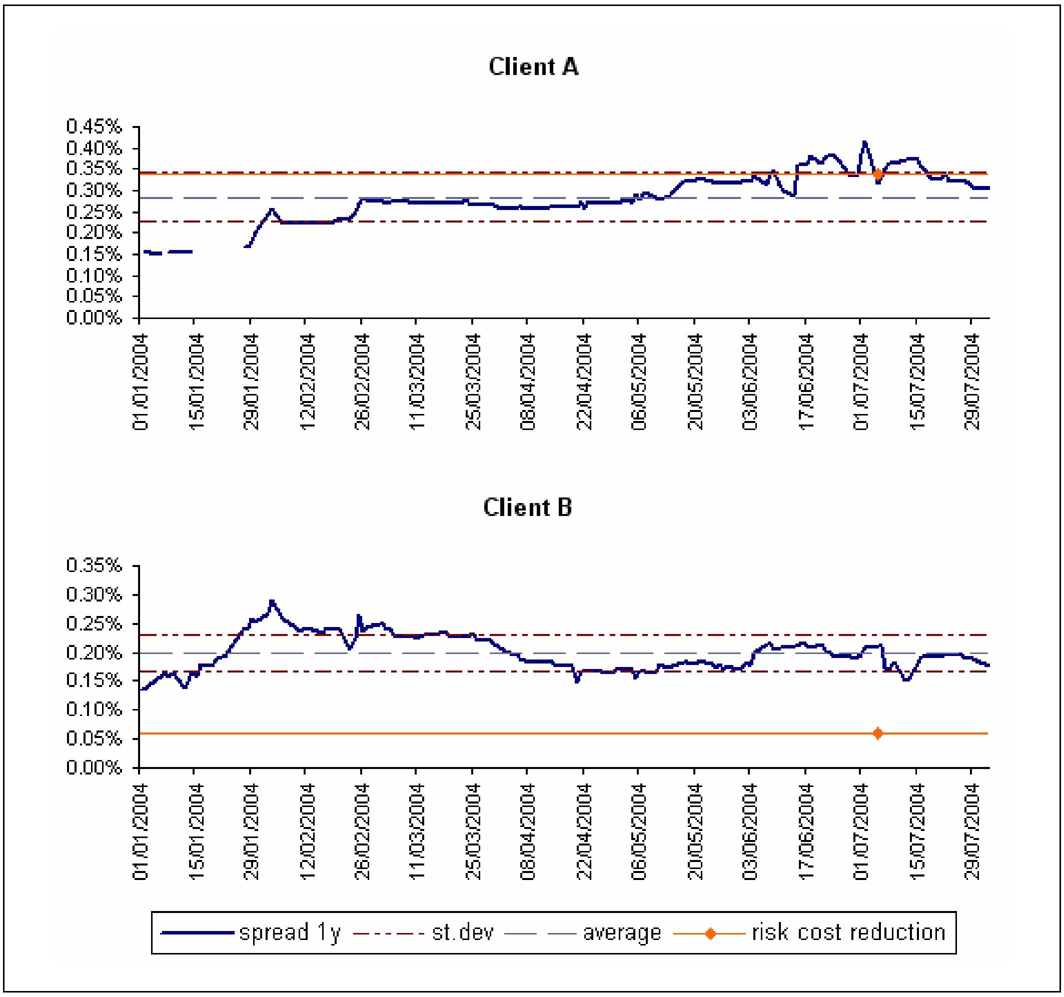


Figure 6.9: Fluctuations of the CDS spread - I

Figure 6.10: Fluctuations of the CDS spread - II

7. The CDO Methodology

7.1 Introduction

With a Collateralised Debt Obligation the credit risk of a pool of assets can be hedged. In a traditional CDO structure the reference assets are sold to the SPV. As a result the valuable client bank relation is compromised. With a synthetic structure this can be prevented, since only the credit risk on the assets is transferred to the SPV by means of a CDS. Thus, the assets remain on the balance sheet of the bank.

In this chapter, a first step is taken in modelling the credit risk reduction by utilisation of a synthetic CDO. Paragraph 7.2 outlines the approach taken, followed by a description of the basic structure of a synthetic CDO in paragraph 7.3. The assumptions made during modelling are also treated in paragraph 7.3. Thereupon, the risk substitution by applying a synthetic CDO is handled in paragraph 7.4. Subsequently, the credit risk on a single tranche and multiple tranches is modelled in paragraph 7.5 and 7.6 respectively. A methodology for determining the RDF for the tranches of a CDO is outlined in paragraph 7.7. Finally, a simple example is discussed in paragraph 7.8.

7.2 Approach

There are various types of Collateralised Debt Obligations (refer to chapter five). The structure that will be modelled in this chapter is the synthetic balance sheet CLO. By utilization of this type of CDO the risk costs are mitigated without removing the assets of the balance sheet. However, there are considerable costs involved in a CDO transaction, i.e. structuring and marketing costs, legal and administration fees, and fees to external rating agencies.

In this chapter, the emphasis lies on modelling the risk cost reduction. To be able to estimate the risk cost after the transaction, the risks of applying a CDO have to be identified and expressed in terms of EL and UL. For this purpose the following steps were taken:

- Determining the EL and UL for a tranche of the CDO;
- Determining the risk diversification factor of a tranche of the CDO;
- Quantifying the risk cost reduction for a CDO.

7.3 Basic Structure

With a synthetic balance sheet CLO the credit risk of a pool of assets is transferred to capital market investors via a SPV. The originating bank enters into a Credit Default Swap with the SPV, where after the SPV issues notes with different risk characteristics. Each group of notes with the same risk characteristics is referred to as a tranche. The tranche that is exposed to highest risk is called the equity tranche, and the tranche with the lowest risk is called the senior tranche. The tranches in-between are called the mezzanine tranches. Typically, the originating bank will retain the equity tranche.
With the proceeds of the note issuance, the SPV buys high-quality collateral. The establishment of a fully funded synthetic CLO structure is illustrated in Figure 7.1.

The yield payments to the tranches depend on the received CDS premium and to the interest income from the high quality collateral. The proceeds are allocated to the prioritised tranches, where the most senior tranche is paid first, then the mezzanine tranches and the remaining amount is paid to the equity holders. This pay-out structure is also referred to as the waterfall. The periodic payments are depicted in Figure 7.2.

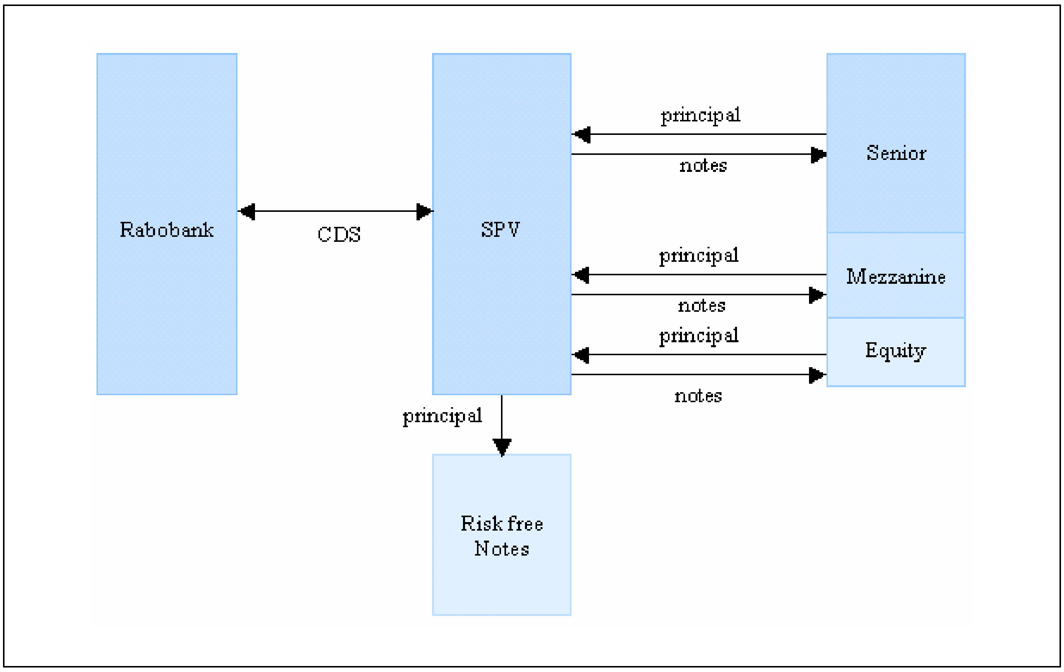


Figure 7.1: Establishment of a synthetic CLO

In case of a default in the reference portfolio, the SPV will sell some of the high quality assets and reimburse the protection buyer for his loss. Depending on the size of the loss, the loss will be assigned to one or multiple tranches, where the equity tranche will absorb the first losses (up to the notional of the tranche), and followed the more senior tranches. Henceforth, the note holders of the tranche will receive their yield payments on the remaining notional of the tranche (notional notes minus the incurred losses).

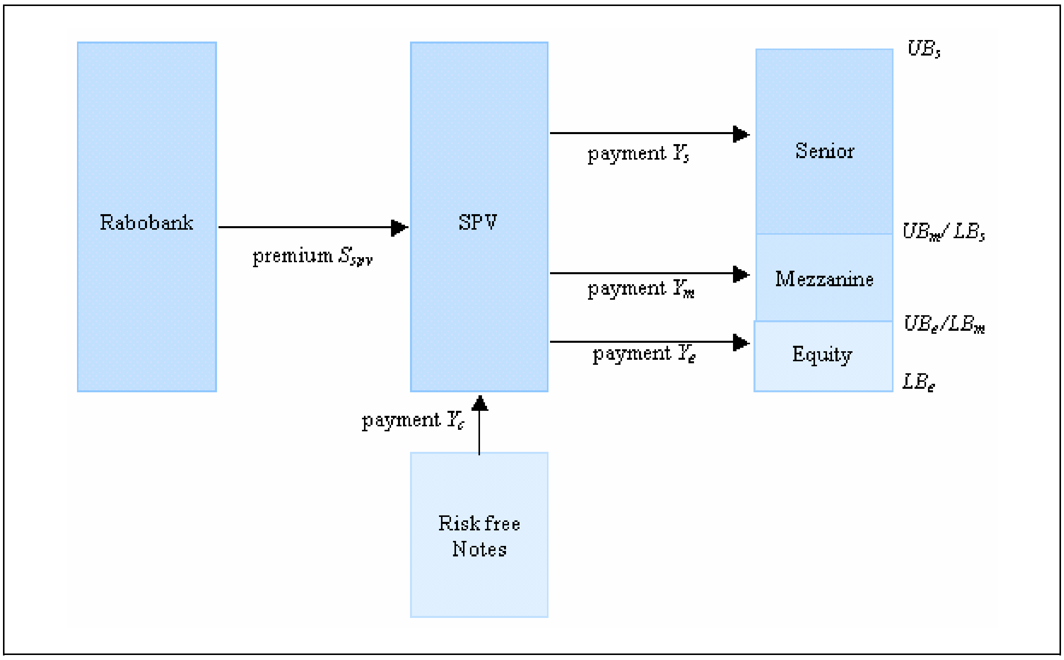


Figure 7.2: Periodic Payments under a synthetic CLO

During modelling, the following assumptions are made:

- The SPV is fully funded, meaning that the SPV issues notes for approximately 100 percent of the reference portfolio.
- The reference portfolio of the CDO only contains loans, and is static during the year.
- The SPV is the counterparty of the CDS.
- The PD, LGD and EAD for each asset in the reference portfolio are known.

