Using CDS spreads as a benchmark for credit risk figures

Improving the validation of low-default portfolios

Master Thesis: N.M. (Niek) Loohuis

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Investigating the possibility of using CDS spreads as a benchmark for credit risk measures. Using a portfolio of exposures to sovereigns as a typical low-default portfolio. All aimed at improving the validation process and capital estimation of the Rabobank.

Preface

This master thesis represents the end of my period as a student. A lot has changed during the previous years. As a teenager I started the study Industrial Engineering and Management at the University of Twente. I developed myself during this period from a young boy into a self-conscious man. The opportunities offered by the University in order to develop yourself where enormous. I tried to use these opportunities to the fullest. This was also the goal during my period at the Rabobank Nederland. The previous six months I travelled from Almelo to Utrecht in order to write my master thesis. Not one day was boring and I enjoyed every second. The colleagues from the RMVM department were a stimulus during this period. I learned a lot from every single colleague and tried to use their knowledge to the fullest. The atmosphere was informal and there was an open culture. Therefore I want to thank everyone from the RMVM department for their help during my graduation project. Especially Leonie van den Berge and Erik Winands for their time and dedication. They gave me the right feedback and pointed me in the right direction. I was involved in all of the team activities and could ask every question I want whenever I want. Next to the colleagues of the RMVM department I want to thank Bart Rotte and Ilse Ouburg for supplying the CDS data. I also want to thank the internal supervisors form the University of Twente. Berend Roorda was able to find the right balance between the theory and practice and was able to indicate the important points. Roorda made me realize that the graduation project should be fun! Reinoud Joosten indicated the importance of academic writing and made me realize that it is not only about what you write, but also how you write it. I want to thank my family for their (financial) support and enthusiasm during my study period, my girlfriend for her patience, sympathy, and distraction, and my friends for the relaxing moments that kept me going.

Name	Niek M. Loohuis BSc				
Student Number	S0167053				
Date	23-05-2013				
Internal Supervisors	Dr. B. Roorda				
	Dr. R. Joosten				
Organisation	University of Twente Drienerlolaan 5 7522 NB Enschede				
External Supervisors	L.A. van den Berge MSc				
	Dr. ir. E.M.M. Winands				
Organisation Rabobank Nederland Croeselaan 18 3521 CB Utrecht					

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Management Summary

The goal of this research is to improve the validation process of credit risk models used for lowdefault portfolios. To achieve this goal credit default swap (CDS) spreads are used as a benchmark for credit figures. Credit risk is defined as the risk of losing money because a borrower cannot repay its obligation(s). The credit risk models currently used for low-default portfolios are validated using qualitative techniques like expert opinions. It is not possible to use quantitative techniques like back tests as the number of observations of the variable of interest (defaults) is low. This makes it difficult to draw conclusions about the performance of the credit risk model based on statistical tests. Benchmarking is a quantitative technique and can be used as alternative. Benchmarking is defined as the comparison of internal estimates across banks and/or with external benchmarks (Basel Committee on Banking Supervision [2005]).

The price of a CDS is partly based on the creditworthiness of a reference party. This makes the CDSs useful for benchmarking purposes. Before these CDSs can be used as a benchmark, a transformation is made from risk neutral to physical credit figures and the point in time character of market prices has been diminished.

The portfolio with exposures to sovereigns is used as a reference portfolio due to the high notional amount, availability of full term structure, the small and restricted sample size and the recent developments in this market. Data from the sovereign CDS market is collected from Markit over a period from 2005 until 2013 and results in a diversified sample of 72 countries over different regions and rating scales.

CDS spreads are collected and the risk neutral Probability of Default (PD) is calculated based on the principle that the present value of the expected payments from the buyer and the seller are equal to each other. Afterwards a country specific Loss Given Default (LGD) is used based on the Markit database. The risk neutral PDs are transformed into physical PDs by extracting the risk premium from the risk neutral PDs.

The physical PD and Expected Loss (EL) calculated from the CDSs are compared with the internal PD and EL and credit figures from S&P and Moody's. Both the ranking and pure credit figures are compared.

Liquidity	Ease of buying/selling CDSs whenever investors want at a fair price. Influenced by market transparency, confidence in counterparty, and the time it takes to close a deal.
Contract Specifications	Effect of different clauses in the contract. For example: Restructuring clause and cheapest- to-deliver option.
Counterparty Credit Risk	Risk that the counterparty goes into default
Speculation/Asymmetric Information	Investors speculate about a potential default of a reference party and thereby increase the CDS spreads. Illustrated by larger difference in short and long term contracts in times of financial distress. Asymmetric information is one source of speculation.
Contagion	Credit conditions in different countries are correlated. This contagion effect is apparent in the sovereign CDS market and is indicated by a high degree of correlation (evident in EU).

A possible way to improve benchmark is to quantify the effect of the components in Table 01.

Table 0.1 Different components priced in CDS spread

Recommendations

- Monitor the difference between short-term and long-term CDS spreads. An increase in this difference can serve as an early warning signal indicating an increased risk of a country.
- Investigate the correlation between sovereign CDSs as an indicator for systematic risk. This could give an indication about the contagion effect and correlation in times of default.

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1 Introduction

It all started with the credit crunch in 2007. Although the economic situation flourished the years before 2007, it really deteriorated the years after. The value of real estate, commodities and other assets declined. Banks became insolvent, government support to banks increased and lending standards became tighter making it more difficult for corporations to invest. Governments, corporations, financial institutions had a hard time repaying their debts. More and more defaults occurred. Entities assumed to be risk free defaulted. This increased number of defaults changed the process of risk assessment and the area of risk management in two ways. First of all the risk assessment process gets more attention due to the high number of defaults. Second, the higher number of defaults will lead to a better estimation of the probability of a default (PD) and the loss given default (LGD).

This is especially the case for portfolios that experience a low number of defaults. Examples of such portfolios are sovereigns, banks and highly rated corporates. While the current crisis increased the number of defaults it is still difficult to validate the credit risk models used for these portfolios quantitatively. Statistical tests will remain useless as the number of observations of the relevant variable, the amount of defaults, is not likely to increase significantly. While the quantitative validation of credit models used for low-default portfolios (LDPs) remains problematic, supervisors and regulators increase the regulation, capital requirements and supervision.

New methods have to be found to improve the validation process of credit models used for lowdefault portfolios. Therefore the Rabobank initiated an investigation in order to evaluate the possibility of using credit default swap (CDS) spreads as a benchmark for credit figures of low-default portfolios.

1.1 Background

The risk of losing money because a borrower cannot repay its obligation(s) is called <u>credit risk</u>. In order to estimate the capital required for credit risk a bank has to determine the credit risk figures probability of default, loss given default, and exposure at default (Hull J. C. [2010]).

- **Probability of Default:** Probability that counterparty will default within one year.
- **Loss Given Default**: The amount of money that is lost in case of a default. LGD is usually presented as a percentage of the EAD.
- **Exposure At Default**: Extent (amount) to which a bank is exposed to a counterparty in case of a default of that counterparty.

Some of the requirements from the regulator are (Basel Committee on Banking Supervision [2006]):

<u>500.</u> Banks must have a robust system in place to validate the accuracy and consistency of rating systems, processes, and the estimation of all relevant risk components.

<u>501.</u> Banks must make a regular comparison between realized default rates and estimated PDs for each grade and must be able to demonstrate that the realized default rates are within the expected range for that grade. When using the advanced IRB approach one also has to show this for the LGD and EAD estimations.

<u>502.</u> Also other quantitative validation tools must be used. The internal assessments of the performance of the rating systems must be based on long data histories, covering a range of economic conditions, and ideally one or more complete business cycles.

<u>503.</u> Demonstrate that quantitative testing methods and other validation methods do not vary systematically with the economic cycle.

The term 'low-default portfolios' is already mentioned, however it is still a vague term. The Basel Committee Accord Implementation Group's Validation Subgroup (AIGV) indicates that there are no strict definitions for low-default portfolios or non-low-default portfolios. AIGV believes that there is a continuum between these two types of portfolios and when a bank's internal data systems include fewer loss events in a portfolio it is closer to the low-default end of the continuum (Basel Committee on Banking Supervision [2005]). Executing a validation process that fits the requirements of the regulator for credit risk models used for low-default portfolios is difficult. A comparison between the realized default rates and the estimated PDs for each grade, also called backtesting, is difficult because of the low number of defaults. Therefore an investigation will be conducted in the field of benchmarking. Benchmarking is defined as the comparison of internal estimates across banks and/or with external benchmarks (Basel Committee on Banking Supervision [2005]). A CDS is a credit derivative and is illustrated in Figure 1.1.



Figure 1.1 Credit default swap

A CDS is an insurance-like product. The buyer of the CDS, called the default protection buyer, will be protected against a potential default of a specific reference entity. The default protection seller agrees to sell this protection against a certain price. This price, usually paid in monthly instalments is called the premium or spread. In case of a default the seller of the CDS has to compensate the protection buyer for the default of the reference entity and settles according to a predefined settlement procedure (Hull J. C. [2010]). It is important to note that the default protection buyer is not obliged to have an interest in the reference entity. So it is free to buy protection whether it has a contract with the reference entity or not.

The protection seller determines the spread, thereby the seller considers the creditworthiness of the reference entity and this is represented in the spread. However, the spread is higher than purely the expected loss from a reference entity. This phenomenon is called the "credit spread puzzle" in the bond market (Amato & Remolona [2003]). Different components are responsible for the higher spread and it is necessary to identify the different building blocks of a CDS spread in order to use it as a benchmark for credit risk figures. Other sources of external information are explored and described

in Appendix 12.1. However, CDSs will be used as benchmark because of their relative liquidity and simplicity. Using the terminology of Amato and Remolona [2003] it can be stated that the research is aimed at solving the credit default swap spread puzzle.

1.2 Research Objective and Methodology

CDSs belong to the group of credit derivatives. This means that they are derived from the creditworthiness of a certain entity or group of entities. As there is a market for CDSs, information on the creditworthiness of certain entities will hopefully be incorporated in the price of the CDSs of these entities as quickly as it becomes available (Breitenfellner & Wagner [2012]). Therefore CDSs incorporate valuable information about certain parties. Especially for credit figures of low-default portfolios, where the defaults are limited and no statistical claim can be made about a credit risk model, the CDSs can help in evaluating the performance of a credit risk model. As the Rabobank wants to know the potential of CDS spreads for benchmarking credit risk figures of low-default portfolios the following research objective can be stated:

Objective: Improve the validation process of the Rabobank for credit risk models used for low-default portfolios by using benchmarks for credit figures extracted from CDS spreads.

This is not a whole new area of interest. It has been studied before, but the objective of our research is to put it in practice. The studies indicate that using CDS spreads will be complex due to variables and relationships driving the CDS spreads. Therefore the results to be gathered must be seen in the light of certain assumptions. In order to reach the goal some other research questions have to be answered. These are described together with the methodology used to answer the questions.

Research question 1: What are the current problems in the quantitative validation process of lowdefault portfolios?

The quantitative validation of low-default portfolios is problematic. In order to illustrate the problems associated with low-default portfolios a back test is carried out and the problems are highlighted. The answer to this research question will indicate the relevance of this research.

Research question 2: In what way can Credit Default Swaps be used in order to improve the validation process of the Rabobank?

This research question needs to be answered in order to indicate why CDS spreads are used and in what way these are able to improve the validation process. The CDS product, the CDS market, and some issues concerning the use of CDS spreads for validation purposes are introduced and explained.

Research question 3: Which low-default portfolio, based on the CDS market, is suitable as a reference portfolio?

Based on the CDS market and the internal portfolios of the Rabobank it is decided which low-default portfolio is used as a reference portfolio.