7.4 Risk Substitution

By utilization of a synthetic CDO the credit risk on a pool of assets is substituted by the credit risk on just a part of the portfolio, namely the tranches that are retained by the bank. Typically, the originator retains the equity tranche, which is usually about 2 percent of the pool of reference assets, but the originator could decide to keep more than one tranche in its own portfolio. Furthermore, the originating bank can have a credit risk exposure on the CDS counterparty.

7.4.1 Credit Risk on a CDO Tranche

The originating party can decide to retain one or more tranche in his own portfolio. By doing so the originator still bears credit risk on part of the reference portfolio. However, the maximum amount that can be lost is limited, for only the notional of the tranche can be lost.

7.4.2 Risk on CDS Counterparty

In a synthetic CDO structure the originating bank enters a customised CDS with a third party. When the third party is another party than the SPV, a large bank for instance, the originator has a risk exposure on the CDS.

The credit default swap with the SPV can be seen as risk free, for the SPV has invested exactly the same amount as its liabilities, in high quality collateral. Thus, it can be assumed that the SPV cannot default.

When the CDS counterparty is a large bank, the originating bank is exposed to replacement and credit risk, since the bank can default.

7.5 Modelling a Single CDO Tranche

The CDO model is based on [Derix, 2004]. Since the loss distribution of a loan portfolio is often approximated by the standard beta distribution, it will also be used to approach the loss distribution of the reference portfolio. In Figure 7.3 the loss distribution of a loan portfolio is given with the boundaries of the various tranches. The equity tranche for instance, is only exposed to a loss of at most 5 percent of the notional of the reference portfolio.

The loss in a tranche can also be approximated by a beta-distribution. However, in this case the distribution has to be truncated at the lower boundary and the upper boundary of the tranche. Thus, if the parameters of the loss distribution of the reference portfolio are known, the EL and the UL for the tranches can be calculated, for these are equivalent to the mean and standard deviation of part of the distribution.

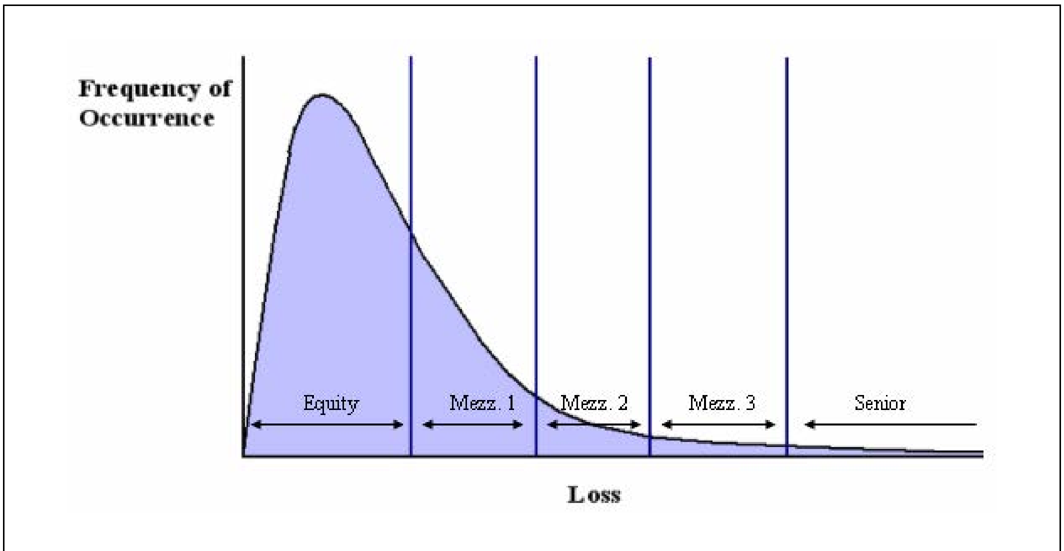


Figure 7.3: The Loan Loss Distribution

7.5.1 The Beta Distribution

The general formula for the probability density function of the beta distribution is given by

$$f(x) = \frac{(x-a)^{\alpha-1}(b-x)^{\beta-1}}{B(\alpha,\beta)(b-a)^{\alpha+\beta-1}}, \quad a \le x \le b; \alpha, \beta > 0$$

where α and β are the shape parameters of the distribution, a and b are the lower and upper bounds of the distribution, and $B(\alpha, \beta)$ is the beta function. The beta function has the formula

$$B(\alpha,\beta) = \int_0^1 t^{\alpha-1}(1-t)^{\beta-1}\,dt$$

In case of the standard beta distribution, a = 0 and b = 1. The equation for the standard distribution is given by

$$f(x) = \frac{1}{B(\alpha,\beta)} x^{\alpha-1}(1-x)^{\beta-1} \quad 0 \le x \le 1; \alpha,\beta > 0 \qquad (7\text{-}1)$$

The formula for the cumulative distribution function of the beta distribution is also called the incomplete beta function ratio and is defined as

$$F(x) = \frac{\int_0^x t^{\alpha-1}(1-t)^{\beta-1}\,dt}{B(\alpha,\beta)} \quad 0 \le x \le 1; \alpha,\beta > 0 \qquad (7\text{-}2)$$

The mean (μ) and the variance (σ^2) of the standard beta distribution is given by:

$$\mu = \frac{\alpha}{\alpha+\beta} \qquad \text{and} \qquad \sigma^2 = \frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}.$$

7.5.2 The Portfolio Loss Distribution

To be able to approach the loss distribution of the reference portfolio the shape parameters of the beta distribution have to be determined. Given the mean (μ) and variance (σ^2) of the loss in the reference portfolio the shape parameters can be calculated as follows:

$$\alpha = \mu \cdot \left(\frac{\mu \cdot (1-\mu)}{\sigma^2} - 1 \right) \qquad \beta = (1-\mu) \cdot \left(\frac{\mu \cdot (1-\mu)}{\sigma^2} - 1 \right)$$

The mean and the standard deviation of the loss distribution of the reference portfolio is equivalent to the expected and unexpected loss of the reference portfolio, and can be determined as described in section 5.4.

Since the standard beta distribution has a range from 0 to 1, the EL and UL have to be rescaled to fall in this interval. Dividing the EL and UL by the notional of the reference portfolio (*NRP*) gives the desired result:

$$EL\% = \frac{EL}{NRP} \quad \text{and} \quad UL\% = \frac{UL}{NRP}.$$

Now the shape parameters, α and β, are given by:

$$\alpha = EL\% \cdot \left(\frac{EL\% \cdot (1 - EL\%)}{UL\%^2} - 1 \right) \quad \text{and} \quad \beta = (1 - EL\%) \cdot \left(\frac{EL\% \cdot (1 - EL\%)}{UL\%^2} - 1 \right).$$

7.5.3 The EL and UL for a Single Tranche

Given that a tranche has a lower boundary *lb* and an upper boundary *ub*, the loss in the tranche can be computed. The tranche will only get hit when the loss occurred in the reference portfolio exceeds the lower boundary of the tranche and the loss in the tranche will never exceed *ub* - *lb*. This can be defined as:

$$loss_{[lb,ub]} = \min(\max(0, l - lb), ub - lb), \qquad (7\text{-}1)$$

where *l* is the loss in the reference portfolio.

Now the EL and UL for that tranche can be calculated, for the expectation and the variance of a random variable *x* is given by:

$$EL = E(X) = \int_0^1 x \cdot f_X(x)dx$$

$$UL^2 = E(X^2) - E(X)^2 = \int_0^1 x^2 \cdot f_X(x)dx - EL^2$$

The EL and UL for a tranche can therefore be determined as:

$$EL\%_{[lb,ub]} = EL\% \cdot (F_{\alpha+1,\beta}(ub) - F_{\alpha+1,\beta}(lb)) - lb \cdot (1 - F_{\alpha,\beta}(lb)) + ub \cdot (1 - F_{\alpha,\beta}(ub))$$

$$
\begin{aligned}
UL\%^2_{[lb,ub]} = & \left(EL\%^2 + UL\%^2\right)\cdot\left(F_{\alpha+2,\beta}(ub) - F_{\alpha+2,\beta}(lb)\right) - 2\cdot lb\cdot EL\%\cdot\left(F_{\alpha+1,\beta}(ub) - F_{\alpha+1,\beta}(lb)\right) \\
& + lb^2\cdot\left(1 - F_{\alpha,\beta}(lb)\right) + ub\cdot\left(ub - 2\cdot lb\right)\cdot\left(1 - F_{\alpha,\beta}(ub)\right) + lb^2\cdot\left(1 - F_{\alpha,\beta}(ub)\right) - EL^2_{[lb,ub]}
\end{aligned}
$$

For the derivation of these formulas refer to Appendix F.

7.6 Modelling Multiple CDO Tranches

When the originator decides to retain more than one tranche of the CDO, the EL and UL for the combination has to be determined. The EL's of the tranches can simply be added, as will be shown in Appendix G. The UL's of the tranches however, cannot, since the losses in the tranches are correlated. In this paragraph the EL and UL for multiple tranches will be derived.

Suppose two tranches are retained, with lower boundary's $lb_{(1)}$ and $lb_{(2)}$ and upper boundary's $ub_{(1)}$ and $ub_{(2)}$, Where $\cdot_{(1)}$ is the boundary of the most subordinated tranche that is retained. The loss for both tranches can now be defined as:

$$
\begin{aligned}
loss_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} = & \min(\max(0, l - lb_{(1)}), ub_{(1)} - lb_{(1)}) \\
& + \min(\max(0, l - lb_{(2)}), ub_{(2)} - lb_{(2)})
\end{aligned}
$$

In this case the EL for both tranches is given by:

$$
EL\%_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} = EL\%_{[lb_{(1)},ub_{(1)}]} + EL\%_{[lb_{(2)},ub_{(2)}]},
$$

and the UL for both tranches is equal to:

$$
\begin{aligned}
UL\%^2_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} = & UL\%^2_{[lb_{(1)},ub_{(1)}]} + UL\%^2_{[lb_{(2)},ub_{(2)}]} \\
& + 2\cdot\left(\left(ub_{(1)} - lb_{(1)}\right) - EL\%_{[lb_{(1)},ub_{(1)}]}\right)\cdot EL\%_{[lb_{(2)},ub_{(2)}]}
\end{aligned}
$$

For the derivation of these formulas refer to Appendix G.

The formula for determining the EL and UL for multiple tranches is given by:

$$
EL\%_{MT} = \sum_{i=1}^{N} EL\%(i),
$$

$$UL\%_{MT} = \sum_{i=1}^{N} \left(UL\%(i) + 2 \cdot \left(\left(UB(i) - LB(i) \right) - EL\%(i) \right) \cdot \sum_{j=i+1}^{N} EL\%(j) \right),$$

where

N = the number of retained tranches,
MT = the boundaries of the retained tranches,
LB(i) = the lower boundary for tranche *i*,
UB(i) = the upper boundary for tranche *i*,
EL(i) = the expected loss for a single tranche *i*,
UL(i) = the unexpected loss for a single tranche *i*.

7.7 The Risk Diversification Factor

To be able to determine the risk diversification factor of a tranche, the loss correlations between a tranche and the various loans in the RI portfolio have to be determined. Since the *EAD* and *LGD* are assumed to be non-stochastic, the loss correlation is equivalent to the default correlation. Because the loans in the portfolio range from a R1 to a R20 rating, it is sufficient to determine the correlation of a tranche with each rating class. For this purpose a simulation is performed.

The dependency between defaults is determined by means of Merton's asset value model, which assumes that a company is in default when the total market value of assets is worth less than the value of its callable liabilities.
The dependence between the asset values is generated by assuming that all components depend on the common unobservable factor *M*, the macro-economic factor. This factor models the global, country, and industry effects that influence all companies. In this case the one-factor Gaussian copula is used to model the dependency structure in the portfolio. Let $(X_1, \ldots, X_n)$ be a Gaussian vector, in a one factor Gaussian copula model X_i can be written as:

$$X_i = \sqrt{R_i^2} \cdot M + \sqrt{1 - R_i^2} \cdot \xi_i, \qquad i = 1, \ldots, n$$

where *M* and ξ_i are independent standard Gaussian random variables. R_i^2 represents the dependence on the macro economic factor, and ξ_i models the firm specific factor.

Assume that the reference portfolio of the CDO consist of *n* loans and the *PD, LGD, EAD* and R^2 for each loan are known. The procedure to estimate the loss correlation between a tranche and the various rating classes in the RI portfolio is the following:

1. Generate a standard normal random variate M (macro economic factor), and n + 20 standard normal random variates ξ_i, where ξ_i represents the firm specific factor for the loans in the reference portfolio (for $i = 1, \ldots, n$) and the various rating classes in the RI portfolio (for $i = n + 1, \ldots, n + 20$).

2. The asset value of a loan can be determined as:

$$X_i = \sqrt{R_i^2} \cdot M + \sqrt{1 - R_i^2} \cdot \xi_i, \qquad i = 1, \ldots, n$$

3. The default point of a loan (Y_i) is given by

$$Y_i = \Phi^{-1}(PD_i), \qquad i = 1, \ldots, n + 20$$

   where Φ^{-1} is the inverse standard normal distribution and PD_i is the default probability of a loan ($i = 1, \ldots, n$) or a rating class ($i = n + 1, \ldots, n + 20$)

4. A default has occurred when $X_i < Y_i$, thus

$$D_i = \begin{cases} 1 & X_i < Y_i \\ 0 & \text{otherwise.} \end{cases} \qquad i = 1, \ldots, n + 20$$

5. The loss in a rating class (j = R1, …, R20), $loss_j$, can now be determined by equation (5-1) and the loss in the reference portfolio of the CDO, $loss_C$, is given by equation (5-4).

6. The loss in a tranche with lower boundary lb and upper boundary ub, $loss_t$, can now be derived by means of equation (7-1), where $l = loss_C$.

7. Repeat procedure 1 to 6 k times. The loss correlation between a tranche and a rating class can be determined as:

$$\rho_{tj} = \frac{Cov(loss_t, loss_j)}{\sigma_t \cdot \sigma_j},$$

   where j represents the rating class ($j = 1, \ldots, 20$) and t represents the tranches of the CDO.

The RDF of a tranche of a CDO in the RI portfolio can now be determined as specified in chapter five.

The RDF of a tranche depends on the composition of the reference portfolio of the CDO. Therefore no benchmark can be given yet, the RDF of the tranches should be determined for each CDO separately.

8. Conclusions and Recommendations

8.1 Introduction

This thesis investigates the effectiveness of mitigating credit risk concentrations of the RI portfolio by utilization of credit derivatives. The objective of this thesis was formulated as: *'Gaining insight in the main credit derivatives that can be applied in credit portfolio management, and taking a first step in developing a framework for measuring the credit risk reduction, when Credit Default Swaps or Collateralised Debt Obligations are applied to the RI Portfolio.'*

In this final chapter, the conclusions will be discussed on the basis of the four questions formulated in the introduction, and some recommendations will be given for further research. In paragraph 8.2 the available risk transfer instruments will be outlined, followed by an overview of the two main credit derivatives used in portfolio management in paragraph 8.3. The effectiveness of applying CDS's and CDO's will be discussed in paragraph 8.4 and 8.5 respectively. Thereupon, some recommendations for future transactions will be given in paragraph 8.6. Finally, in paragraph 8.7 a few issues for improvement will be pointed out with respect to the developed CDS and CDO framework, and the current internal RI framework.

8.2 Portfolio Management Instruments

The risk concentrations in a loan portfolio can be reduced by means of risk transfer instruments, like secondary sales, securitisation, credit insurance or credit derivatives. With secondary sales a single asset or a pool of assets is sold in the secondary market. With traditional securitisation also a pool of assets is sold. However, the credit risk on the pool of assets is tranched into various securities with different levels of subordination, which are sold in the capital market. By means of credit insurance only the credit risk of the assets are transferred to a third party, in return for periodic premium payments. Credit derivatives are similar products, however, they enable the free trade of credit risk in capital markets.

Each of aforementioned instruments has its own benefits. The portfolio manager has to decide which instrument should be used, taking into account the liquidity and risk characteristics of the assets and the client bank relationship. Since the Rabobank is interested in transferring the risk concentrations in the RI portfolio to capital market investors, without actually removing the assets of the balance sheet, credit derivatives are considered to be the best solution.

8.3 Credit Derivatives

The purpose of these credit derivatives is to allow market participants to trade the credit risk associated with certain debt instruments. Credit derivatives are useful instruments for credit portfolio management, for they enable partial regulatory and economic capital relief, without actually selling the assets. Thus, the valuable bank client relation is not compromised. Furthermore, the transactions are relatively easy to execute. However, the downsides of credit derivatives are the illiquidity of the market, and the high prices that have to be paid for protection on unknown companies.

According to estimates of the British Bankers' Association the Credit Default Swap (CDS) and the Collateralised Loan Obligation (CDO) will be the most used credit derivatives in the global market in 2004. A CDS enables the risk transfer on a single asset, whereas the Collateralised Debt Obligation (CDO) involves the risk transfer of a portfolio of assets.

8.4 Modelling CDS's

Credit Default Swaps are not completely risk free. By buying a CDS, the credit risk on the reference asset is substituted by a smaller risk exposure, depending on the CDS counterparty and the reference assets. The risks involved are identified as double default risk, replacement risk, and in case of a standardised CDS an additional basis risk. To determine the effectiveness of a CDS transaction, the anticipated risk cost reduction is considered against the costs made to transfer the risk (spread costs).

It turned out that CDS transactions are not always profitable for the Rabobank. Often, the risk cost reduction is smaller than the spread paid for protection, […]. Furthermore, the timing of buying the CDS is important for the outcome.

In case it is decided to buy a standardised CDS, the CDS has to be carefully selected. Before closing the CDS deal the documentation has to be checked on the default definition and the deliverable assets. Furthermore, the characteristics of the reference assets should be checked.

8.5 Modelling CDO's

When a fully funded synthetic CLO is set up by RI, RI is only exposed to credit risk on the retained tranches, for the CDS with the SPV can be seen as risk free. It is assumed that RI will always keep the equity tranche, but in addition one of the other tranches could also be retained.

During modelling, the risk costs for retaining a single tranche or multiple tranches of a fully funded synthetic CDO are determined. However, nothing can be said about the effectiveness of the deal yet, because the transaction costs, the premium payments, and the interest payments on the tranches still have to be assessed.

8.6 Recommendations for Future Transactions

Since the risk-cost assessment for a CDO transaction has not completely been modelled, only recommendations can be made for future CDS transactions. Research has shown that not all CDS transactions are profitable for the Rabobank. In the current framework, only the hedging of name concentrations is proven to be cost effective. Thus, loans with relatively high risk diversification penalties could be hedged with a CDS.
Furthermore, the bank could profit from the different appraisals of the credit risk associated with a certain company. Sometimes, the market assesses the credit quality of the client to be better than the Rabobank assumes. In this case, it would be cheaper to buy protection in the market, instead of retaining the credit risk. Thus, the timing of the transaction can be of influence whether the transaction is cost effective or not.

It has to be pointed out that before a CDS transaction is done, the contract documentation has to be investigated carefully regarding the definition of a credit event, and the deliverable assets.

8.7 Suggestions for Improvement

In this final paragraph a few suggestions will be made for further research, and some issues for improvement of the developed CDS and CDO framework, as well as the RI framework will be pointed out.

8.7.1 The CDS Framework

- In the current CDS framework the possibility of future gain is included, while determining the variance of the loss. This should be corrected for the bank only reserves capital for the possibility of future losses, and not for the possibility of future gains.
- The mismatch in default moments is omitted in the current framework. However, this is an important issue for future research, since it can lead to significant losses when the loan is in default and the reference bond is not.
- The replacement cost estimation should be considered a real loss and should also be included while determining the expected and unexpected loss. This scenario is not that likely to occur, but the losses could be significant.
- The current CDS framework, with a timeframe of just one year, should be expanded to a multi-year framework so that the effectiveness of CDS's with a longer term could be determined.

8.7.2 The CDO Framework

- In the current CDO framework only the risk costs savings are quantified. To be able to assess the effectiveness of the deal the start up costs of the CDO structure have to be determined as well as the spread costs paid by the bank.
- The 'waterfall' of the principal and interest payments in the CDO should be researched, for the expected interest income on the retained tranches has to be quantified.
- The factors that influence the risk diversification factor of the tranches should be studied, like the composition of the reference portfolio for instance.

8.7.3 The Credit Risk Framework of RI

The current credit risk framework of RI assumes that the loss given default (LGD) is known, and deterministic. This assumption cannot be justified, for the exact recovery at default is unknown and the volatility of the LGD can lead to losses that cannot be covered with the capital buffer. In determining the basis risk for a credit default swap this assumption also causes some problems, for part of the basis risk is caused by a pay-out mismatch due to the volatility of the recovery on the bonds and loan.