Research question 4: Based on the reference portfolio, which data are needed and can be obtained from the Markit database?

When it is known which reference portfolio will be used, the CDS data can be collected. Characteristics that have to be kept in mind will be explained and data gathering will be elaborated. This is based on the Markit database, Markit is a provider of CDS quotes for different kind of entities.

Research question 5: Which model is suitable to extract the risk neutral PD from the CDS data and what are the risk neutral PDs resulting from this method?

A PD measure could be given as a risk neutral PD or a physical PD. The risk neutral PD takes into account the valuation effect of a possible default while the physical PD is just the probability of a default. The risk neutral PD incorporates a premium for the risk that investors are bearing. The physical PD can be calculated by extracting this risk premium from the risk neutral PD. In order to find the best applicable method from the literature a small literature search will be done. A method has to be found that is not too complex and that is able to give a clear indication about the risk neutral PD.

Research question 6: How can the risk premium be extracted from the risk neutral PD in order to calculate the physical PD?

As stated, the risk premium is the difference between the risk neutral PD and the physical PD. The physical PD is needed in order to make a comparison with the internal credit figures. In order to find the risk premium a method has to be found that is able to give an indication about the risk premium. For this external sources will be used.

Research question 7: What is the match between the benchmark credit figures and internal/external credit figures?

The match between the calculated benchmark credit figures can be determined making a comparison with the credit figures from external sources (rating agencies) and internal source (internal credit figures). The match in ranking and real credit figures is considered. Also the rank ordering of the pure CDS spreads will be taken into account in order to determine if the executed calculations are necessary in order to get a satisfying rank ordering.

Research question 8: What is the interpretation of the match/mismatch between credit figures extracted from the CDSs and internal/external credit figures?

The aim of this research question is to interpret the match or mismatch between the different credit figures. It is used to examine the results and must be seen as a guidance for further research that could be used in order to improve the benchmark.

1.2.1 Methodology

In order to be able to answer the research questions different methodologies are used. Per research question it is denoted what methodology is used to answer it.

- Research question 1: Statistical analysis is used to illustrate shortcomings of back testing.
- Research question 2: Literature review.
- Research question 3: Data analysis of the CDS market.
- Research question 4: CDS data collection and analysis.

- Research question 5: A literature research is conducted and findings are applied.
- Research question 6: A literature research is conducted and findings are applied.
- Research question 7: Statistical analysis is used to investigate the match.
- Research question 8: Literature review.

Every research question is treated in a separate chapter starting with Research Question 1 in Chapter 2.

1.2.2 Relevance

The contribution to the academic field and the business field should be considered. CDS spreads and the implied credit figures in these spreads are not new. Several authors investigated this subject and even the name 'credit spread puzzle' is assigned to the subject. Its value lies in the use of existing sources, the critical evaluation, and applied methodology.

2 Validation Issues LDP

The goal of this research is to improve the validation of credit risk models used for low-default portfolios. Therefore it is important to know what the issues are in the validation process that is currently used for these credit risk models. This chapter will explain the current validation process and the issues that arise due to the low amount of defaults. This will give an answer to the first research question.

Validation of risk models consists of qualitative techniques and quantitative techniques and consists of many different processes as indicated in Section 1.1. The focus of this chapter will be on the most commonly used quantitative technique called backtesting. Backtesting is a technique that determines if the forecasts of a model line up with realisations (Basel Committee on Banking Supervision [2010]). So within the area of credit risk models, the estimated PD, LGD, and EAD have to be compared with the realized PD, LGD and EAD. When the number of defaults in a portfolio is small it is difficult to compare the realized values with the estimated ones. This problem is noticed by the regulators and described in the Basel Committee on Banking Supervision (BCBS) report: "Validation of low-default portfolios in the Basel II Framework". The AIGV states in this report that low-default portfolios present challenges for risk quantification and validation (Basel Committee on Banking Supervision [2005]). These challenges are caused by the lack of historical relevant data.

The backtesting framework of the Rabobank used for credit risk models does not make a distinction between portfolios. It is a uniform framework used to validate credit figures for all kinds of portfolios. When this framework is used for credit risk models used for low-default portfolios no solid conclusions can be drawn on the outcome of such a backtest. This is due to the lack of statistical power of the backtesting framework. In cases where there are a few observations of the outcome of interest (the defaults), statistical tests may not be very informative about the performance of the model (Jacobs [2010]). Before the power of the test will be explained first the type of errors incorporated in a statistical test will be described (Basel Committee on Banking Supervision [2006]):

Type I error (α): The probability that an accurate risk model would be classified as inaccurate. **Type II error** (β): The probability that an inaccurate model would be classified as accurate.

These errors are illustrated in Figure 2.1. The number of defaults that actually have occurred is denoted by μ_R , the expected number of defaults according to the model is denoted by μ_M . If the null hypothesis is $\mu_R = \mu_M$ and it seems that in reality the null hypothesis is correct (within the confidence bounds based on the assumed confidence level), a test should indicate that this hypothesis is correct and should accept the null hypothesis. If the test rejects the null hypothesis while in reality the null hypothesis is correct, a Type I error occurs. In the other case, when the same null hypothesis is used and in reality $\mu_R \neq \mu_M$, the test must reject the null hypothesis because it is incorrect. If the test does not reject the null hypothesis a Type II error occurs.

	Reality					
	$H_0 \text{ correct}$ $\mu_R = \mu_M$	H _o incorrect μ _R ≠μ _M				
Not Reject H ₀	No Error Type II error					
Reject H ₀	Type I error	No Error				

Figure 2.1 Illustration Type I and Type II error

Figure 2.1 is a simplification. The situation whereby $\mu_R = \mu_M$ rarely occurs. When the test is carried out some kind of confidence level is incorporated based on the realized values. The value of the model μ_M should lie within (out of) this confidence interval in order to be not rejected (rejected).

The Type II error is related to the statistical power a test. As the Type II error is denoted by β (in percentages), the statistical power can be determined by formula (1).

Statistical power of a test =
$$1 - \beta$$
 (1)

The statistical power of a test indicates to what extent a certain test can identify an inaccurate model as an inaccurate model. This is an important feature of a test from a risk management perspective. If a model is used in order to estimate the credit risk figures and the estimates are incorrect, a certain test must indicate that the model is incorrect. A test with high statistical power will increase the confidence of a bank in the performance of a model. As stated before, backtesting credit risk models for low-default portfolios will lead to an unsatisfactory result as no solid conclusions can be drawn. This will be illustrated by the execution of a backtest on a credit risk model used for a low-default portfolio.

3 The Use of CDSs in the Validation Process

The previous chapter indicated the problems in the validation process of credit risk models for lowdefault portfolios. To improve this validation process credit default swaps will be used as a benchmark. This chapter focuses on the question of how these credit default swaps can be used in order to improve the validation process. Therefore the CDS as a product will be described together with the market in which these CDSs are traded. When these two subjects are explained the focus will lie on the issues that arise when CDSs are used in the validation process.

Credit risk models are used in order to determine the credit risk associated with certain issuers. The credit risk is expressed in the already introduced credit figures PD, LGD, and EAD. These figures are based on the creditworthiness of a certain issuer; this creditworthiness also determines the price of a credit default swap.

Functioning of a CDS

The CDS is illustrated in Figure 3.1 and the country considered is Spain. The spread (premium) paid by the protection buyer and received by the protection seller is determined by the creditworthiness of the reference entity. This creditworthiness is based on several criteria concerning the political, economic, fiscal and social situation of a sovereign entity. While the spread is considered to be based on the expected loss of the reference entity it will also be determined by the market in which it is traded. Take for example the liquidity in a certain market, if a market is highly liquid the prices will be lower than they would be if the market is highly illiquid. So it can be argued that there are more components included in the CDS spread making it higher than it would be if it were a pure presentation of the expected loss. The influence of these components will be analysed later.



Figure 3.1 CDS Spain (Hull J. C. [2008], Standard & Poor's [2012])

As the spread is determined (partly) by the expected loss of a reference entity and the expected loss consists of the probability of default times the loss given default (see Equation (5)), this can be a benchmark for the expected loss of a portfolio with exposures to sovereigns. The challenge in retrieving a benchmark value for the credit figures is to untangle the credit default swap spread.

Expected Loss = PD * LGD (5)

Characteristics CDS

While the credit default swap as illustrated in Figure 3.1 can be seen as some kind of insurance against the potential default of a third (reference) party, there are some differences. The buyer of an insurance contract has to own the reference asset, while this does not hold for CDS buyers. These can be bought even if the buyer does not have a relation with the reference entity. However, CDSs are the most insurance-like credit derivatives (Culp [2006]). The price agreed upon by the seller and buyer of protection is known as the premium or spread and is denoted in a percentage of the notional principal. The buyer of protection pays this spread in periodic, usually quarterly, intervals. These intervals are standardised by the International Swaps and Derivatives Association (ISDA) and the payments dates are set at the 20th of March, the 20th of June, the 20th of September and the 20th of December. The protection seller agrees to settle in case of a credit event. There is a broad range of credit events like bankruptcy, credit event upon merger, cross default, cross acceleration, downgrade, failure to pay, repudiation, and restructuring (Duffie & Singleton [2003], Culp [2006]). However the ISDA states that the following events are classified as credit events: bankruptcy, failure to pay and restructuring whereby, restructuring can be split into four different types (Tang & Yan [2007]):

- Full Restructuring
- Modified Restructuring
 - \circ $\,$ Only bond with maturity shorter than 30 months can be delivered
- Modified-Modified Restructuring
 - Restructured obligations with maturity shorter than 30 months and other obligations with maturity shorter than 30 months can be delivered
- No Restructuring

The buyer and seller of protection have to decide beforehand what settlement procedure they follow when a credit event occurs. This can be cash settlement or physical settlement. When using cash settlement the protection seller will pay the difference between the face value of the reference asset and the market value directly after the credit event. If physical settlement is used, the protection buyer will deliver the defaulted bonds or loans and the protection seller will pay the face value in cash (Tang & Yan [2007]).

This is the task of five regional ISDA Credit Derivatives Determinations Committees. A committee consists of 10 sell side firms and 5 buy side firms. These members have to decide if a credit event has occurred based on the ISDA definitions of a credit event. Every member gets a vote and a minimal of 12 votes is required to state that a credit event has occurred (ISDA [2011]). A recent example of the application of the Determinations Committee is the credit event associated with Greece. The committee decided that a haircut has occurred. This is characterised as a credit event defined by the ISDA Credit Derivatives Definitions and therefore has consequences for the CDS market (ISDA [2012]).

CDS Market

The CDS was developed and introduced by JP Morgan in 1997. At that time the notional open interest in CDSs was approximately 200 billion USD while at the top period of the market in the second half of 2007 the notional amount reached almost 60 trillion USD as is illustrated in Figure 12.4 of Appendix 12.1 (Avellaneda & Cont [2010]). The CDSs are mainly traded in the over-the-counter market (OTC market). An interested party will contact a counterparty; this can be directly or via a broker or dealer. The interested party and counterparty have to negotiate terms of a contract in order to make a deal. The protection buyer agrees a price with the protection seller in order to buy protection for a possible default of a specific reference entity. The negotiating parties had a lot of space to negotiate the terms of the contract previously. Since the 20th of March 2009 the ISDA introduced new standardised CDS contracts. All aimed at improving the transparency of the CDS market and prepare the product for clearing (Avellaneda & Cont [2010]).

Based on the characteristics of the credit default swaps these derivatives can be useful in the validation process. Differences in creditworthiness between reference entities are illustrated by the CDS spreads and can be compared with the internal model. Also credit figures can be extracted from the credit spreads and these can be compared to internal credit figures. But the comparison of absolute figures depends on the other components included in the spread. When CDSs are used as a benchmark for credit risk purposes there are several issues that have to be kept in mind. These are risk neutral and physical valuation, arbitrage and point-in-time (PIT) versus through-the-cycle (TTC) measures.