Furthermore, the loss on the bond and the loss on the loan are correlated. It is important to determine the relation between the two, meaning, whether they are positively or negatively correlated. In the current CDS framework the difference between the losses is modelled as a random variable, trying to include the interrelation, but this is not the perfect solution.

During this internship, the effect of adding derivative products on the risk diversification factor of the remaining products in the RI portfolio has not been studied. However, this is an important issue, for the diversification affect of the loans in the portfolio could change significantly, by which current investments might not be that attractive anymore.

Glossary

Asset Backed Security	Bonds or notes backed by loan paper or accounts receivable originated by banks, credit card companies, or other providers of credit. Mortgages are not included.
Asset Securitisation	Asset securitisation is the process where loans, receivables and other illiquid assets with similar characteristics in the balance sheet are packaged into interest-bearing securities that offer attractive investment opportunities.
Bank of International Settlements	The Bank of International Settlements, located in Basle, Switzerland, was founded in 1930 and is an important forum for banking supervisors and central banks of the major industrialised nations to discuss and co-ordinate risk policies.
Basis point	One basis point stands for 0.01 percent.
British Bankers' Association	The British Bankers' Association (BBA) is the leading trade association in the banking and financial services industry representing banks and other financial services firms operating in the UK. The BBA credit derivatives survey is widely considered the most comprehensive benchmark of market activity, expectations and sentiment.
Business Risk	The risk of a loss due to changes in the competitive environment or the adaptability of the company.
Capital Market	Financial market where corporations and government agencies raise funds by selling stocks, bonds, and marketable securities with maturities greater than one year. Securities are distributed through public exchanges or through private placement sales to investors.
Collateralized Bond Obligation	A Collateralized Bond Obligation is a specific kind of CDO, where the debt security is only backed by a pool of investment grade or high-yield bonds.
Collateralized Debt Obligation	A Collateralized Debt Obligation is a debt security backed by a pool of corporate or sovereign debt securities or bank loans. A CDO security usually has both senior and

subordinated debt classes. The senior debt usually carries an investment grade rating. The subordinated debt has a higher coupon yield than the senior debt, but has a higher default risk.

Collateralized Loan Obligation
A Collateralized Loan Obligation is specific type of CDO where the reference portfolio consists of bank loans only.

Commercial Mortgage Backed Securities
A Commercial Mortgage Backed Security is a Mortgage Backed Security, but secured by loans with commercial property.

Cost Of Capital
The rate of return required by investors on the capital provided by them.

Country Risk
The risk that a country won't be able to honour its financial commitments. When a country defaults it can harm the performance of all other financial instruments in that country as well as other countries it has relations with. This type of risk is most often seen in emerging markets or countries that have a severe deficit.

Covenant
A covenant is a promise in an indenture, or any other formal debt agreement, that certain activities will or will not be carried out. The purpose of a covenant is to monitor and possibly restrict the actions of the client. Covenants can cover everything from limited dividend payments to levels that must be maintained in working capital.

Credit Default Swap
A credit default swap is a bilateral financial contract in which one party, the protection buyer, agrees to pay a fixed periodic fee to the counterparty, the protection seller, in return for a reimbursement of his loss on the reference asset in case of a credit event.

Credit Derivative
A credit derivative is a specialised financial contract that allows participants to increase or decrease their credit exposure to a particular name, for a particular period of time.

Credit Linked Note
A credit linked note is a securitised form of a credit derivative. This implies that credit linked notes are funded and that the proceeds of the notes are used to buy government bonds.

Credit Rating	A credit rating is a subjective assessment of the borrower’s creditworthiness, measured on an alphanumeric scale.
Credit Risk	The risk that a company or individual will be unable to pay the contractual interest or principal on its debt obligations.
Default	A debtor is said to be in default when he fails to meet a contractual obligation, such as the repayment of either principal or interest.
Disintermediation	Commercial banks intermediate by standing between depositors and borrowers. Disintermediation is the reverse process where loans which were previously made by banks are financed directly by the investor/depositor, often by buying securities.
Economic Capital	Economic Capital is the capital buffer that is reserved based on the *internal* capital requirements specified by the bank itself. The Economic Capital considers the ‘actual’ risk of the bank.
Expected Loss	The anticipated, annual level of credit losses.
Exposure At Default	The expected size of the banks exposure to a customer or counterparty at the time of default.
Foreign Exchange Rate Risk	Foreign exchange rate risk applies to all financial instruments that are in a currency other than the domestic currency. When investing in foreign countries you must consider the fact that currency exchange rates can change the price of the asset as well.
Hedging	Practice of offsetting the price risk inherent in any cash market position by taking an equal but opposite position in the futures market.
Insurance Risk	The risk of loss due to an unforeseen increase in non-catastrophe claims such as car accidents, fires and so forth.
Interest Rate Risk	The risk of (market) value changes that can be lost due to unexpected rate changes, compared to the expected future value.

International Swaps and Derivatives Association	The International Swaps and Derivatives Association is a global trade association representing participants in the privately negotiated derivatives industry. ISDA’s ‘Master Agreement’ has become the industry standard for derivative contract documentation.
Liquidity Risk	The risk stemming from the lack of marketability of an investment that cannot be bought or sold quickly enough to prevent or minimize a loss.
London Inter-Bank Offered Rate	The London Inter-Bank Offered Rate (LIBOR) is a key rate in international bank lending. LIBOR is the rate at which major bank is London are willing to lend Eurodollars to each other and is used to determine the interest rate charged to creditworthy borrowers.
Loss Given Default	*See* Severity
Market Risk	The risk of adverse movements in market factors, such as asset prices, foreign exchange rates and interest rates, which cause volatility in a company’s profit and loss.
Migration	The probability that the credit rating of the customer will change.
Mortgage Backed Securities	A Mortgage Backed Security is an investment instrument that represents ownership of an undivided interest in a group of mortgages. Principal and interest from the individual mortgages are used to pay principal and interest on the MBS.
Notional	The principal amount.
Off-balance-sheet Risk	Off-balance-sheet risk is the risk on for example guarantees or credit derivatives, and it can be seen as a combination of market risk, credit risk and FX risk.
Operational Risk	The risk of loss resulting from inadequate or failed internal processes, people and systems or from external events.
Over The Counter	An over the counter contract is a privately negotiated contract.
Political Risk	This represents the financial risk that a country's government will suddenly change its policies. This is a

major reason that second and third world countries lack foreign investment.

Portfolio	Combined holding of more than one stock, bond, commodity, cash equivalent, or other asset by an individual or institutional investor.
Probability of Default	The probability of default represents the likelihood that a default event will occur in a one-year time horizon.
Regulatory Capital	The capital buffer determined by the requirements prescribed by the Bank Of International Settlement.
Residential Mortgage Backed Securities	A security similar to a Mortgage Backed Security, but secured by loans with residential property.
Risk aversion	Risk aversion is a characteristic of an individual's preferences in risk-taking situations; it is a measure of willingness to pay to reduce one's exposure to risk.
Securitisation	*See* Asset Securitisation
Severity	The best estimate of the likely amount at risk to be realized after completion of workout processes. The severity is expressed as a percentage of the exposure at default.
Special Purpose Vehicle	A special purpose vehicle is a company whose operations are limited to the acquisition and financing of specific assets. The SPV is usually a subsidiary company with an asset/liability structure and legal status that makes its obligations secure even if the parent company goes bankrupt.
Spread	The difference between the negotiated and fixed rate of a swap. The spread is determined by characteristics of market supply and the credit worthiness of the creditor.
Total Rate of Return Swap	*See* Total Return Swap
Total Return Swap	Under a Total Return Swap a synthetic exchange of assets is realized. All the proceeds of a risky asset are swapped against a contracted prefixed return.
Transfer Risk	The risk due to the possibility that funds in foreign currencies cannot be transferred out of a country.

Unexpected Loss	The annual volatility of expected losses.

Bibliography

- Allen, L. and Saunders, A. (2002), *Credit Risk Measurement - New Approaches to Value at Risk and Other Paradigms*, John Wiley & Sons, Inc., New York
- Ammann, M. (1999), *Pricing Derivative Credit Risk*, Springer, 148-150.
- Andelson, M. (2004), *Credit Default Swap Primer*, Nomura Securities International Inc., New York
  http://www.securitization.net/pdf/content/nomura_cds_primer_12may04.pdf
- Bomfim, A.N. (2001), *Understanding Credit Derivatives and their Potential to Synthesize Riskless Assets*, Finance and Economics Discussion Series 2001-50, Board of Governors of the Federal Reserve System (U.S.)
  http://www.federalreserve.gov/pubs/feds/2001/200150/200150pap.pdf
- BBA (1999), *Credit Derivatives: key issues - 2nd edition* (Introduction), British Bankers' Association
  http://www.bba.org.uk/bba/jsp/polopoly.jsp?d=146&a=592
- BBA (2002), *Credit Derivatives 2003 - Key issues* (executive summary), British Bankers' Association
  http://www.bba.org.uk/content/1/c4/19/37/58304.pdf
- Bodie, Z. and Merton, R.C. (2000), *Finance* (Chapters 10-13), Prentice Hall Inc., New Jersey
- Brown, K.C. and Reilly, F.K. (1997), *Investment Analysis and Portfolio Management* (Chapter 8) , Dreyden
- Cornett, M.M. and Saunders, A. (2002), *Financial Institutions Management* (Sheets Chapter 7), McGraw-Hill Companies Inc.
  http://highered.mcgraw-hill.com/sites/dl/free/0072486198/54619/SC07.ppt

o Datek: http://datek.smartmoney.com/glossary/index.cfm?letter=R

- Derix, M. (2004), *Structured Finance Model – Technical Documentation* (Appendix A.5 – A.6), Rabobank International
- Donaldson, T.H. (1989), *Credit Risk and Exposure in Securitisation and Transactions*, The MacMillan Press ltd.
- Dufey, G. and Rehm, F. (2000), *An Introduction to Credit Derivatives*, Working Paper No. 00-013, University of Michigan Business School
- Effenberger, D. (2003), *Credit Derivatives: Implications for credit markets*, Frankfurt Voice, Deutsche Bank Research
- Ghosh, A. (2003), *Solution Framework for Credit Risk under Basel II*, White Paper, Wipro Technologies.

o Investopedia.com: http://www.investopedia.com/university/risk/

- ISDA (2004), *ISDA Announces Year-End 2003 Market Survey Results*, News Release, International Swaps and Derivatives Association.
  http://www.isda.org/press/press040104-market.html
- Jobst, A. (2002), *Collateralized Loan Obligations (CLO's) – A Primer*, CFS Working Papers Series, Centre for Financial Studies No. 2002/13

http://www.ifk-cfs.de/papers/02_13.pdf
- KRM, Credit Policy Desk (2004), *KRM's Rating Policies & Procedures Manual* (CRE version 2.0), Rabobank Nederland
- Kukler, A., Mesters, M. and Sijtsma, H. (2004), *Interim Correlation Solution*, Rabobank International
- Lam, M. (2004), *Project Finance Portfolio Management*, Rabobank International
- Longstaff, F.A., Mithal, S. and Neis, E. (2003), *The Credit-Default Swap Market: Is Credit Protection Priced Correctly?*
  http://www.mccombs.utexas.edu/dept/finance/seminars/2003/cdsnew.pdf
- Lucas, M. (2001), *CDO Handbook*, Global Structured Finance Research, J.P. Morgan Securities Inc., New York
  http://www.mayerbrownrowe.com/cdo/news/JPMorganCDOHandbook.pdf
- Markowitz, H.M. (1991), *Portfolio Selection Efficient: Diversification of Investment*, Blackwell Publishers
- Neal, R.S. (1996), *Credit Derivatives: New Financial Instruments for Controlling Credit Risk*, Federal Reserve Bank of Kansas City, Economic Review
  http://www.kc.frb.org/publicat/econrev/pdf/2q96neal.pdf
- Ong, Micheal K. (1999), *Internal credit risk models, capital allocation and performance measurement*, Risk books, London
- OWC (2001), *Project Group Credit Risk*, Oliver, Wyman & Company (confidential)
- Picone, D. (2002), *Collateralized Debt Obligations*, City University Business School, London & Royal bank of Scotland
  http://www.defaultrisk.com/pdf__files/Collateralised_Debt_Obligations.pdf
- RAROC Project Group (2004), *Towards New Capital Requirements - External And Internal Rules*, Control Rabobank Group
- RMF Investment Consultants (2002), *Collateralized Debt Obligation – Introduction to the CDO market*, RMF Research, Switzerland
  http://www.rmf.ch/accdofv500q202.pdf

o WRL Ratings: http://www.westernreserve.com/site1/about_us/ratings

Appendix A: The Rabobank Risk Rating Classes

The Rabobank Risk Rating (RRR) master scale is represented below [KRM-Appendix III, 2004] and consists of 21 performing classes, R0 to R20, and four default classes, D1 to D4. The mapping of the RRR scale to the S&P scale is also represented in the table.

RRR	PD (bps)	Corresponding S&P grade	Description
R0	0 - 0	zero-risk	Zero risk class for regulatory purposes e.g. US Treasuries
R1	0 - 1.6	AAA	EXTREMELY STRONG capacity to meet financial commitments. The highest Rabobank Risk Rating
R2	1.6 - 2.3	AA+	VERY STRONG capacity to meet financial commitments. Counterparties in these grades differ from the highest Rabobank Risk Rated counterparties only in small degree.
R3	2.3 - 3.2	AA	
R4	3.2 - 4.5	AA-	
R5	4.5 - 6.3	A+	STRONG capacity to meet financial commitments but somewhat more susceptible to adverse effects of changes in circumstances and economic conditions than higher-rated counterparties.
R6	6.3 - 8.9	A	
R7	8.9 - 12	A-	
R8	12 - 17	BBB+	ADEQUATE capacity to meet financial commitments. However, adverse economic conditions or changing circumstances are more likely to lead to a weakened capacity to meet financial commitments.
R9	17 - 27	BBB	
R10	27 - 40	BBB-	
R11	40 - 61	BB+	LESS VULNERABLE in the near term than other lower-rated counterparties. However, major ongoing uncertainties and exposure to adverse business, financial, or economic conditions could lead to the counterparty having inadequate capacity to meet its financial commitments.
R12	61 - 91	BB+	
R13	91 - 140	BB	
R14	140 - 210	BB-	
R15	210 - 310	B+	MORE VULNERABLE than counterparties rated R11-R14, but currently has the capacity to meet its financial commitments. Adverse business, financial, or economic conditions will likely impair capacity or willingness to meet financial commitments.
R16	310 - 460	B	
R17	460 - 690	B	
R18	690 - 1000	B-	
R19	1000 - 1600	B-	
R20	>1600	CCC	CURRENTLY VULNERABLE, and dependent upon favourable business, financial, and economic conditions.

RRR	PD (bps)	Corresponding S&P grade	Description
D1	n.a.		The obligor is past due more than 90 days after the delinquency date on any credit obligation. (In the case of retail and PSE obligations, for the 90 days figure the supervisor may substitute a figure up to 180 days for different products as it considers appropriate to local conditions), and D2, D3 or D4 are not applicable.
D2	n.a.		It is determined that the obligor is unlikely to pay its debt obligation (principal, interest, or fees) in full, without recourse by the bank to actions as realising security (if held); and/or A credit loss event associated with any obligation of the obligor, such as a charge-off or specific provision resulting from a significant perceived decline in credit quality subsequent to the bank taking on the exposure and without recourse by the bank to actions as realising security (if held); and D3 or D4 are not applicable.
D3	n.a.		A distressed sale involving credit-related economic loss by the bank to a third party, or distressed restructuring likely to involve credit-related economic loss, for example involving the forgiveness, subordination or postponement of principal, interest, or fees.
D4	n.a.		The obligor has filed for bankruptcy or similar protection from creditors, or a bankruptcy or similar order has been granted in respect of the obligor.

Appendix B: Coverage Tests

A CDO can either have a cash flow or market value credit structure. In both cases, the coupon payments on the tranches depend on two types of coverage tests. These tests are designed to protect investors against the deterioration of the reference portfolio. The coverage ratio of a certain tranche is compared to the required minimum ratio for that tranche as specified in the guidelines. The higher the ratios, the greater the protection for the investors.

In this appendix the coverage tests for both, a cash flow CDO and a market value CDO, will be discussed.

B.1 Cash Flow CDO

For a Cash Flow CDO two coverage tests are designed, namely the over-collateralisation test and the interest coverage test.

Over-collateralisation is the extent to which the par amount of collateral assets exceeds the rated liabilities [RMF, 2002]. The OC ratio is determined for each tranche:

$$\text{OC ratio for Senior Notes} = \frac{\text{par value of the reference portfolio}}{\text{par value of senior notes}}$$

$$\text{OC ratio for Mezzanine Notes} = \frac{\text{par value of the reference portfolio}}{\text{par value of senior notes} + \text{par value of mezzanine notes}}$$

The interest coverage test is applied to test if the interest income of collateral is sufficient to cover losses and still make interest payment to the senior notes. This credit support is also known as excess spread [Picone] and is determined as:

$$\text{IC ratio for Senior Notes} = \frac{\text{scheduled interest due on the reference portfolio}}{\text{scheduled interest to senior notes}}$$

$$\text{IC ratio for Mezzanine Notes} = \frac{\text{scheduled interest due on the reference portfolio}}{\text{scheduled interest to senior and mezzanine notes}}$$

B.2 Market value CDO

For a market value CDO the over-collateralisation and interest coverage test are also used to protect the investors against deterioration of the reference portfolio. However, instead of the par value, the mark-to-market prices are used to test for over-collateralisation.

The market value of the collateral multiplied by the advance rate has to be greater than the par value of the notes. The advance rate is a stress factor; it adjusts the market value of the assets in order to provide a cushion against market risk. The advance rates are assigned by rating agencies and depend on the volatility of the assets return and on the liquidity of the asset in the market. Assets with a higher return volatility and lower liquidity are typically assigned lower advance rates [Picone].

Appendix C: Derivation of the Unexpected Loss for a standardised CDS

The loss for a loan with a standardised CDS is given by:

$$loss_{CDS} = (1 - D_L) \cdot D_C \cdot loss_2 + (1 - D_C) \cdot D_L \cdot loss_3 + D_L \cdot D_C \cdot loss_4,$$

where

$loss_2 = RC,$

$loss_3 = B \cdot EAD_L,$

$loss_4 = B \cdot EAD_R + LGD_R \cdot LGD_C \cdot EAD_R.$

Since it is decided that no Economic Capital is reserved to cover the replacement costs, the UL of the loan with CDS given by:

$$\begin{aligned}
UL^2 &= E(((1-D_C)\cdot D_L \cdot loss_3 + D_L \cdot D_C \cdot loss_4)^2) - E(loss_{CDS} - (1-D_L)\cdot D_C \cdot loss_2)^2 \\
&= E(((1-D_C)\cdot D_L)^2)\cdot E(loss_3^2) + E((D_L \cdot D_C)^2)\cdot E(loss_4^2) \\
&\quad - E((1-D_C)\cdot D_L \cdot loss_3 + D_L \cdot D_C \cdot loss_4)^2 \\
&= E(((1-D_C)\cdot D_L)^2)\cdot E(loss_3^2) + E((D_L \cdot D_C)^2)\cdot E(loss_4^2) \\
&\quad - (E((1-D_C)\cdot D_L)\cdot E(loss_3) + E(D_L \cdot D_C)\cdot E(loss_4))^2 \\
&= (PD_L - PL_{C,L})\cdot \sigma_B^2 \cdot EAD_L^2 + PD_{C,L}\cdot(\sigma_B^2 \cdot EAD_L^2 + LGD_C^2 \cdot LGD_L^2 \cdot EAD_L^2) \\
&\quad - PD_{C,L}^2 \cdot LGD_C^2 \cdot LGD_L^2 \cdot EAD_L^2 \\
&= PD_L \cdot \sigma_B^2 \cdot EAD_L^2 + PD_{C,L}\cdot(1-PD_{C,L})\cdot LGD_C^2 \cdot LGD_L^2 \cdot EAD_L^2
\end{aligned}$$

Since,

$$E(loss_3) = E(B \cdot EAD_L) = E(B)\cdot EAD_L = 0$$

$$E(loss_3^2) = E((B \cdot EAD_L)^2) = E(B^2)\cdot EAD_L^2 = \sigma_B^2 \cdot EAD_L^2$$

$$E(loss_4) = E(B \cdot EAD_L + LGD_C \cdot LGD_R \cdot EAD_R) = LGD_C \cdot LGD_R \cdot EAD_R$$

$$\begin{aligned}
E(loss_4^2) &= E((B \cdot EAD_L + LGD_C \cdot LGD_R \cdot EAD_R)^2) \\
&= E((B \cdot EAD_L)^2) + E((LGD_C \cdot LGD_R \cdot EAD_R)^2) \\
&\quad + 2 \cdot E(B \cdot EAD_L)\cdot E(LGD_C \cdot LGD_R \cdot EAD_R) \\
&= \sigma_B^2 \cdot EAD_L^2 + LGD_C^2 \cdot LGD_R^2 \cdot EAD_R^2 \\
&= \sigma_B^2 \cdot EAD_L^2 + LGD_C^2 \cdot LGD_L^2 \cdot EAD_L^2
\end{aligned}$$

Appendix D: Derivation of Default Correlation for a Loan with CDS

Given the loss on the loan with CDS the correlation with other loans in the portfolio can be calculated. The following subscripts are used:

- *L* indicates the loan being hedged with a CDS.
- *R* indicates the reference bond of the CDS.
- *C* indicates the CDS provider.
- *T* indicates the loan of a third party.