3.1 Risk-Neutral and Physical Valuation

A difficulty in using CDS spreads in order to benchmark the probability of default and the loss given default is the different between risk neutral and physical (real-world) valuation. The default probabilities estimated from historical data are much lower than those derived from bond prices (Hull J. C. [2008]). This is illustrated in Table 3.1; the absolute difference between the two default probability measures is given in the last column and increases as creditworthiness declines. The relative difference (absolute difference divided by historical default intensity) decreases as the creditworthiness declines. The historical default intensity is the physical PD, the default intensity from bonds is the risk neutral PD.

Rating	Historical default intensity	Default intensity from bonds	Absolute difference	Relative difference
Aaa	0,04	0,67	0,63	15,75
Aa	0,06	0,78	0,72	12,00
А	0,13	1,28	1,15	8,85
Ваа	0,47	2,38	1,91	4,06
Ва	2,47	5,07	2,67	1,08
В	7,69	9,02	1,53	0,20
Caa	16,9	21,3	4,4	0,26

Table 3.1 Seven year average default intensities (% per annum) (Hull J. C. [2008])

The difference between both measures can be explained as follows:

Physical PD: The probability of a default

Risk Neutral PD: The valuation effect of a possible default

Risk Premium = Risk Neutral PD - Physical PD (6)

This can be illustrated with Table 3.1. In this example it can be stated that the probability of a default of an Aaa rated bond is 0,04%. So the chance that such a bond will default is very low. This is the physical PD. The risk neutral PD shows the valuation effect of such a possible default. This shows the effect of a default of the Aaa rated bond. The difference between both measures is the risk premium, see (6).

Consider a random sovereign entity say Germany. The probability of a default for Germany is not high, but when it defaults it will have serious consequences. Therefore the risk neutral PD is higher than the physical PD, it takes into account the valuation effect. Because of the fact that the valuation effect is higher than the physical probability of default investors require a risk premium to get compensated for the increased risk they take.

Within the context of CDS spreads and credit risk models the concept of risk neutral and physical valuation can be illustrated by the PD calculated by both valuation methods. The physical PDs are calculated using historical data and are also called real-world PDs. The PDs extracted from the CDS spreads are called risk neutral PDs. Physical PDs are smaller than risk neutral PDs as illustrated before. The risk neutral PDs are used in order to value credit derivatives while the physical PDs are used in scenario analysis and the determination of capital requirements under Basel II (Hull, Predescu, & Alan [2005]). This illustrates the issue in the use of CDS spreads as a benchmark for the expected loss calculated by the credit risk models. The CDS spreads are valued using the risk neutral property and thereby the backed out expected loss is a risk neutral measure. The expected loss calculated with the credit risk models uses physical measures. Therefore there is a discrepancy between the two and this discrepancy has to be solved in order to use CDS spreads as a benchmark for the expected losses generated by credit risk models.

3.2 Arbitrage Relationship

The arbitrage relationship that is evident in the CDS market helps to explain why there are several other components included in the CDS spreads that will make it higher than if it was a pure representation of the expected loss and risk premium.

Possible arbitrage in the CDS market is based on the arbitrage relationship between bond yields, CDS spreads and risk free interest rates. For example if a (risky) bond yields 8% and the risk free rate is 5% one could earn 3% more than the risk free rate by investing in the risky bond. Therefore one takes on the credit risk of the bond issuer in order to receive a higher return than the risk free rate. This percentage is 3% and can be seen as the credit spread and represents the credit risk of the bond issuer. So relationship (7) must hold:

Bond yield
$$y = risk$$
 free rate $r + CDS$ spread s (7)

If this relationship does not hold one could earn more than the risk free rate if (Hull J. C. [2008]):

- CDS spread s < bond yield y risk free rate r
 - \circ $\;$ Risk free profit can be earned by buying the bond and protection.
- CDS spread s > bond yield y risk free rate r
 - Risk free profit can be earned by borrowing at less than risk free rate by shorting the bond and selling the CDS protection

It has to be stated that these arbitrage relationships are not perfect. This will be explained by the relationship with asset swaps. However, in normal markets they give a good view on the relationship between CDS spreads and bond yields.

Relation with Asset Swaps

Arbitrage relationships can also be illustrated using asset swaps. An explanation of asset swaps can be found in Appendix 12.1. For now it is sufficient to know that the asset swap spread for a bond is a direct estimate of the excess of the bond's yield over the risk free rate (Hull J. C. [2008]). Therefore the asset swaps function as a reference point for traders in credit markets.

From (7) it can be seen that the CDS spread is the excess of the bond yield over the risk free rate. This is also the definition of the asset swap spread. So based on the arbitrage relationship the asset swap spread should be equal to the CDS spread. However, the CDS spread and asset swap spread can differ in reality. Therefore the CDS-bond basis is introduced and this is the excess of the CDS spread over the asset swap spread as given in Equation (8).

$$CDS \ bond \ basis = CDS \ spread - Asset \ swap \ spread$$
(8)

The CDS bond basis, as explained, should be close to zero based on the arbitrage argument. But there are a number of reasons why the CDS-bond basis is not zero. Some of these reasons are (Hull J. C. [2008]):

- Underlying bond sells for a price that is significantly different from par.
- There is a counterparty credit default risk in a CDS.
- There is a cheapest to deliver bond option in a CDS.
- The payoff in a CDS does not include accrued interest on the bond that is delivered.
- The restructuring clause in a CDS contract may lead to a payoff when there is no default.
- LIBOR is greater than the risk free rate assumed by the market.

These reasons indicate why the arbitrage relationship is not perfect. Other components are included in the price of the CDSs. These have to be identified in order to fine-tune the benchmark.

3.3 Through the Cycle and Point in Time

In order to compare the market prices of sovereign CDSs with the expected loss figures from the sovereign model used by the Rabobank a distinction has to be made between through the cycle and point in time measures. These two concepts usually apply to credit ratings. Through the cycle is already named in Section 2 indicating the goal of rating agencies when determining their ratings. Point in time (PIT) and through the cycle (TTC) can be explained as follows (Basel Committee on Banking Supervision [2005]):

- **Point in time:** These are measurements that adjust quickly to a changing economic environment. Such measures are used for pricing purposes or in order to track current portfolio risk.
- **Through the cycle:** These are measurements that tend to remain more-or-less constant as macro-economic situations change. These measures are used mainly for underwriting purposes.



Figure 3.2 Through the cycle vs. point in time

In Figure 3.2 the difference between through the cycle measures and point in time measures is illustrated. Note that it is a schematic representation (cycles or not stationary) in order to illustrate the difference between PIT and TTC. This difference is important to notice because a capital model will be compared with market information. Market information is a point in time measure, whereby new information is incorporated in the market as quickly as possible. So the sovereign CDS market will respond to new information about a sovereign entity instantaneously. However, a capital model is used in order to determine the capital needed for a certain portfolio. A bank does not want to change this capital estimation very often because this will cost money. They aim at an estimation that is less dependent on the economic environment.

In order to compare a model with the market information the market information must be transformed into through the cycle measures. The CDS contracts are issued in different maturities. By using contracts with a longer maturity the point in time effect will be reduced. The maturity is one of the characteristics of the CDS data and will be explained in the next chapter

3.4 Conclusion

CDSs can be useful in the validation process based on their specific characteristics. CDS spreads can give an indication about the differences in creditworthiness between reference industries. Based on these differences a ranking can be made of entities and compared to the internal credit figures. It can

also be tried to extract the credit figures from the CDS spreads in order to compare these with internal absolute figures. When comparing the absolute figures the other components included in the CDS spreads have to be determined. The fact that these components are included in the CDS spread can be explained by the arbitrage relationship with bonds and asset swaps. To come to a useful benchmark the risk neutral CDS spreads have to be transformed into physical credit figures, otherwise it is not possible to make a comparison with internal figures. It is also important to consider the CDS spreads over a longer time in order to diminish the point-in-time character and come to through the cycle figures comparable to internal models.

4 Reference Low-default portfolio

The previous chapters have dealt with the issues in the validation process of credit risk models used for low-default portfolios and the use of CDSs to improve this process. These findings hold for the low-default portfolios in general and are not based on one certain reference portfolio. Within this chapter a choice will be made between different reference low-default portfolios that will be used for further analysis. This will help in understanding the different results. However, it must be noticed that the goal is to find a method that can be used for different low-default portfolios and among different asset classes.

Different forms of low-default portfolios exist and one of these has to be chosen in order to use as reference portfolio. There are several causes of a low number of defaults in a certain portfolio (Basel Committee on Banking Supervision [2005]):

- Portfolios that experienced low numbers of defaults
- Portfolios that are relatively small in size. They can be small at a bank or global level.
- Portfolios where the bank just entered.
- Portfolios that do not have incurred major losses, but there are indications that suggest a higher likelihood of losses than is captured in the data.

In certain situations a bank can use data enhancing methods like data pooling in order to use sufficient data for a backtest procedure. In other cases this remains difficult because of the limited amount of reference entities in a portfolio and the limited amount of defaults. Examples of the latter type of portfolios are exposures to sovereigns, financials, and highly rated corporates (Basel Committee on Banking Supervision [2005]). While the recent crisis increased the number of defaults in these portfolios and the awareness that these parties are not risk free, the number of defaults is still too low in order to use a backtest as indicated in Chapter 2.

In order to determine what low-default portfolio will be taken as a reference portfolio the CDS market has to be taken into account. The entities in the reference portfolio must be represented in the CDS market. Credit derivatives depend for their success on the liquidity of the market and therefore bonds and commercial paper issued by sovereign entities and major firms are most likely to offer scope for credit derivatives to be written against them (Batten & Hogan [2002]).Thus makes sovereign entities and major corporations the typical reference entities in the CDS market. The group corporations is a collection of different types of corporations from different industries. These industries are: basic materials, consumer goods, consumer services, energy, healthcare, industrials, technology, telecommunication services, utilities and other. Financials are also part of the collection of corporations, but these are isolated in this research from the group of corporations because the financials also experience a low number of defaults.

By separating the financials from the group of corporations this group can be taken into consideration in the choice for a reference low-default portfolio. The low-default portfolios represented in the CDS market are financials, highly rated corporates, and sovereigns. These three groups of entities are nearly responsible for the whole notional outstanding in the CDS market as represented by Figure 4.1.



Figure 4.1 Share of gross notional per reference entity (DTCC [2013])

As mentioned, the corporations form a group of different industries. This explains the large share of the gross notional amount. Additional information will be presented in Table 4.1. This information consists of the gross notional amount, the number of contracts and the ratio between these two for every reference entity.

Reference Entity	Gross Notional	Number of Contracts	Gross Notional/Contracts
Corporations	\$ 7.305.048.369.816,00	1.281.216	\$ 5.701.652,47
Financials	\$ 2.946.267.368.569,00	422.336	\$ 6.976.121,78
Sovereigns	\$ 2.975.055.602.740,00	216.831	\$ 13.720.619,30
Loans	\$ 22.029.588.265,00	5.668	\$ 3.886.659,89
Mortgage Backed Securities	\$ 50.790.044.613,00	7.841	\$ 6.477.495,81
Municipal	\$ 3.449.700.000,00	274	\$ 12.590.145,99
Total	\$ 13.302.640.674.003,00	1.934.166	\$ 6.877.714,05

Table 4.1 CDS market characteristics (DTCC [2013])

It can be seen that the groups loans, mortgage backed securities and municipal represent a small percentage of the overall gross notional amount and have a low number of contracts outstanding. Corporate CDSs represent the biggest part of the overall gross notional amount and have the largest number of contracts. Financials and sovereigns share an equal amount of gross notional; however financials have twice the number of contracts as sovereigns. Sovereigns (and municipals) have the largest gross national amount per contract. It must be stated that the collection of corporates has the biggest share of the gross notional amount, but the financial industry is the only industry with a higher gross notional amount than sovereigns. A final difference between financials, corporations and sovereigns is the trading volume per maturity. Financial CDSs and corporate CDSs are mainly traded at 5 year maturity, while sovereign CDSs are traded across a wide range of maturities (Pan & Singleton [2008]). This makes it possible to construct a full term structure.