The loss on the loan with standardised CDS ($loss_{CDS}$) is given by:

$$loss_{CDS} = D_L \cdot (B \cdot EAD_L + D_C \cdot LGD_C \cdot LGD_R \cdot EAD_R),$$

where $\mu_B = 0$ and volatility is σ_B (expressed as a percentage of the EAD_L).

The loss on any other loan in the portfolio, which will be referred to as the third party loan ($loss_{loan}$), is given by:

$$loss_{loan} = D_T \cdot LGD_T \cdot EAD_T$$

Now that this is noted, the loss correlation between the loan with a standardised CDS and any other loan can be calculated as follows:

$$cor(loss_{CDS}, loss_{loan}) = \frac{\operatorname{cov}(loss_{CDS}, loss_{loan})}{\sqrt{\operatorname{var}(loss_{CDS}) \cdot \operatorname{var}(loss_{loan})}} \qquad \text{(D-1)}$$

First the covariance of the loan with a CDS and the third party loan can be computed as:

$$\begin{aligned}
\operatorname{cov}(loss_{CDS}, loss_{loan}) &= \operatorname{cov}(D_R \cdot (B \cdot EAD_L + D_C \cdot LGD_C \cdot LGD_R \cdot EAD_R), D_T \cdot LGD_T \cdot EAD_T) \\
&= \operatorname{cov}(D_R \cdot B \cdot EAD_L, D_T \cdot LGD_T \cdot EAD_T) \\
&\quad + \operatorname{cov}(D_R \cdot D_C \cdot LGD_C \cdot LGD_R \cdot EAD_R, D_T \cdot LGD_T \cdot EAD_T) \\
&= (PD_{C,R,T} - PD_{C,R} \cdot PD_T) \cdot LGD_C \cdot LGD_R \cdot LGD_T \cdot EAD_R \cdot EAD_T
\end{aligned}$$

Since the $\operatorname{cov}(D_R \cdot B \cdot EAD_L, D_T \cdot LGD_T \cdot EAD_T)$ is given by:

$$
\begin{aligned}
&= E\left(\left(D_R \cdot B \cdot EAD_L - E(D_R \cdot B \cdot EAD_L)\right) \cdot \left(D_T \cdot LGD_T \cdot EAD_T - E\left(D_T \cdot LGD_T \cdot EAD_T\right)\right)\right) \\
&= E\left(\left(D_R \cdot B \cdot EAD_L\right) \cdot \left(D_T \cdot LGD_T \cdot EAD_T - PD_T \cdot LGD_T \cdot EAD_T\right)\right) \\
&= 0
\end{aligned}
$$

The second and last equality is justified by the independence of B with the other random variables and its expectation being equal to 0.

Furthermore, the cov($D_R \cdot D_C \cdot LGD_C \cdot LGD_R$, $D_T \cdot LGD_T \cdot EAD_T$) is given by:

$$
\begin{aligned}
&= E\left(\left(D_R \cdot D_C \cdot LGD_C \cdot LGD_R \cdot EAD_R - E\left(D_R \cdot D_C \cdot LGD_C \cdot LGD_R \cdot EAD_R\right)\right)\right. \\
&\quad \left.\cdot \left(D_T \cdot LGD_T \cdot EAD_T - E\left(D_T \cdot LGD_T \cdot EAD_T\right)\right)\right) \\
&= E\left(\left(D_R \cdot D_C - PD_{C,R}\right) \cdot \left(D_T - PD_T\right)\right) \cdot LGD_C \cdot LGD_R \cdot EAD_R \cdot EAD_T \\
&= E\left(D_R \cdot D_C \cdot D_T - PD_{C,R} \cdot D_T - D_R \cdot D_C \cdot PD_T + PD_{C,R} \cdot PD_T\right) \\
&\quad \cdot LGD_C \cdot LGD_R \cdot EAD_R \cdot EAD_T \\
&= \left(PD_{C,R,T} - PD_{C,R} \cdot PD_T\right) \cdot LGD_C \cdot LGD_R \cdot EAD_R \cdot EAD_T
\end{aligned}
$$

Secondly, the variance of the third party loan is given by,

$$
\mathrm{var}\left(D_T \cdot LGD_T \cdot EAD_T\right) = (PD_T - PD_T^2) \cdot LGD_T^2 \cdot EAD_T^2
$$

Finally, the variance of the loan with CDS can be determined as:

$$
\begin{aligned}
\mathrm{var}\left(loss_{CDS}\right) &= \mathrm{var}\left(D_R \cdot B \cdot EAD_L + D_R \cdot D_C \cdot LGD_C \cdot LGD_R \cdot EAD_R\right) \\
&= E\left(D_R^2 \cdot B^2 \cdot EAD_L^2\right) + E\left(D_R^2 \cdot D_C^2 \cdot LGD_C^2 \cdot LGD_R^2 \cdot EAD_R^2\right) \\
&\quad + E\left(D_R^2 \cdot D_C \cdot B \cdot LGD_C \cdot LGD_R \cdot EAD_R \cdot EAD_L\right) \\
&\quad - E\left(D_R \cdot B \cdot EAD_L + D_R \cdot D_C \cdot LGD_C \cdot LGD_R \cdot EAD_R\right)^2 \\
&= PD_R \cdot \sigma_B^2 \cdot EAD_L^2 + PD_{C,R} \cdot LGD_C^2 \cdot LGD_R^2 \cdot EAD_R^2 \\
&\quad + PD_{C,R} \cdot \mu_B \cdot LGD_C \cdot LGD_R \cdot EAD_R \cdot EAD_L - PD_R^2 \cdot \mu_B^2 \cdot EAD_L^2 \\
&\quad - PD_{C,R}^2 \cdot LGD_C^2 \cdot LGD_R^2 \cdot EAD_R^2
\end{aligned}
$$

Given that $\mu_B = 0$, it follows that:

$$
\begin{aligned}
\mathrm{var}(loss_{CDS}) &= PD_R \cdot \sigma_B^2 \cdot EAD_L^2 + PD_{C,R} \cdot LGD_C^2 \cdot LGD_R^2 \cdot EAD_R^2 \\
&\quad + PD_{C,R}^2 \cdot LGD_C^2 \cdot LGD_R^2 \cdot EAD_R^2 \\
&= \left(PD_R \cdot \sigma_B^2 + PD_{C,R} \cdot \left(1 - PD_{C,R}\right) \cdot LGD_C^2 \cdot LGD_L^2\right) \cdot EAD_L^2
\end{aligned}
$$

Since $\mu_B = 0$, the equality $LGD_R \cdot EAD_R = LGD_L \cdot EAD_L$ is applied in the last equation.

Substituting all this in equation (D.1) gives the desired correlation:

$$\operatorname{cor}(loss_{CDS}, loss_{loan}) = \frac{\left(PD_{L,B,T} - PD_{L,B} \cdot PD_T\right) \cdot LGD_L \cdot LGD_B}{\sqrt{\left(PD_T - PD_T^2\right) \cdot \left(PD_R \cdot \sigma_B^2 + PD_{C,R} \cdot \left(1 - PD_{C,R}\right) \cdot LGD_C^2 \cdot LGD_L^2\right)}}$$

Appendix E: The CDS Framework

The CDS methodology is implemented in an Excel spreadsheet in order to simplify the process of assessing the profitability of a transaction. The sheet is self-explanatory. By specifying the characteristics of the loan, the reference bonds and the CDS counterparty, the 'profitability' of a CDS transaction is calculated. In this appendix the sheet is explained by three steps.

Step 1: Specifying the parameters and assumptions

In the upper left box of the main screen the parameters and assumptions have to be filled out. Since the current framework assumes an asset correlation of 20 percent, and an expected loss due to basis risk equal to nil, these cells cannot be changed. The following parameters can be specified:

- Cost of Capital: the rate of return required by investors on the capital provided by them. Within the Rabobank this is assumed to be 12.5 percent.
- UL Portfolio: the unexpected loss for the entire portfolio. The UL for the RI portfolio is estimated to be € 400 million.
- Capital Multiplier: The Rabobank employs a capital multiplier of 8.

The user can also choose to include or exclude the replacement risk 'penalty' in determining the profitability of the deal. Furthermore, the volatility of the losses due to basis risk can be specified. The volatility is expressed as a percentage of the exposure on the loan, and the user can choose from six options. Eventually, a benchmark can be specified for the expected LGD on a loan, bond and the CDS counterparty. This value will only be used when the specific LGD is not specified for a transaction.

Step 2: Determining the risk costs

To be able to assess the risk costs for the loan, the characteristics of the loan need be specified in the lower left box of the main screen. For each loan the credit rating of the debtor and the exposure on the loan (EAD) are mandatory input. Information on the loss given default for the loan, however, is optional. If this information is omitted, the benchmark will be used that was specified earlier (step 1).

Step 3: Determining the risk costs of the hedged asset

When the risk costs for the loan are relatively high, the bank could decide to hedge the risk with a credit default swap. The costs of the transaction can be determined, by specifying the characteristics of the CDS.

The mandatory input includes the credit rating of the CDS counterparty, and the current spread and the future spread of the CDS. The future spread is approximated by the spread costs for the same entity in case of a rating downgrade of two major rating classes, e.g. from a BBB to B rating. The LGD's of the CDS counterparty and the reference assets are optional information. When this information is not given, the benchmark specified in step 1 will be used.