The typical low-default portfolios (sovereigns and financials) were considered to be almost risk free in the past. However, this consideration changed rapidly within the previous years and an accurate estimation of the risk associated with both portfolios is needed. The difference in the two portfolios is the fact that the number of entities that fall under sovereigns is lower than the number of financial entities. As there are more financial institutions than sovereign entities and it is unlikely that many new sovereigns will come to existence. So the portfolio of exposures to sovereigns is small in sample size (globally) and experiences a low number of defaults. The low-default portfolio with exposures to financials is larger in sample size.

The portfolio that will be used as a benchmark portfolio will be the portfolio with exposures to sovereigns. The high gross notional amount, the small sample size, a full term structure and recent developments make this portfolio an interesting topic for research. Some further information will be given about the portfolio with exposure to sovereigns.

4.1 Sovereigns

Government debts have risen the previous years. Countries like Greece, Ireland, Italy, Spain, Cyprus and Portugal are facing difficulties in Europe. Unemployment, high debts and a declining economic growth are characteristics of these countries. The sovereign debt level of European countries as a percentage of the Gross Domestic Product (GDP) is illustrated in Figure 4.2.



Figure 4.2 General government debt as percentage of GDP 2011 (European Central Bank [2011])

A bank usually has a significant exposure to sovereign entities. Especially to their home country because of the interdepence between the bank and its home country. Therefore they have to estimate the risks associated with exposures to such an entity and this risk is called sovereign risk. Sovereign risk is part of the area of credit risk and the definition is given below.

Definition Sovereign risk: The risk that a sovereign entity, acting through its authorized intermediary (e.g. the ministry of finance or central bank) repudiates, delays, or amends its obligations (Kaplan Schweser [2011])

4.2 Conclusion

The goal of the research is to come up with a general benchmark based on CDS spreads that can be used among different asset classes. In order to test the use of CDSs as a benchmark one reference portfolio is needed in order to perform the different calculations. This reference portfolio will be the portfolio with exposures to sovereigns. This portfolio is chosen because of the high gross notional amount outstanding in the CDS market, the availability of a full term structure, the small (restricted) sample size, and the recent developments concerning sovereigns. The increasing debt levels, higher unemployment, and declining economic growth illustrate the European sovereign market and the necessity to determine the risk of these countries in an appropriate way. The low default character is

characterized by the distribution of the countries across the rating scale, indicating that most of the countries lie to the low risk end of the scale.

Public Report

5 Data (Confidential)

6 Method for Extracting the Risk Neutral PD

The area of credit models can be divided in two categories. The first category is concerned with structural models and the other category consists of reduced-form (intensity) models (Ben-Ameur, Brigo, & Errais [2009]). The difference between the two models is the default process. The two types can be explained as follows (Brigo & Mercurio [2006]):

- **Structural:** Based on the value of an entity. Default occurs when the value of the entity hits a certain barrier from above. This barrier could be stochastic or deterministic and usually the barrier is based on the debt level.
- **Reduced-form:** Based on the fact that default occurs all of a sudden. The default process is modelled as the first jump time of some kind of Poisson process. The intensity of the Poisson process can either be deterministic or stochastic.

The structural and reduced form models are used to model the default process. The default process is used to calculate the probability of default. Within this research it is not the goal to model the default process and to determine the PD using this default process. The PD needs to be extracted from the given CDS spreads. So it works the other way around and therefore the underlying default process is of less importance. The use of structural and reduced-form models is illustrated in Figure 6.1.



Figure 6.1 Modelling the default process

As explained, a model can be used for the default process. With this default process a certain probability of default can be calculated and this PD in combination with an assumed LGD will result in an expected loss figure. This expected loss will determine the credit default swap spread. In this relationship it is assumed that the spread is determined by solely the expected loss of an entity, this does not hold in reality. Other components are included in the CDS spread. These components will be investigated in Chapter 9.

6.1 Model

We use a model from Duffie & Singleton [2003], Hull & White [2000], and Duffie [1999]. The Deutsche Bank, Fitch, and Nomura are using the same model (Beumee, Brigo, Schiemert, & Stoyle [2009], Deutsche Bank Research [2012], Nomura Securities International, Inc., [2004]). The model is a guide and serves as an initial indication of the relationship between spreads and expected loss. It is the same model as in Hull [2010]. Therefore many articles refer to the method and price the

simplicity of this method (Holemans, van Vuuren, & Styger [2011], Garcia, Van Ginderen, & Garcia [2002], Gündüz & Uhrig-Homburg [2011], Hu & Ye, [2007], Hull & White, [2006]). The focus within the financial world also shifted from complex and comprehensive models to simpler models. This will increase the transparency and therefore a simple model is preferred.

The model is based on the fact that the expected value of the payments made by the two parties should be equal if these parties want to settle a deal. The buyer of protection pays the premium every 20th of the months March, June, September, and December until maturity or the time of default. If a default occurs between two payment dates an accrual payment has to be made dependent on the day of default. Furthermore it is assumed that if the default occurs between two payment dates, this will be in the middle of the interval. The protection seller pays one sum of money at the event of a default and zero otherwise. This method does not depend on a (structural or reduced-form) model and fits the purpose for extracting the PD (Beumee, Brigo, Schiemert, & Stoyle [2009]).

So the model is based on the principle that the present value (PV) of the payments made by the two parties must be equal. This is based on market practice. It can also be seen from a no-arbitrage point of view. This arbitrage argument has to be considered in combination with the underlying bond as explained in Section 4.2. Based on the fact that the present value of payments should be equal (no arbitrage), the following Equation (9) must hold.

PV Premium Payments + PV Accrued Payments = PV Payoff(9)

Two situations can occur that are similar to the arbitrage opportunities illustrated in section 4.2.

- The present value of the payments from the protection buyer (left hand side of Equation (9)) could be more than present value of the payoff from the protection seller (right hand side of Equation (9)). In this case the price paid for protection is more than the expected loss one will suffer. So this corresponds with the situation of: *CDS spread s > bond yield y risk free rate r*
- The present value of the payments from the protection buyer (left hand side of Equation (9)) could be less than present value of the payoff from the protection seller (right hand side of Equation (9)). So the price paid for protection is lower than the expected loss. This corresponds with the situation: *CDS spread s < bond yield y risk free rate r*

In both situations it is possible to achieve a riskless profit. As argued, this arbitrage relationship is not perfect in practice, due to liquidity issues and other components incorporated in the CDS spread. For the purpose of this chapter we assume that the arbitrage relationship holds. Therefore the following assumptions must also hold:

- The protection buyer and protection seller are assumed to be default free. Therefore no counterparty credit risk is involved.
- The market is assumed to be perfectly liquid, so no transaction costs are involved. In practice, there will be some transaction costs as illustrated by the bid-ask spread.
- Tax effects will be ignored.
- Recovery rate, probability of default and interest rates are independent.

- If there is a default between two coupons dates, the default will be in the middle of this interval. In this situation an accrual payment has to be done at the time of default.
- The first premium is paid at t=0,25.

Besides these assumptions based on the model that is used another assumption is made. The recovery rates that will be used are based on the market information extracted from Markit (see Appendix 12.4 for further information).

The model used at first will be aimed at extracting the risk neutral PD from CDS market spreads. This risk neutral PD will give a conservative value of the probability of default of the sovereigns. This view is conservative because the spread is assumed to consist of the expected loss. Several reasons can be named for this assumption. First of all it is not clear what components are included in the spread and how one can account for these components. This will be investigated later, but an initial look at the literature shows that incorporating these components will lead to more complex models with uncertain outcomes. The effect of the components can be seen after investigating the match between the benchmark and the other sources. Second, the goal of our research is to get to a benchmark. The simpler a benchmark can be calculated the better it fits the purpose of validation.

Model description

The following parameters and variables are used within the model.

t: time in years, range is from t = 0.25 until t = T whereby T denotes the maturity of the contract. D(t): discount factor, value of receiving one unit of the relevant currency at time t seen from t = 0.

 α : time between two different payment dates, time in years.

R: recovery rate, percentage of face value that will be recovered after a credit event. LGD = 1 - R. S_T : spread that corresponds to maturity T. For this research only contracts with a maturity of 5 or 10 years will be used. S_T indicates the spread on a yearly basis.

q(t): survival probability at time t, the probability of default at time t will be 1 - q(t).

Using these notations the premium leg is given by (10). This is simply the expected value of all the premium payments done until maturity. This expected value is determined by the probability of survival and the discount factor.

Premium Leg =
$$\sum_{t=0,25}^{T} D(t) * q(t) * S_T * \alpha \quad (10)$$

The accrual payments are given by (11). The expected value of these payments are determined by the probability of default during a certain period ((t- α) until t) and the discount factor. It is assumed that if a default occurs between two payments dates, this default occurs in the middle of the interval.

Accrued Payments Leg =
$$\sum_{t=0,25}^{T} \frac{D(t) * (q(t-\alpha) - q(t)) * S_T * \alpha}{2}$$
(11)

The sum of the premium and accrual payments should be equal to the expected value of the protection payment. This payment is given by Equation (12). It illustrated the expected loss given a credit event and is based on the discount rate and probability of default within a certain interval.

Protection Leg =
$$(1 - R) * \sum_{t=0,25}^{T} D(t) * (q(t - \alpha) - q(t))$$
 (12)

The first step is to determine the probability of default. This PD together with an assumed LGD is used to determine the CDS spread S_T . In formula form the goal is to find the value for q(t) for which the following relationship holds (13). Note that all the legs are based on the spread.

 $Premium \ Leg + Accrued \ Payments \ Leg - Protection \ Leg = 0 \ (13)$

This is the usual way in order to determine the spread. In this research the market spreads are used in order to derive a figure for the PD given a LGD. By using the same formula, but some form of reverse engineering it must be able to achieve this goal. The CDS spread indicates the fair market price. Therefore, given this CDS spread, the expected payments of the buyer equal the expected payments of the seller. This implicates that the sum of the expected premium and accrued payments minus the protection payment should be zero. This can be represented as a Linear Programming (LP) problem. Note that the notation of parameters and decision variables has changed.

Parameters

 α : space between two time intervals (0,25 in this case) spr: spread for maturity T (5 or 10 years) t: time from t= α until t=T in steps of α d_t: discount factor at time t rr: recovery rate (1-rr = LGD)

Decision Variable

 Q_t : survival probability at time t, where $t \in [\alpha, T]$

Objective Function

$$\min_{Q_t, where \ t \ \epsilon \ [\alpha, T]} z = \min_{Q_t, where \ t \ \epsilon \ [\alpha, T]} \left(\begin{array}{c} \sum_{t=\alpha}^T d_t * Q_t * \alpha * spr + \sum_{t=\alpha}^T \frac{d_t * (Q_{t-\alpha} - Q_t) * \alpha * spr}{2} & - \\ (1 - rr) * \sum_{t=\alpha}^T d_t * (Q_{t-\alpha} - Q_t) & - \end{array} \right)$$

Constraints

•

$$\begin{array}{ll} 0 \leq Q_t \leq 1 & \forall t \in [\alpha, T] \\ 0 \leq (Q_{t-\alpha} - Q_t) \leq 1 & \forall t \in [\alpha, T] \\ Q_0 = 1 & \\ z \geq 0 & \end{array}$$

This LP problem can be solved using Excel. As already named the spreads of the five-year and tenyear CDS contracts will be used in order to solve the model.

6.1.1 Risk Free Interest Rate

For this model to be used the risk free rate of interest has to be determined. This rate will be the rate at which future cash flows will be discounted in order to retrieve the present value of future payments. The studies that focus on CDS spreads have mainly used the US treasury rate or the swap rate as the risk free interest rate (Fabozzi, Cheng, & Chen [2007]). Examples of such studies are Longstaff et al [2005] and Blanco et al [2005]. For this research a swap rate will be used because these are used in the CDS market (Houweling & Vorst [2005]). In their research Houweling and Vorst [2005] state the following:

"We find that swap and repo curves significantly outperform the government curve as proxy for default-free interest rates for investment grade issuers, but that their performance is similar for speculative grade issuers. As such, this is one of the first studies to empirically confirm that financial markets no longer see Treasury bonds as the default-free benchmark".

Until 1998 the government bonds were used as default-free interest rates for credit risk modelling. From 1998 onwards swap and repo contracts were used instead. Houweling & Vorst [2005] show that government bonds result in a significant overestimation of credit risk for investment grade issuers. There are others who see the swap rate as the default-free benchmark (Hull, White, & Predescu [2004]) and the finding of Houweling and Vorst is also used in other recent studies (Chen, Cheng, & Wu [2011], Delatte, Gex, & López-Villavicencio [2012]). The reason why government securities are seen as unsuitable for pricing other fixed-income securities is the fact that the securities have become sensitive to liquidity risk in addition to market risk (Houweling & Vorst [2005]). While the swap rates will be used for this research it must be stated that these are seen to be virtually risk free. During the years 2007/2008 it became clear that swap rates were not risk free rates. These swap rates are subject to counterparty credit risk making them somewhat higher than the risk free rate. However, it is out of the scope of this research to determine what the real risk free rate of interest is.

Examples of swap rates are the Euro Interbank Offered Rate (EURIBOR) and the London Interbank Offered Rate (LIBOR). These are the interest rates used by highly rated banks in order to lend each other money. Thereby the EURIBOR is focused on the European Banks and the LIBOR is determined by the banks on the London money market. Both rates are presented up to a period of 12 months indicating the short term interest rate. To get the risk free interest rate for longer periods than one year the EURIBOR swap or LIBOR swap will be used. The EURIBOR is more focused on the Euromarket while the LIBOR Swap rates are traded in different currencies including the US Dollar. The fact that the LIBOR swap Rates are traded in different maturities and different currencies justifies the choice for the LIBOR swap rates as risk-free rates.

The LIBOR swap rate denoted in USD will be used as the risk free rate. The LIBOR swap rates are obtained from the first of April 2005 until the 15th of February 2013. The Central Bank of America, the Federal Reserve, makes the LIBOR swap rates denoted in USD available. The mid-market rates are gathered and illustrated in Figure 6.3.



Figure 6.3 LIBOR swap rates in US Dollars (Board of Governors of the Federal Reserve System [2013])

The LIBOR Swap Rates are denoted in several maturities from one to ten years. These maturities are the same as the maturities of the used CDS spreads. Therefore no adjustments have to be made to these maturities. There were however some dates without a quoted swap rate. In order to make use of these dates linear interpolation is used as illustrated in Equation (14).

Swap rate day
$$i = day_{i-1} + (day_i - day_{i-1}) * \frac{swap rate day_{i+1} - swap rate day_{i-1}}{day_{i+1} - day_{i-1}}$$
 (14)

Thereby *i* is the number of the day. The first of April 2005 is day 1 and the 15th of February 2013 is day 2056. Within this period only business days are taken into account.

6.2 Risk Neutral PD Results (Confidential)

6.3 Conclusion (Confidential)

7 Calculating the Physical PD

Credit risk models are based on the physical PD. The goal of this chapter is to transform the risk neutral PD results from the previous chapter into physical PD measures. This is needed in order to be able to compare the credit figures subtracted from CDS spreads with the internal credit risk parameters. The CDS spreads consists of an expected loss and a risk premium as given Equation (15) (Amato [2005]). The goal is to extract the risk premium from the CDS spread to get the value for the expected loss.

$$CDS \ spread \cong Expected \ Loss + Risk \ Premium$$
 (15)

The CDS spreads consist of a part covering the expected loss and one part concerning the price for uncertainty among this expected loss (risk premium). By extracting the risk premium from the CDS spreads both components are split and taken into account. If there are other components that influence the CDS spreads these will influence the expected loss and/or risk premium and cannot be isolated from these two main components.

To transform the PDs extracted from the CDS market, Formula (16) is used. This formula is based on the Black-Scholes/Merton's structural framework [1974] and is also used by other market participants. The equation is used by Moody's for example in order to calculate the physical PD from CDS spreads (Dwyer, Li, Qu, Russel, & Zhang [2010], (Vasicek [2002]).

$$Q_t = N(N^{-1}(P_t) + \lambda \rho \sqrt{t})$$
(16)

Definition of variables and parameters

- *t* : Time horizon in years
- Q_t : Cumulative risk neutral probability of default
- P_t : Cumulative physical probability of default
- λ : Sharpe Ratio (Market price of risk)
- ρ : Asset correlation of issuer with the market
- *N*: Cumulative Normal distribution
- N^{-1} : Inverse of the cumulative Normal distribution

Formula (16) can be rewritten in order to get a formula for the physical probability.

$$P_t = N(N^{-1}(Q_t) - \lambda \rho \sqrt{t}) \quad (17)$$

The cumulative risk neutral probability of default is known, just as the time horizon which is one year. The cumulative physical probability of default is the variable of interest. Before it is possible to calculate the physical probability the Sharpe ratio and the correlation have to be known.

Correlation

In order to get a reliable picture for the correlation of each issuer with the market the asset correlation given in Basel III is used. This formula is given in Equation (18) (Basel Committee on Banking Supervision [2010]).

$$\rho_{asset} = 0.12 * \frac{1 - \exp(-50*PD)}{1 - \exp(-50)} + 0.24 * \left(1 - \frac{1 - \exp(-50*PD)}{1 - \exp(-50)}\right)$$
(18)

The asset correlation is needed in order to calculate the regulatory capital requirements and subsequently the risk weighted assets for corporate and sovereign exposures. It can be seen that the asset correlation depends on the (physical) probability of default of the issuer. This is based on an analysis executed by the BCBS illustrating that the higher the probability of default of an issuer the higher its idiosyncratic risk will be. A higher idiosyncratic risk of a certain issuer means that the dependence on the market will be lower (lower systematic risk). The formula indicates that there are two limits on the correlation. The lower limit is 0,12 or 12% and the higher limit is 0,24 or 24%. The correlations in-between are based on an exponentially weighting function. The shape of the function is illustrated in Figure 7.1. The asset correlation formula will be used in order to come from a risk neutral PD to a physical PD. The PD denoted in the asset correlation function is the physical PD and formula (18) is also calibrated by Basel using the physical PD. Due to the fact that the BCBS as a regulator uses the same formula in their capital requirements calculations it can be assumed that it gives a fair representation of the asset correlation with the market.



Figure 7.1 Asset correlation based on the PD

Sharpe Ratio

The remaining unknown parameter in Equation (16) is the Sharpe ratio. This ratio is also called the market price of risk and indicated the risk adjusted return and is developed by William Sharpe [1964]. The Sharpe ratio can be calculated by using formula (19).

$$\lambda = rac{\mu - r}{\sigma}$$
 (19)

Where

- μ : Expected return of investment asset
- *r*: Risk free rate
- σ : Volatility of the expected excess return

The formula indicates that the ratio is based on the excess average return per unit of total risk. This excess return is volatile through the time, just as the degree to which investors are risk averse. Therefore Sharpe ratios are volatile through the time as the risk preferences of the investors also change during the time. In times of recession the market price of risk is usually high while it is low in times of good economic conditions. During times of recession the investors are more risk averse and therefore they demand a higher return for the risks they are bearing than they would demand during situations in which the economy flourishes.

The calculations for the risk neutral PDs are based on the average CDS spreads during a certain period. This average is taken in order to get a picture that is constant through the observed period. This must also hold for the market price of risk. Therefore the average market price of risk will be used in Equation (18).

The average Sharpe ratio will be determined by looking for information in external sources. The Sharpe ratio is the market price of risk and can indicate the risk preferences in the sovereign CDS market. Several sources are found that indicate the Sharpe ratio for sovereign CDSs. Moody's generated different reports in which Sharpe ratios are included.

In one of these reports Moody's calculated the Sharpe ratios for investment grade corporates in different regions. These Sharpe ratios are also used for the sovereign market. In which they assume that the Sharpe ratio of investment grade companies from North America can be used for all the sovereign issuers. This assumption is made due to the observation that sovereign foreign currency debt investors are most likely to come from developed markets. On top of this fact the North American debt market is the most liquid when looking at trading depth (Dwyer, Li, Qu, Russel, & Zhang [2010]). In Table 7.1 the Sharpe ratios for the different years and regions are given.

	2004	2005	2006	2007	2008	2009	2010	Average
Europe	0,2	0,25	0,45	0,45	0,75	0,9	0,475	0,55
North America	0,375	0,375	0,6	0,52	0,75	0,9	0,4	0,59
Japan	0	-0,1	0,2	0,075	0,1	0,25	0,01	0,09
Asia And South America	0,375	0,35	0,5	0,51	0,875	1,2	0,65	0,68

Table 7.1 Sharpe ratios per region and year

Another study conducted by the European Central Bank (ECB) is based on the iTraxx Europe and the CDX.NA.IG index. Thereby the Sharpe ratios are calculated for the period April 2004 until March 2009 based on CDS contracts with different maturities (Berg [2010]). In Table 7.2 the Sharpe ratios for Europe are given based on this research. There are more points of data and the average is a weighted average over the available time points. This also holds for the Sharpe ratio of the United States given in Table 7.3.

Europe	2005	2006	2007	2008	2009	Average
5yr	0,317	0,435	0,473	0,765	0,680	0,529
10yr	0,317	0,430	0,468	0,595	0,465	0,462
	and the F					

Table 7.2 Sharpe ratio Europe

United States	2005	2006	2007	2008	2009	Average
5yr	0,527	0,578	0,630	0,778	0,455	0,614
10yr	0,493	0,530	0,585	0,585	0,300	0,522
10yr	0,493	0,530	0,585	0,585	0,300	0,5

Table 7.3 Sharpe ratio United States

It can be seen that the Sharpe ratio for the ten-year CDS spreads is somewhat lower than the Sharpe ratio for the five-year CDS spread. This can be explained by the dependency on the market and the point in time character of the five-year contract compared to the ten-year contract. A contract with a shorter maturity is more sensitive to temporary risk preference changes than contracts with a longer maturity.

This is confirmed by a report made by the Sarasin Group. They have determined the Sharpe ratio for sustainable countries to be between 0,41 and 0,5 over the period 2006-2011 (Sarasin Group [2011]). According to the research the sustainable countries are mostly developed countries. All the above given Sharpe ratios lie within the range of 0,40 and 0,60. These are all through the cycle measures and can therefore be used to extract the risk premium from the risk neutral values. To determine the effect of the Sharpe ratio on the value of the physical PD different Sharpe ratios will be used within the range of 0,4 and 0,6.