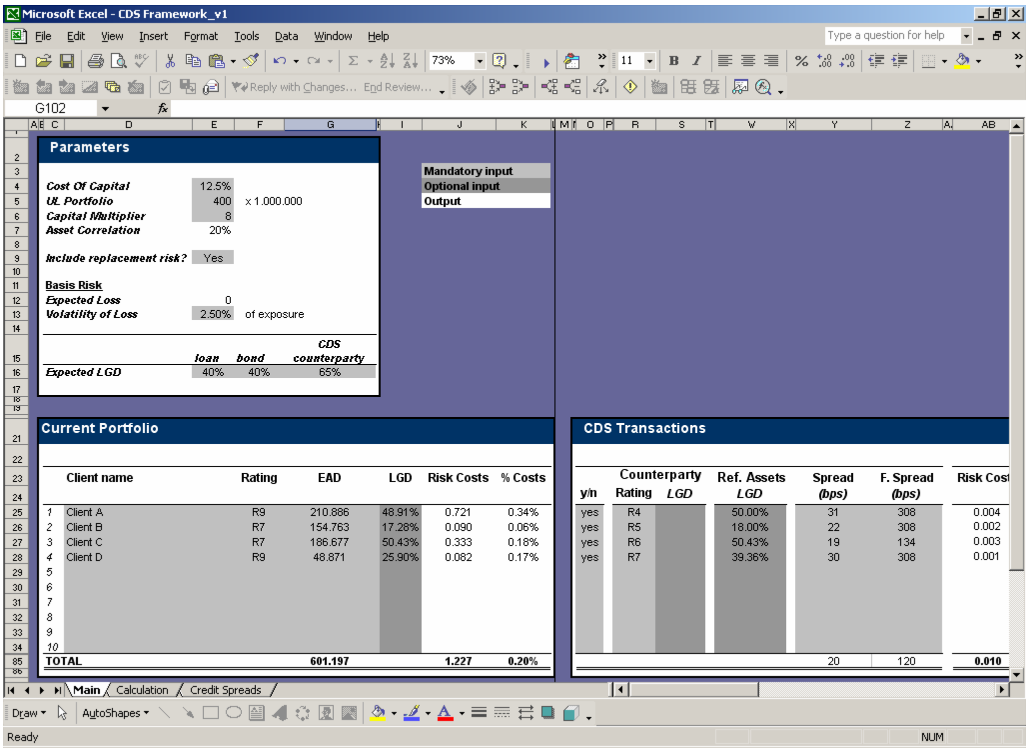


Figure E.1: Screenshot of CDS sheet

Appendix F: Derivation of the EL and UL of a CDO Tranche

The loss in a tranche with lower boundary *lb* and upper boundary *ub* is given by:

$$loss_{[lb,ub]} = \min(\max(0, l - lb), ub - lb) ,$$

where l is the loss in the reference portfolio. The loss in the reference portfolio is approached with a beta distribution, with shape parameters α and β.

Now, the EL and UL for a tranche can be derived [Derix, 2004], for the expectation and the variance of a random variable is given by:

$$EL = E(X) = \int_0^1 x \cdot f_X(x)dx$$

$$UL^2 = E\left(X^2\right) - E(X)^2 = \int_0^1 x^2 \cdot f_X(x)dx - EL^2$$

This EL% for a tranche can now be determined as follows:

$$\begin{aligned}
EL\%_{[lb,ub]} &= \int_0^1 loss_{[lb,ub]} \cdot f_{\alpha,\beta}(l)dl \\
&= \int_0^{lb} 0 \cdot f_{\alpha,\beta}(l)dl + \int_{lb}^{ub}(l - lb) \cdot f_{\alpha,\beta}(l)dl + (ub - lb) \cdot \int_{ub}^1 f_{\alpha,\beta}(l)dl \\
&= \int_{lb}^{ub}(l - lb) \cdot f_{\alpha,\beta}(l)dl + (ub - lb) \cdot P_{\alpha,\beta}(l > ub) \\
&= \int_{lb}^{ub}(l - lb) \cdot f_{\alpha,\beta}(l)dl + (ub - lb) \cdot (1 - F_{\alpha,\beta}(ub)) \\
&= \int_{lb}^{ub} l \cdot f_{\alpha,\beta}(l)dl - lb \cdot \int_{lb}^{ub} f_{\alpha,\beta}(l)dl + (ub - lb) \cdot (1 - F_{\alpha,\beta}(ub))
\end{aligned}$$

Substituting the probability density function of a beta distribution (formula 7-1) gives:

$$\begin{aligned}
EL\%_{[lb,ub]} = &\frac{1}{B(\alpha,\beta)} \cdot \int_{lb}^{ub} l^{(\alpha+1)-1} \cdot (1-l)^{\beta-1} dl - \frac{lb}{B(\alpha,\beta)} \cdot \int_{lb}^{ub} l^{\alpha-1}(1-l)^{\beta-1} dl \\
&+ (ub - lb) \cdot (1 - F_{\alpha,\beta}(ub))
\end{aligned}$$

Following the formula of Binet, the Beta-function can be written as:

$$B(\alpha,\beta)=\frac{\Gamma(\alpha)\Gamma(\beta)}{\Gamma(\alpha+\beta)},$$

where Γ(r) is the gamma function given by:

$$\Gamma(r)=\int_0^{\infty} x^{r-1}\cdot e^{-x}dx \qquad \text{r > 0.}$$

By means of partial integration it can be derived that:

$$\Gamma(r)=(r-1)\cdot\Gamma(r-1) \qquad \text{r > 1.}$$

Given the above, B(α+1, β) can be written as:

$$\begin{aligned}B(\alpha+1,\beta)&=\frac{\Gamma(\alpha+1)\cdot\Gamma(\beta)}{\Gamma(\alpha+\beta+1)}\\&=\frac{\alpha}{\alpha+\beta}\cdot\frac{\Gamma(\alpha)\cdot\Gamma(\beta)}{\Gamma(\alpha+\beta)}\\&=EL\%\cdot B(\alpha,\beta)\end{aligned}$$

which can be inverted to give: $\frac{1}{B(\alpha,\beta)}=\frac{EL\%}{B(\alpha+1,\beta)}$.

Substituting this in the EL% equation above gives:

$$\begin{aligned}EL\%_{[lb,ub]}&=\frac{EL\%}{B(\alpha+1,\beta)}\cdot\int_{lb}^{ub} l^{(\alpha+1)-1}\cdot(1-l)^{\beta-1}dl\\&-\frac{lb}{B(\alpha,\beta)}\cdot\int_{lb}^{ub} l^{\alpha-1}(1-l)^{\beta-1}dl+(ub-lb)\cdot(1-F_{\alpha,\beta}(ub))\end{aligned}$$

By means of formula 7.2 (the cumulative distribution function) this can be written as:

$$\begin{aligned}EL\%_{[lb,ub]}&=EL\%\cdot(F_{\alpha+1,\beta}(ub)-F_{\alpha+1,\beta}(lb))-lb\cdot F_{\alpha,\beta}(ub)+lb\cdot F_{\alpha,\beta}(lb)+ub\\&-ub\cdot F_{\alpha,\beta}(ub)-lb+lb\cdot F_{\alpha,\beta}(ub)\\&=EL\%\cdot(F_{\alpha+1,\beta}(ub)-F_{\alpha+1,\beta}(lb))+lb\cdot F_{\alpha,\beta}(lb)+ub-ub\cdot F_{\alpha,\beta}(ub)-lb\\&=EL\%\cdot(F_{\alpha+1,\beta}(ub)-F_{\alpha+1,\beta}(lb))-lb\cdot(1-F_{\alpha,\beta}(lb))+ub\cdot(1-F_{\alpha,\beta}(ub))\end{aligned}$$

The UL for a tranche can be determined in the same way:

$$
\begin{aligned}
UL\%^2_{[lb,ub]} &= \int_{lb}^{ub} (l-lb)^2 \cdot f_{\alpha,\beta}(l)dl + (ub-lb)^2 \cdot P_{\alpha,\beta}(l>ub) - EL^2_{[lb,ub]} \\
&= \int_{lb}^{ub} (l-lb)^2 \cdot f_{\alpha,\beta}(l)dl + (ub-lb)^2 \cdot (1-F_{\alpha,\beta}(ub)) - EL^2_{[lb,ub]} \\
&= \int_{lb}^{ub} l^2 \cdot f_{\alpha,\beta}(l)dl - 2\cdot lb \cdot \int_{lb}^{ub} l \cdot f_{\alpha,\beta}(l)dl + lb^2 \cdot \int_{lb}^{ub} f_{\alpha,\beta}(l)dl \\
&\quad + (ub-lb)^2 \cdot (1-F_{\alpha,\beta}(ub)) - EL^2_{[lb,ub]}
\end{aligned}
$$

Substituting formula 7.1 gives:

$$
\begin{aligned}
UL\%^2_{[lb,ub]} &= \int_{lb}^{ub} \frac{1}{B(\alpha,\beta)} l^{(\alpha+2)-1}(1-l)^{\beta-1}dl - 2\cdot lb \cdot \int_{lb}^{ub} \frac{1}{B(\alpha,\beta)} l^{(\alpha+1)-1}(1-l)^{\beta-1}dl \\
&\quad + lb^2 \cdot \int_{lb}^{ub} \frac{1}{B(\alpha,\beta)} l^{\alpha-1}(1-l)^{\beta-1}dl + (ub-lb)^2 \cdot (1-F_{\alpha,\beta}(ub)) - EL^2_{[lb,ub]}
\end{aligned}
$$

By means of 7.2 this can be written as

$$
\begin{aligned}
UL\%^2_{[lb,ub]} &= \left(EL\%^2 + UL\%^2\right)\cdot\left(F_{\alpha+2,\beta}(ub) - F_{\alpha+2,\beta}(lb)\right) \\
&\quad - 2\cdot lb \cdot EL\% \cdot \left(F_{\alpha+1,\beta}(ub) - F_{\alpha+1,\beta}(lb)\right) + lb^2 \cdot \left(1-F_{\alpha,\beta}(lb)\right) \\
&\quad + ub \cdot (ub - 2\cdot lb)\cdot\left(1-F_{\alpha,\beta}(ub)\right) + lb^2 \cdot \left(1-F_{\alpha,\beta}(ub)\right) - EL^2_{[lb,ub]}
\end{aligned}
$$

for B(α+2, β) is equal to

$$
\begin{aligned}
B(\alpha+2,\beta) &= \frac{\Gamma(\alpha+2)\cdot\Gamma(\beta)}{\Gamma(\alpha+\beta+2)} \\
&= \frac{(\alpha+1)\cdot\alpha}{(\alpha+\beta+1)\cdot(\alpha+\beta)} \cdot \frac{\Gamma(\alpha)\cdot\Gamma(\beta)}{\Gamma(\alpha+\beta)} \\
&= \left(\frac{\alpha^2}{(\alpha+\beta)^2} + \frac{\beta\alpha}{(\alpha+\beta+1)\cdot(\alpha+\beta)^2}\right)\cdot B(\alpha,\beta) \\
&= \left(EL\%^2 + UL\%^2\right)\cdot B(\alpha,\beta)
\end{aligned}
$$

Appendix G: Derivation of the EL and UL of Multiple Tranches

Given that two tranches, with lower boundary's $lb_{(1)}$ and $lb_{(2)}$ and upper boundary's $ub_{(1)}$ and $ub_{(2)}$, are retained ($\cdot_{(1)}$ is the boundary of the most subordinated tranche) the loss is defined as:

$$\begin{aligned} loss_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} &= \min(\max(0, l - lb_{(1)}), ub_{(1)} - lb_{(1)}) \\ &+ \min(\max(0, l - lb_{(2)}), ub_{(2)} - lb_{(2)}) \end{aligned}$$

where l is the loss in the reference portfolio.