- 7.1 Five-year CDS (Confidential)
- 7.2 Ten-year CDS (Confidential)
- 7.3 Conclusion (Confidential)

Public Report

8 Comparison of the Credit Figures (Confidential)

9 Components Credit Default Swap Spread

A literature research is conducted in order to find the other components that are incorporated in the CDS spreads and that will influence the CDS spread. Evidence that the components are included in the CDS spreads is already given (Berndt, Douglas, Duffie, Ferguson, & Schranz [2005]). The goal of this chapter is to indicate these components and the goal is not to quantify these. Further research can be dedicated to this quantification.

9.1 Components

CDS spreads are financial products and therefore subject to different influences. Several of these influences are taken into account in the development of the benchmark. The following issues are addressed:

- Effect of the business cycle is diminished by taking into account long time averages.
- Cash flows are discounted in order to take into account the time effect and the influence of the risk free interest rate.
- Risk preferences of investors are considered using the Sharpe ratio and the asset correlation.
- Country specific credit risk is inherently addressed using the CDS spreads.

Other factors that influence the CDS spreads are for example credit ratings and heterogeneous beliefs (Dieckmann & Gallmeyer [2013], Fabozzi, Cheng, & Chen [2007]). These factors influence the components that are priced in the CDS spreads. But it is not the goal of this chapter to indicate all these influences and their relationships with the different components. The goal is to explain some of the components priced in the CDS spreads that make the credit figures extracted from the CDSs higher than the figures from other sources. The benchmark may be improved when these components are quantified and therefore this chapter can also be seen as a start for further investigation.

The structure of the literature research is presented in Appendix 12.9. This structure is used to investigate the components priced in the CDS spreads.

The relationship in Equation (26) was already introduced in Chapter 7. The expected loss indicates the expected loss associated with the reference entity and the risk premium covers the uncertainty surrounding this loss. The different components illustrated in this chapter cannot be isolated from this expected loss and uncertain loss. These components influence the expected loss and/or the risk premium.

 $CDS spread \cong Expected Loss + Risk Premium$ (26)

The literature is not solely based on sovereign CDSs. Therefore it is indicated to what specific family (sovereigns, corporates or banks) of CDSs a certain finding belongs.

9.1.1 Liquidity

'Liquid' implies that investors are able to quickly buy or sell their financial product whenever they want at a fair price (Lesplingart, Majois, & Petitjean [2012]).

Sovereign

Part of the CDS spread is the compensation for expected liquidity (Bongaerts, de Jong, & Driessen [2008], Tang & Yan [2007], Remolona, Scatigna, & Wu [2008]). A liquid market will give more accurate prices as it reflects the perceptions and expectations of many investors. In the CDS market liquidity is influenced by transparency (information efficiency), confidence in the counterparty and the time it takes to close a deal in the OTC-market (Lesplingart, Majois, & Petitjean [2012]). For investors in the bond market it could be difficult to untangle their position. This problem is not apparent in the CDS market as there is no exchange of notional principal and one does not take any position. The difficulty to untangle a CDS position is therefore not apparent and does not influence the liquidity of the CDS.

The importance of the liquidity is indicated by the percentage of the CDS spreads that is attributable to liquidity risk. Badaoui, Cathcart, and El-Jahel [2013] calculated that this is 49,91% for sovereign CDSs. In their research these authors also indicated that systematic liquidity and flight-to-liquidity risk do not have a heavily impact on sovereign CDSs (Badaoui, Cathcart, & El-Jahel [2013]). Liquidity has an important impact on the CDSs and a low degree of liquidity will make it difficult to estimate the real value of the CDS. The issue of liquidity is partly caused by intermediation that is needed in order to settle a CDS contract and could be less if electronic trading systems will be used (Gunduz, Ludecke, & Uhrig-Homburg [2007]). This liquidity could be measured by the relative number of market participants (Mayordomo, Peña, & Romo [2011]).

Corporates

Researchers also found a significant impact of the liquidity on corporate CDS spreads (Fabozzi, Cheng, & Chen [2007]). The inclusion of the liquidity in the CDS prices has proven to be significant for CDSs on Korean firms (Kim & Park [2012]). Corporate CDSs shows that the illiquidity increases as the credit quality of a specific firm decreases (Das & Hanouna [2009]). So including liquidity will improve the CDS valuation process. This is also the finding of Dunbar [2007] in the US corporate CDS market. This author indicated that failing to include the liquidity proxy will underestimate the credit risk (Dunbar [2007]). The effect of liquidity on CDS spreads is dominated by the influence of worsening credit conditions and deteriorating investors' expectations about default risk. Liquidity, measured as proportional bid-ask spread seemed to have been deteriorating around the Subprime crisis, and the increase in the CDS spread during this period was mainly caused by increased credit risk (Lesplingart, Majois, & Petitjean [2012]).

Banks

Beside the corporates in general also the bank CDSs include a liquidity component. This is confirmed for Euro area bank CDS spreads. It seems for these bank CDS spreads the individual CDS liquidity and market wide liquidity played a dominant role during the financial crisis (Annaert, De Ceuster, van Roy, & Vespro [2010]). When using the bid-ask spread of the CDS as a proxy for liquidity it seems that liquidity had a significant effect on two German banks (Dullmann & Sosinska [2007]).

9.1.2 Contract Specifications

One of the specifications that influence the CDS price is the maturity of the contract. A longer time to maturity increases the uncertainty concerning the creditworthiness of the reference party and/or counterparty (Abid & Naifar [2006]). This effect is already taken into account by using five- and tenyear CDS contracts in order to calculate the one-year PD. However, there are other specifications that could be investigated.

Restructuring Clause

As mentioned in Chapter 5 a characteristic of the CDS contract is the DocClause. Such a clause indicates what kind of restructuring events are taken into account and influence the CDS spreads. Contracts including restructuring events will have a higher CDS spreads than contracts without such an event. It seems that corporate CDS contracts including the restructuring event have an average restructuring risk premium between the 6% and 8% of the CDS spread without restructuring. This premium depends on firm specific balance-sheet and macroeconomic variables (Berndt, Jarrow, & Kang [2007]).

Contract imperfections

Contract imperfections have an influence on the CDS spread (Blanco, Brennan, & Marsh [2005]). One of the specifications in the contract can be the cheapest-to-deliver option. This option embedded in the CDS spread has an influence on the absolute value of the CDS spread (Mayordomo, Peña, & Romo [2011]). The price of CDSs with a cheapest-to-deliver option is seen as an upper bound for the true price of credit risk (Blanco, Brennan, & Marsh [2005]).

Standardization introduced in the CDS market solved contract imperfections that were apparent in the beginning of the CDS market (Gunduz, Ludecke, & Uhrig-Homburg [2007]). This standardization is initiated by ISDA and resulted in lower transaction costs (Partnoy & Skeel [2007]). This standardization solved previous issues and further standardization will improve the ability to use CDS spreads for benchmarking purposes.

9.1.3 Risk Premium

The risk premium component is already taken into account. The transformation from risk neutral to physical PD is done by extracting the risk premium from the risk neutral PD.

Researches also indicate the importance and appearance of a risk premium in the CDS spreads. This is seen as a remuneration for investors for unexpected changes in default intensity (Zinna [2013]). The risk premium is related to several other factors. One of these is the business cycle; investors are more risk averse in times of recession for example. There are authors that have tried to give a value to the risk premium. Longstaff, Pan, Pederson & Singleton [2011] indicate that the risk premium is on average one-third of the credit spread. Default risk premium tent to increase with a rising default probability when default probability is low, but declines when default probability reaches a certain level and continuous to rise (Zhang [2008]). So when default probabilities are low the risk premium has a primary impact on the pricing of CDS spreads, when the default probabilities are high the risk premium is of secondary importance. This confirms the finding made in Section 7.1.1. The relative risk premium declines as credit quality worsens

9.1.4 Counterparty Credit Risk

When signing a CDS contract one will introduce counterparty credit risk. This is the risk that a certain counterparty will go in default and adds up to the credit risk premium associated with the reference entity of the CDS contract. The existence of counterpart credit risk in the CDS contract is confirmed by several authors (Mayordomo, Peña, & Romo [2011], Blanco, Brennan, & Marsh [2005]). Ignoring this risk will lead to the mispricing of CDS spreads (Jarrow & Yu [2001]). Counterparty credit risk became apparent after the failure of American banks and the near failure of AIG and is part of the CDS spreads (Coudert & Gex [2010]). The appearance of counterparty credit risk results in the fact that CDS contracts are usually traded with institutions with a high credit rating (Blanco, Brennan, & Marsh [2005]). Counterparty credit risk will tend to decrease due to the development of central clearing houses as part of the standardization process. This will have a positive impact on the liquidity (Lesplingart, Majois, & Petitjean [2012]).

A goal for further research is to calculate the counterparty credit risk in CDS transactions. The CDS data from Markit indicates a composite mid-market spreads and does not indicate which counterparty gives the quotes. Therefore another database has to be addresses indicating the counterparty behind he quotes in order to be able to improve the benchmark process.

9.1.5 Speculation/Asymmetric Information

When credit quality worsens, speculation will lead to an increase in the CDS spread. Bad news about a sovereign entity could lead to speculation about decreasing credit conditions of that entity. Speculators will buy the CDS contract without owning the underlying bond (Kucuk [2010]). This leads to higher CDS premiums and this increase is not directly related to the risk premium of the underlying. Speculation can be seen in most of the credit derivatives markets and this is also the case for CDSs. These are also used for other purposes than to protect against a certain default (Coudert & Gex [2010]). A reason for this speculation could lie in the asymmetric information between counterparties (buyer and seller) about firm type and swapping motive (Mozumdar [2001]).

This speculation was also indicated by the increases in CDS spreads for short-term contracts compared to long-term contracts when there is an important news event concerning a sovereign. A terroristic attack or important political decision influences the CDS spreads and is most likely caused by speculation.

Speculation and asymmetric information could be addresses by further research in order to improve the benchmark. However, it will be difficult to quantify this effect.

9.1.6 Contagion Effect

Correlation seems to be evident in the sovereign CDS market and pairwise correlations in excess of 80% are not rare (Longstaff, Pan, Pedersen, & Singleton [2011]). Contagion is one of the main reasons for this correlation and the effect of contagion is significant (Balding [2011]). This contagion effect increases in times of market stress and became apparent due to the US subprime-crisis and Lehman collapse (Fender, Hayo, & Neuenkirch [2012]).

The contagion effect explains why defaults are not independent and why there is some form of correlation between these defaults leading to correlation in credit risk (Pu & Zhao [2010]). This is

illustrated by Balding [2011] using the Czech Republic as an example and it seems that the shock of the debt crisis was incorporated in the credit premium. This indicates the contagion effect. By extending this result to other countries it seems that contagion has an impact in Europe (Komarkova, Lesanovska, & Komarek [2013]).

The data analysis section already illustrated the correlation between the different CDS spreads. The correlation could help in order to determine the effect of contagion among countries. Further research in the field of this contagion effect could improve the match between the different credit figures and thereby the use of the benchmark

9.2 Conclusion

Based on the literature review conducted in this chapter different components are identified. These components are possible explanations for the mismatch between the credit figures and quantifying these components will improve the benchmark. The components identified in this chapter are liquidity, contract specifications, counterparty credit risk, speculation/asymmetric information, and contagion effects. These influence the price of the CDS and are explained in Table 9.1.