The EL for both tranches can be derived in the same way as for a single tranche:

$$\begin{aligned} EL\%_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} &= \int_{lb_{(1)}}^{ub_{(1)}} (l - lb_{(1)}) \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(1)}}^{lb_{(2)}} (ub_{(1)} - lb_{(1)}) \cdot f_{\alpha,\beta}(l)dl \\ &+ \int_{lb_{(2)}}^{ub_{(2)}} \left((ub_{(1)} - lb_{(1)}) + (l - lb_{(2)})\right) \cdot f_{\alpha,\beta}(l)dl \\ &+ \int_{ub_{(2)}}^{1} \left((ub_{(1)} - lb_{(1)}) + (ub_{(2)} - lb_{(2)})\right) \cdot f_{\alpha,\beta}(l)dl \\ &= \int_{lb_{(1)}}^{ub_{(1)}} (l - lb_{(1)}) \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(1)}}^{1} (ub_{(1)} - lb_{(1)}) \cdot f_{\alpha,\beta}(l)dl \\ &+ \int_{lb_{(2)}}^{ub_{(2)}} (l - lb_{(2)}) \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(2)}}^{1} (ub_{(2)} - lb_{(2)}) \cdot f_{\alpha,\beta}(l)dl \end{aligned}$$

Which is equivalent to:

$$EL\%_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} = EL\%_{[lb_{(1)},ub_{(1)}]} + EL\%_{[lb_{(2)},ub_{(2)}]}$$

The UL for both tranches can be determined similarly:

$$\begin{aligned} UL\%^2_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} &= \int_{lb_{(1)}}^{ub_{(1)}} (l - lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(1)}}^{lb_{(2)}} (ub_{(1)} - lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl \\ &+ \int_{lb_{(2)}}^{ub_{(2)}} \left((ub_{(1)} - lb_{(1)}) + (l - lb_{(2)})\right)^2 \cdot f_{\alpha,\beta}(l)dl \\ &+ \int_{ub_{(2)}}^{1} \left((ub_{(1)} - lb_{(1)}) + (ub_{(2)} - lb_{(2)})\right)^2 \cdot f_{\alpha,\beta}(l)dl \\ &- EL^2_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} \end{aligned}$$

This can be written as:

$$
\begin{aligned}
UL\%^2_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} &= \int_{lb_{(1)}}^{ub_{(1)}} (l-lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(1)}}^{lb_{(2)}} (ub_{(1)}-lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl \\
&+ \int_{lb_{(2)}}^{ub_{(2)}} (ub_{(1)}-lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl + \int_{lb_{(2)}}^{ub_{(2)}} (l-lb_{(2)})^2 \cdot f_{\alpha,\beta}(l)dl \\
&+ 2\cdot \int_{lb_{(2)}}^{ub_{(2)}} (ub_{(1)}-lb_{(1)})\cdot(l-lb_{(2)})\cdot f_{\alpha,\beta}(l)dl \\
&+ \int_{ub_{(2)}}^{1} (ub_{(1)}-lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(2)}}^{1} (ub_{(2)}-lb_{(2)})^2 \cdot f_{\alpha,\beta}(l)dl \\
&+ 2\cdot \int_{ub_{(2)}}^{1} (ub_{(1)}-lb_{(1)})\cdot(ub_{(2)}-lb_{(2)})\cdot f_{\alpha,\beta}(l)dl \\
&- EL^2_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} \\
&= \int_{lb_{(1)}}^{ub_{(1)}} (l-lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(1)}}^{1} (ub_{(1)}-lb_{(1)})^2 \cdot f_{\alpha,\beta}(l)dl \\
&+ \int_{lb_{(2)}}^{ub_{(2)}} (l-lb_{(2)})^2 \cdot f_{\alpha,\beta}(l)dl + \int_{ub_{(2)}}^{1} (ub_{(2)}-lb_{(2)})^2 \cdot f_{\alpha,\beta}(l)dl \\
&+ 2\cdot \int_{ub_{(2)}}^{1} (ub_{(1)}-lb_{(1)})\cdot(ub_{(2)}-lb_{(2)})\cdot f_{\alpha,\beta}(l)dl \\
&+ 2\cdot \int_{lb_{(2)}}^{ub_{(2)}} (ub_{(1)}-lb_{(1)})\cdot(l-lb_{(2)})\cdot f_{\alpha,\beta}(l)dl - EL\%^2_{[lb_{(1)},ub_{(1)}]} \\
&- EL\%^2_{[lb_{(2)},ub_{(2)}]} - 2\cdot EL\%_{[lb_{(1)},ub_{(1)}]}\cdot EL\%_{[lb_{(2)},ub_{(2)}]} \\
&= UL\%^2_{[lb_{(1)},ub_{(1)}]} + UL\%^2_{[lb_{(2)},ub_{(2)}]} \\
&+ 2\cdot \int_{ub_{(2)}}^{1} (ub_{(1)}-lb_{(1)})\cdot(ub_{(2)}-lb_{(2)})\cdot f_{\alpha,\beta}(l)dl \\
&+ 2\cdot \int_{lb_{(2)}}^{ub_{(2)}} (ub_{(1)}-lb_{(1)})\cdot(l-lb_{(2)})\cdot f_{\alpha,\beta}(l)dl \\
&- 2\cdot EL\%_{[lb_{(1)},ub_{(1)}]}\cdot EL\%_{[lb_{(2)},ub_{(2)}]}
\end{aligned}
$$

And can be simplified to give:

$$
\begin{aligned}
UL\%^2_{[lb_{(1)},ub_{(1)}][lb_{(2)},ub_{(2)}]} &= UL\%^2_{[lb_{(1)},ub_{(1)}]} + UL\%^2_{[lb_{(2)},ub_{(2)}]} \\
&+ 2\cdot\left(\left(ub_{(1)}-lb_{(1)}\right) - EL\%_{[lb_{(1)},ub_{(1)}]}\right)\cdot EL\%_{[lb_{(2)},ub_{(2)}]}
\end{aligned}
$$

The EL and UL when multiple tranches are retained can be derived in the same way:

$$
EL\%_{MT} = \sum_{i=1}^{N} EL\%(i)\ ,
$$

$$UL\%_{MT} = \sum_{i=1}^{N} UL\%(i) + 2 \cdot \left(\left(UB(i) - LB(i)\right) - EL\%(i)\right) \cdot \sum_{j=i+1}^{N} EL\%(j),$$

where

N = the number of retained tranches,

MT = the boundaries of the retained tranches,

$LB(i)$ = the lower boundary for tranche i,

$UB(i)$ = the upper boundary for tranche i,

$EL(i)$ = the expected loss for a single tranche i,

$UL(i)$ = the unexpected loss for a single tranche i.

Appendix H: The CDO Framework

The foundation for a CDO framework has been laid to assess the profitability of a CDO transaction. In order to simplify the process of assessing the profitability of a transaction the model is implemented in an Excel spreadsheet. In this appendix the sheet is explained in three steps.

Step 1: Specifying the parameters and assumptions

In the upper left box of the main screen the parameters and assumptions have to be filled out. Since the current framework assumes an asset correlation of 20 percent this cell cannot be changed. The following parameters can be specified:

- Cost of Capital: the rate of return required by investors on the capital provided by them. Within the Rabobank this is assumed to be 12.5 percent.
- UL Portfolio: the unexpected loss for the entire portfolio. The UL for the RI portfolio is estimated to be € 400 million.
- Capital Multiplier: the Rabobank employs a capital multiplier of 8.
- Average Maturity: the average maturity of the loans in the reference portfolio. This could range from 1 to 10 years.
- Expected LGD: the expected loss given default on a facility. This value will be used when the specific LGD is not specified for a transaction.

Step 2: Specifying the Reference Portfolio

To be able to assess the risk costs before and after the CDO transaction, the loans in the reference portfolio have to be specified. This can be done in the box below the summary. For each loan the credit rating of the debtor and the exposure on the loan (EAD) are mandatory input. Information on the loss given default for the loan, however, is optional. If this information is omitted, the benchmark will be used that was specified earlier (step 1). Each specified loan can be included or excluded from the transaction at any time, by selecting 'Yes' or 'No' at the end of the row.

Step 3: Defining the Tranches

Now the tranches of the CDO can be defined in the upper right box. For each tranche only the upper boundary has to be specified. By scrolling to the left an overview can be seen of the tranches of the CDO. Besides the lower and upper boundary of each tranche, also the EL and UL are given. The user can specify which tranche will be retained by the bank. Typically, only the equity tranche is retained by the originating bank.

Step 4: Risk Cost Reduction

The risk cost reduction of the deal is depicted in the summary given in the box under the parameters (see Figure E.2).

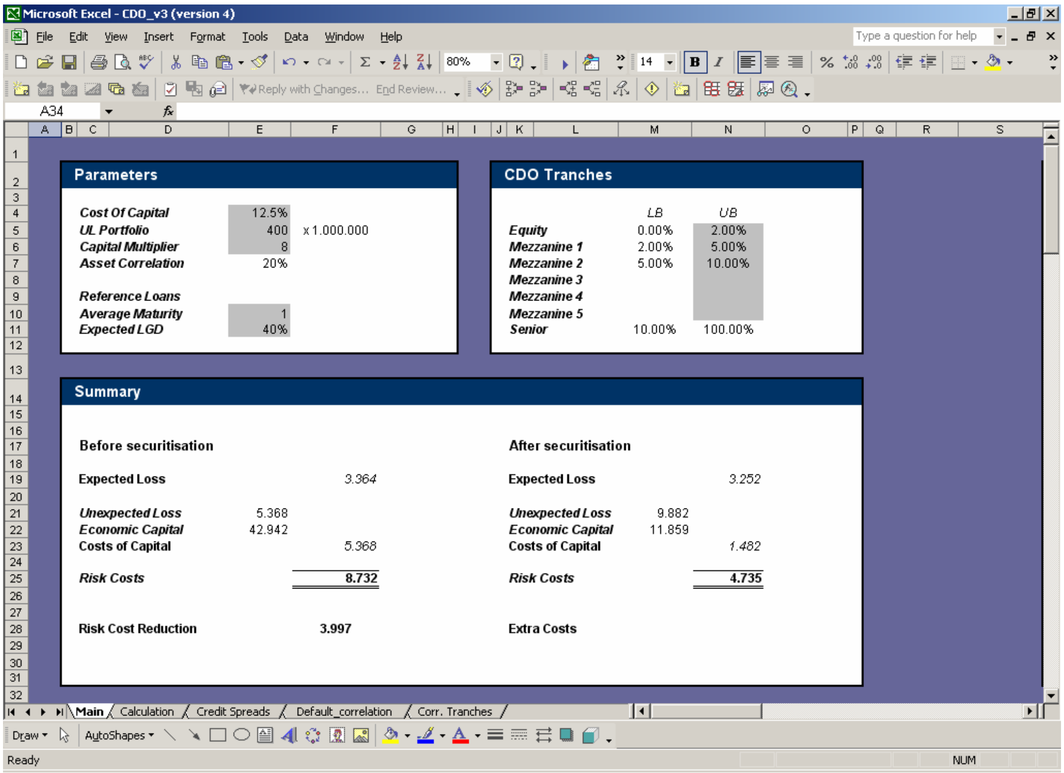


Figure E.2: Screenshot of Excel sheet