Liquidity	Ease of buying/selling CDSs whenever investors want at a fair price. Influenced by market
	transparency, confidence in counterparty, and the time it takes to close a deal
Contract Specifications	Effect of clauses in the contract. Examples are: Restructuring clause (number of
	restructuring events included) and cheapest-to-deliver option.
Counterparty Credit Risk	Risk that the counterparty goes into default
Speculation/Asymmetric Information	Investors speculate about a potential default of a reference party. This will increase the CDS spreads (see effect of short term contracts and long term contracts in times of financial distress). Asymmetric information is one source of speculation.
Contagion	Credit conditions in different countries are correlated. This contagion effect is apparent in the sovereign CDS market and is indicated by a high degree of correlation (for example in the EU)

Table 9.1 Explanation of different components priced in CDS

10 Conclusion, Recommendations and Further Research

10.1 Conclusion

The goal of this research was to improve the validation process of the Rabobank credit risk models used for low-default portfolios by using benchmarks for credit figures extracted from the CDS spreads. The necessity for an improvement of this validation process is caused by the difficulty of performing a quantitative validation. The number of observations of the variable of interest, the number of defaults, is low and therefore it is not possible to draw conclusions about the functioning of a model based on statistical tests. So qualitative validation is currently used and a benchmark based on CDS spreads could improve the quality of this process by giving quantitative references in the form of credit figures.

We use a portfolio with exposures to sovereigns as a reference low-default portfolio and therefore sovereign CDSs are collected. By analysing the collected CDS spreads from 72 countries over the period 2005-2013 there are some interesting findings.

Due to the high liquidity the five-year CDS contracts and the through-the-cycle character of the tenyear CDS contracts we have found legitimate ground to use these contracts in calculating the risk neutral and physical credit figures.

The credit figures extracted from the CDS spreads are compared with the internal credit figures and external credit ratings from S&P and Moody's. This comparison is based on the ranking of the credit figures and on the pure credit figures.

Besides credit risk and the risk premium other components are apparent in the CDS spread. Investigating and quantifying different components that are priced into the CDS may improve the match between the benchmark and internal and external sources. Previous research indicates that liquidity, contract specifications, speculation, counterparty credit risk, and contagion are priced into the CDS spreads. These are subjects for further research.

We conclude that the CDS spreads are useful as a benchmark.

10.2 Recommendations

Based on this research some recommendations can be made about the use of CDS spreads in the validation process of credit risk models used for low-default portfolios.

- The difference between the short-term CDS spreads and the long-term CDS spreads is appropriate as an indicator of increasing risk. We found that this difference increases when the credit conditions of a sovereign deteriorates. This can be due to a common factor like the credit crunch or country-specific factors like national politics or terroristic attacks. The increase in one year CDS spreads compared to ten-year CDS spreads should therefore be used as an early warning signal.
- The correlation in the sovereign CDS market could give an indication about the systematic risk and contagion effect when determining the risk associated with certain sovereign entities. This correlation is evident within the market and also calculated for different

countries. This correlation helps in order to understand what the dependencies are between different sovereign entities and what the effect is of global events. A further analysis will improve the understanding of sovereign credit risk.

10.3 Further Research

This thesis could be seen as a start and it could initiate different other investigations. Several different characteristics can be further analysed in order to improve the use of CDSs.

- Besides the credit risk and risk premium several other components are priced into the CDS spreads. Further investigation is needed in order to quantify these components and their role in the pricing process. This may improve the benchmark ability of CDS spreads.
- The same method could be used for other low-default portfolios. Highly rated corporations and financial institutions are the other portfolios characterised by a low number of defaults.
 Further research must indicate whether the ranking is comparable among these other asset classes and whether there is a match in credit figures.
- One of the problems in comparing the data set with the internal credit figures is the time over which the CDS spreads are quoted. Some countries have quotes over a period of almost eight years while other have data over a period of two years. How many years have to be taken into account in order to retrieve credit figures that can be compared to the internal credit figures?
- An interesting question to ask is in what way the correlation between the CDS spreads can be used in order to estimate the contagion effect between different sovereign entities.
 Contagion effects the sovereign CDSs, but how can this factor be quantified? This could help in order to improve the area of risk management.

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12 Appendices

Information, tables and figures are presented in these appendices. These form an additional source of information to the main body of the report.

12.1 Possible External Benchmarks

This appendix illustrates the different external information sources that could be used as a benchmark for credit figures. It gives background information on the choice for CDS spreads and the different possibilities for benchmarking the creditworthiness of sovereign entities. It is worth noticing that banks are flexible in choosing their benchmark (Basel Committee on Banking Supervision [2005]). Per benchmark a small description will be given.

Sovereign Credit Ratings

The creditworthiness of a sovereign party is characterized by the credit rating. These ratings are provided by rating agencies as Moody's, Standard & Poor's and Fitch (Hull J. C. [2010]). Credit ratings represent credit risk. The different ratings used by the agencies are given in Table 12.1.

Credit Grade	Moody's	S&P	Fitch
Highest	Ааа	AAA	AAA
Very high	Aa1, Aa2, Aa3	ΑΑ+, ΑΑ, ΑΑ-	AA+, AA, AA-
High	A1, A2, A3	A+, A, A-	A+, A, A-
Good	Baa1, Baa2, Baa3, Baa4	BBB+, BBB, BBB-	BBB+, BBB, BBB-
Speculative	Ba1, Ba2, Ba3	BB+, BB, BB-	BB+, BB, BB-
Very Speculative	B1, B2, B3	B+, B, B-	В+, В, В-
Substantial risks – in default	Caa1, Caa2, Caa3, Ca	CCC+, CCC, CCC-, CC, C, D	CCC+, CC, C, RD, D

Table 12.1 Credit ratings from rating agencies (The Wall Street Journal [2012])

These ratings could be used in order to benchmark the internal rating models. The discriminative power could be assessed based on the external ratings of sovereign parties as well as the predictive power. The goal of the rating agencies is to achieve rating stability. The agencies do not want to make frequent changes in creditworthiness. The focus is on the long term and ratings are only changed when the agencies believe that there is a long term change in the creditworthiness of a party. These ratings are therefore characterised as "through the cycle" thereby focussing on the long term and not on short term temporarily market disturbances. The ratings are based on several criteria that, according to the agencies, represent the creditworthiness of the sovereigns. Typical examples of those criteria are political risk, economic structure and growth prospects, external liquidity and international investment position, fiscal performance and flexibility (also debt burden), and monetary flexibility (Standard & Poor's [2012]). The ratings of the European countries are given in Table 12.2. The ratings are ordered from high to low.

Country	Moody's	Fitch	S&P	Country	Moody's	Fitch	S&P
Finland	Aaa	AAA	AAA	Poland	A2	A-	A-
Germany	Aaa	AAA	AAA	Slovenia	Baa2	A-	А
Denmark	Aaa	AAA	AAA	Italy	Baa2	A-	BBB+
Netherlands	Aaa	AAA	AAA	Lithuania	Baa1	BBB	BBB
Luxembourg	Aaa	AAA	AAA	Bulgaria	Baa2	BBB-	BBB
Sweden	Aaa	AAA	AAA	Spain	Baa3	BBB	BBB-
United Kingdom	Aaa	AAA	AAA	Latvia	Baa3	BBB-	BBB-
France	Aaa	AAA	AA+	Ireland	Ba1	BBB+	BBB+
Austria	Aaa	AAA	AA+	Romania	Baa3	BBB-	BB+
Belgium	Aa3	AA	AA	Hungary	Ba1	BB+	BB+
Czech Republic	A1	A+	AA-	Portugal	Ba3	BB+	BB
Estonia	A1	A+	AA-	Cyprus	B3	BB+	BB
Slovakia	A2	A+	А	Greece	С	CCC	CCC
Malta	A3	A+	A-				

Table 12.2 Credit ratings of European countries (The Wall Street Journal [2012])

Equity Prices

The equity of a company can be used in order to calculate the risk-neutral probability of default. This equity will be seen as an option on the assets of the company and a Merton model and Black Scholes formula is used to determine the PD (Hull J. C. [2010]).

Government (Sovereign) Bonds

These are bonds issued by a national government whereby a promise is made to pay the face value at a certain date in the future together with interest payments. The investor loans an amount of money to the government. Bonds issued in the country's own currency are usually called government bonds and bonds issued in a foreign currency are called sovereign bonds. In the past government bonds from OECD countries were seen as free of risk. A drastic change has been seen in the risk involved in government bonds as a consequence of increasing debts and credit risk in countries.

Credit derivatives

These are derivatives explicitly designed to shift credit risk between parties (Mengle [2007]). The most well-known type of credit derivatives is the credit default swap (CDS). Other forms are the total return swaps, asset swaps, credit spread option and future, credit linked note and floating rate note.

Credit Default Swaps

A CDS is a product that gives insurance against the risk of a default by a particular company. The company referred to is known as the reference entity and the default of this reference entity is called a credit event. The protection buyer pays a periodic fee to the protection seller and the protection seller has to compare the protection buyer for the loss in case of a credit event. This is done by using some predefined settlement procedure (Hull J. C. [2010]). The process is illustrated in Figure 12.1.



Figure 12.1 The credit default swap process

The amount one has to pay per year, as a percentage of the notional principal, is called the CDS spread. As expected, the CDS spread is determined by the credit risk associated with a reference entity. A lower credit risk will lead to a lower spread and a higher risk to a higher spread. But there are more components that determine the CDS spread, one of these is for example the liquidity of such a product. Therefore it is not easy to isolate the credit risk from the spread.

Total Return Swap

Within a total return swap the total economic performance of a reference obligation is transferred from a total return payer to a total return receiver. Market risk is transferred with credit risk and therefore a credit event does not have to occur before payments are made between parties (Mengle [2007]). In this case the total return receiver is the legal owner of the reference obligation and the receiver will pay the total return earned on this obligation to the total return receiver. The total return receiver will pay a money market rate like LIBOR plus some additional spread. This is illustrated in Figure 12.2.



Figure 12.2 Total return swap

In this case the total return receiver will have a long position in the credit and market risk of the reference obligation. And the total return payer has the short positions in credit and market risk. So the credit and market risk are transferred from the payer to the receiver and the receiver will pay the LIBOR + spread in return. The total return consists of interest, fees and appreciation/depreciation.

Asset Swap

An asset swap combines the interest-rate swap with a bond. Asset swaps are both seen as interest rate derivatives and credit derivatives. It is a commonly used instrument in the credit derivatives market because it sets out the price of credit as a spread over LIBOR. The holder of the bond pays a coupon into an interest rate swap that has the same maturity. Because of the fact that the bond coupon is usually larger than the current swap rate, a spread is added to the LIBOR rate equal to the difference between the coupon rate of the bond and the interest rate swap rate (both prevailing at the trade date) (Mengle [2007]). This is illustrated in Figure 12.3.



Figure 12.3 Asset swap

Because of the fact that the interest rate swap takes away the interest rate risk of the bond, the bondholder will be left with the credit risk of the bond. The asset swap spread compensates the bond holder for credit risk and therefore this spread should be related to the credit default swap spread (Mengle [2007]). This has to be based on the arbitrage argument. If CDS spreads are low relative to asset swap spreads, one could buy an asset-swapped bond and offset it by buying protection and thereby locking in a profit. The other way around works not that well because one has to short a bond and this is depends on the liquidity of the underlying bond market (Mengle [2007]).

Credit Spread Option

This product gives the buyer the right to pay (or receive) a specified credit spread to a given period. This is a right and not an obligation. These options have put way to CDS swaptions that give the buyer the right to buy or sell CDS protection. However, the market is declining for these options (Mengle [2007]).

Credit Spread Forwards

This is a forward contract with the credit spread as underlying asset. The payoff is characterised by the difference between the credit spread today and at a future time t. This amount is then multiplied by the duration and the notional amount. The payoff therefore is based on the changed credit quality of a reference credit.

Credit Linked Notes (CLN)

As the name implies the payments of the notes are related to the creditworthiness of a reference entity. The buyer of the CLN will receive the payments for the note if the reference entity does not

go into default. The coupon payments have to be linked to the credit risk associated with the reference entity.

Floating rate Note (FRN)

This is a bond that pays a coupon linked to a variable interest rate index. The variable interest rate used is normally LIBOR or EURIBOR indicating the rate at which highly rated banks can borrow. So these rates reflect the credit quality of this AA rated commercial banking sector. Because many floaters are issued by corporates with much lower credit ratings and because many AA-rated banks issue subordinated floating rate notes the investors will require a higher yield for the increased credit risk. Also the coupons of the bond must be discounted at a higher interest rate than LIBOR or EURIBOR to take into account the higher credit risk. Therefore the coupon of the FRN must be set at a fixed spread over LIBOR when the FRN is issued at par. This spread must be equal to the spread over LIBOR/EURIBOR that is used to discount the cash flows of the issuer. This spread is called the par floated spread and can be seen as a measure of the market-perceived credit risk of the note-issuer. It indicated the credit quality of the issuer at par (O'Kane [2011]).

Credit Indices

These are indices that track the credit default swap spreads. Within these portfolios only investment grade entities are used. The two most important indices used for companies are the CDX NA IG consisting of 125 companies in North America and the iTraxx Europe consisting of 125 companies from Europe. However, these indices are also used for sovereign entities. Thereby groups of sovereigns are taken together per region like Asia Pacific, Latin America and Western Europe. Such an index could also be used to calculate the PD of a certain group of sovereigns using the spread. With such a portfolio one can buy protection on all of the parties representing the index (Hull J. C. [2008]).

Basket Credit Default Swaps

An index is a form of a basket consisting of several reference entities. A basket consists of a number of reference entities. There are different types of baskets.

- Add-up basket: payoff when any of the reference entities default
- Kth to default payoff only when the k-th default occurs

Asset backed securities and credit default obligations

These are securities created from a portfolio of some financial assets. A CDO is an example of the asset backed securities and consist of the payoff from bonds (Hull J. C. [2008]). Usually the payoff is arranged in certain tranches. CDOs are well known because of the subprime crises. However, these products are complex and therefore will not be considered as benchmark.

Choice of benchmark

As pointed out there are many products used that incorporate sovereign credit risk. The interest lies mainly in the expected loss benchmark as given by (2).

$$Expected \ loss = PD \ x \ LGD \tag{2}$$

The credit derivatives described above state something about the creditworthiness and thereby the expected loss of a sovereign entity. Credit derivatives are liquid markets compared to bonds and therefore they can quickly process information and improve the monitoring of the creditworthiness of a country (Breitenfellner & Wagner [2012]). Most of the credit derivatives are a combination of a credit default swap and some other product(s). The notional amount of credit default swaps outstanding is illustrated in Figure 12.4 and the notional amount as a percentage of the total OTC derivatives market is illustrated in12.5.



Figure 12.4 Notional amounts of CDSs in billion USD (Basel Committee on Banking Supervision [2006], [2008], [2010], [2012])



Figure 12.5 Notional amount of CDS s as percentage of total OTC derivatives market

The Figures 12.4 and 12.5 are an indication about the notional amount of CDSs outstanding and thereby single-name and multi-name CDSs are combined. The single-name CDSs correspond to a single entity while the multi-name CDSs correspond to a combination of entities. However, the share of single-name entities is larger than multi-name entities (Basel Committee on Banking Supervision

[2006], [2008], [2010], [2012]). Besides the liquidity of the CDS market it is also one of the simplest credit derivatives. Other credit derivatives are a combination of products and usually include CDSs. This makes them more complex than a single-name CDS. Therefore single-name credit default spreads are chosen for further research. Usually credit default swaps are used in order to hedge the credit risks associated with government bonds.

Using CDS spreads in order to determine the expected loss is also allowed by the Basel Committee on Banking Supervision (BCBS). The BCBS states that there are four methods in order to estimate the LGD; these are (Basel Committee on Banking Supervision [2005]):

- 1. Calculating the LGD by using the discounted cash flows after default;
- 2. Use the prices of traded defaulted loans in order to determine a market LGD
- 3. Use non-defaulted bond prices in order to determine an implied market LGD using an asset pricing model
- 4. An implied historical LGD based on the experience of total losses and PD estimates (in case of a retail portfolio)

A reference data set of sovereigns is a low-default portfolio. This means that the reference data set consists largely of non-defaulted facilities. The LGD of such a portfolios (or data sets) can be estimated from market information like credit spreads (Basel Committee on Banking Supervision [2005]).

12.2 Confidential

12.3 Confidential

12.4 Confidential

12.5 Confidential

12.6 Confidential

12.7 Confidential

12.8 Confidential

12.9 Literature Research

A literature research is carried out to answer the following research question:

What is the interpretation of the match/mismatch between credit figures extracted from the CDSs and internal/external credit figures?

In order to execute a literature research decisions have to be made about the following components.

- Choice for research database
- Choice for search terms used
- Selection criteria

- Keep track of number of papers found and excluded at each stage
- Synthesising literature
- Conclusion

In order to conduct a literature review that is complete and unbiased a systematic review has to be conducted. Because of the limited amount of time, an exhaustive literature review is only possible if systematic prioritization is used. Therefore choices have to be made about the components described above.

Databases

Benchmarking, CDS spreads and risk model validation are part of the financial world as a whole. Therefore the main field of interest will be "Economics, Econometrics and Finance" which is part of the Social Sciences. A database is needed that covers this field in a comprehensive way. Besides the fact that the database must include social sciences it can be stated that the more fields are included the better the database.

There are different databases in use for scientific articles. Examples of these are:

Scopus: This database covers Scientific, Technical, Medical and Social Sciences, and Arts and Humanities. Scopus contains 18.500 journals in these fields. Thereby Scopus does have a tool that can improve the searching process by sorting, analysing and selecting (SciVerse [2012]).

Web of Knowledge: The focus of this database is on Sciences, Social Sciences, Arts, and Humanities. Within these sectors a total of 256 disciplines are covered. There are 23.000 journals available and it is possible to analyse, select and sort the search results (Web of Knowledge [2012]).

Inspec: This database is focused on Electronics, Computer Science, Physics, Electrical, Control, Production and Mechanical Engineering. This database covers 5.000 journals. However, no access is granted to students of the University of Twente.

Social Science Research Network: As the name implies, the focus of this database is on Social Sciences. The database contains a total of 367.500 downloadable full text documents.

Scopus is a database that is frequently used within our university environment. Thereby this database also covers the field of interest, together with additional interesting fields. Therefore the search will start with the Scopus database.

Search terms

Within this research the focus is on sovereign CDS spreads. Thereby the effect of different components on the price of the CDS spread is the main focus.

Different words can mean the same thing. Components have synonyms; one could use parts, determinants, features and even ingredients. Therefore one has to think carefully about the different possibilities. Also combinations can be made between words with operators like AND, OR and NOT.

AND will restrict the number of articles found, OR will enlarge the number of articles and NOT will search for articles that exclude a certain aspect. Also an "*" is used in order to collect related search words. For example, when one is searching for terms related to validation, one could use validate, validation, validating, etc. By using validat* all these terms are searched for at once.

Relevant search terms are based on the goal of this research and the specific research question. The search terms are collected in Table 12.13.

Search Terms	Results	Search Terms	Results
CDS spread	256	Credit swap spread	210
AND components	35	AND components	36
AND parts	27	AND parts	8
AND determinants	75	AND determinants	92
AND features	15	AND features	10
AND ingredients	1	AND ingredients	0
AND building blocks	2	AND building blocks	0
Credit Default Swap Spread	190	Credit default swap	413
AND components	31	AND components	43
AND parts	8	AND parts	21
AND determinants	84	AND determinants	122
AND features	9	AND features	19
AND ingredients	0	AND ingredients	0
AND building blocks	0	AND Building Blocks	1
Credit Spread Puzzle	14		

Table 12.13 Result search terms Scopus

The combinations in Table 12.11 will be used. Besides the search terms also backward and forward search is used. Backward search is done by searching the used literature of already found articles. Forward search is done by looking for articles that cite the already found article. The search terms in Table 9.1 are the initial search terms based on the current knowledge of the field. During the literature search new terms can be added.

The search terms are chosen in such a way that the whole field of interest is covered. The search term 'credit spread' is not included as this is not the same as credit default swap spread and would lead to results outside the scope of this research. Analysing these search results will cost a lot of time and effort and therefore the decision is made to use the search terms denoted in Table 12.13.

Selection Criteria

Different inclusion and exclusion criteria are needed in order to come to a selection of articles that is comprehensive and not too large to analyse.

- Dutch or English text
- Full text available
- Relevance based on title and journal
 - For some articles the title and type of journal already indicate that the subject of the paper is irrelevant. Some search results focus on the compact disc or CDs. This looks like CDS but is a whole different subject.
- Not older than 1997, this was the year in which JP Morgan invented the CDS market.

- When an article is selected based on the above criteria the abstract is studied. If the article seems irrelevant based on the abstract it is rejected.

The selection process can be described as follows. All the selection criteria are used. First of all the search term CDS spread is used together with the different combinations. Then in chronological sequence the following search terms with the different combinations are used: credit default swap spread, credit spread puzzle, credit swap spread and credit default swap. From the 667 results all the double results are removed. The next step is to eliminate results that are too old followed by eliminating irrelevant articles based on journal and title. Then articles without a full text or written in another language than Dutch or English are excluded. Lastly the abstracts of the remaining articles are read and the irrelevant articles are eliminated resulting in a total of 63 remaining articles. This process is illustrated in Figure 12.12. Based on this selection process it can be stated that the credit spread puzzle is not focussing on the components included in the credit default swap spread. It is a broader concept that tries to describe the difference in the bond spread of an entity and the CDS spread of the same entity. Thereby the CDS spread is often taken as a fixed indicator of the expected loss and therefore the articles found using the credit spread puzzle search term all seemed to be irrelevant. The articles found divided per search term are presented in Table 12.14.



Figure 12.12 Search process covering different selection criteria

	Initial	Unique	Too Old	Not	Full	Not	Abstract	End
	results	Chronological		Financial	text	Dutch/		result
						English		
CDS spread								
AND components	35	35	0	8	1	0	13	13
AND parts	27	25	1	16	0	0	7	1
AND determinants	75	45	0	0	4	1	18	22
AND features	15	7	0	4	0	0	3	0
AND ingredients	1	1	0	1	0	0	0	0
AND building blocks	2	2	0	2	0	0	0	0
Credit Default Swap								
Spread								
AND components	31	13	0	0	1	0	8	4
AND parts	8	3	0	0	0	0	3	0
AND determinants	84	16	0	0	0	0	12	4
AND features	9	4	0	0	0	0	4	0
AND ingredients	0	0	0	0	0	0	0	0
AND building blocks	0	0	0	0	0	0	0	0
Credit Spread Puzzle	14	14	0	0	0	0	14	0
Credit swap spread								
AND components	36	9	0	0	2	0	4	3
AND parts	8	1	0	0	0	0	0	1
AND determinants	92	11	0	0	1	1	7	2
AND features	10	0	0	0	0	0	0	0
AND building blocks	0	0	0	0	0	0	0	0
AND ingredients	0	0	0	0	0	0	0	0
Credit default swap								
AND components	48	12	0	0	0	0	9	3
AND parts	23	13	1	0	2	0	10	0
AND determinants	129	31	0	0	2	1	19	9
AND features	19	6	0	0	0	0	5	1
AND ingredients	0	0	0	0	0	0	0	0
AND building blocks	1	1	0	0	0	0	1	0
Total	667	249	2	31	13	3	137	63

Table 12.14 Search terms used in literature review

Based on these articles the components are described. No prioritisation is used as the goal is to indicate and describe the different components. The different articles are scanned and the findings based on the different components are used. The search terms include the terms 'determinants' and 'components'. All aimed at finding as much information as possible. The goal is to find the different components that could be the cause for a mismatch between credit figures extracted from different sources.