# An introduction to credit risks, with a link to insurance


## Authors

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## Abstract

A systematic credit risk exposure has subtle but serious implications for the management of assets and liabilities within insurance companies and pension funds. In accordance with the increasing share of corporate debt in European debt markets, a revolution has taken place in the management and measurement of credit risks in the recent years. Reasons for this increasing interest are increasing number of bankruptcies, competition between financial institutions, growth of off-balance derivatives, technology and regulation requirements. To measure the credit risk of an individual bond or a portfolio containing multiple bonds, some credit risk models are introduced. Also, as a result of the changes in European debt markets, adjustments have been made in the accounting rules concerning credit risky assets.

This paper will provide an introduction to the theory of credit risks. It will empirically explain the excess return on corporate bonds. In addition, the models that are widely and successfully applied by banks are discussed and evaluated. Furthermore, a link to insurers and more specifically a link to reserving and solvency is presented.



## Keywords

Credit Risk, Risk measurement, Asset and Liability Management, Credit Risk Models


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# 1 Introduction

In the past decades, Euro debt capital markets were primarily dominated by government debt (Allen and Gale (2000)). The European corporate financial system has always been bank-oriented instead of capital-market-oriented in the sense that corporate finance typically relies on close-banking relationships instead of on corporate debt issues in capital markets. Only recently, corporate debt issues have become more and more numerous.

The relatively under-developed role of corporate debt in European capital markets has mainly been attributed to two factors: the allowance of universal banking and the small size of national financial markets. However, while phenomena like technology, financial innovation and privatisation have already contributed to more developed and more liquid capital markets, the small size of the European capital markets has definitely disappeared with the arrival of the Euro.

In this perspective the introduction of the European Monetary Union (henceforth: EMU) has been of major importance: it has increased liquidity and transparency, and has decreased transaction costs in Euro debt capital markets. Increased liquidity and transparency and lower transaction costs make capital markets more efficient and more complete, which is likely to accelerate the development of corporate debt financial markets and strengthen cross-border competition in the financial sector (ECB (1999)). Indeed, the transition from several national financial systems to one Euro financial system has already increased –and is expected to further increase– market-dominance at the cost of bank-dominance as we will see below.

The developments described above have increased the importance of credit risk (modelling) in three ways:

1. Since the introduction of the EMU has eliminated the risk of exchange between Euro countries, the emphasis in valuations and risk management, both from management's as from shareholders' perspective, has moved to considerations on credit risk.
2. The share of credit risky assets in the Euro debt capital market has increased considerably. In addition to the arguments and developments described above, this is due to the fact that Euro government debt has been –and will be further– reduced as a consequence of the Stability and Growth Pact (OECD (1999)). Hence, governments will lose market share as bond issuer to corporate market players, which were already more likely to issue in this new large and liquid capital market. This has led to a relative halving of the input of government issuance against a nearly tripled total amount of debt issued over the last four years (Figure 1-1).

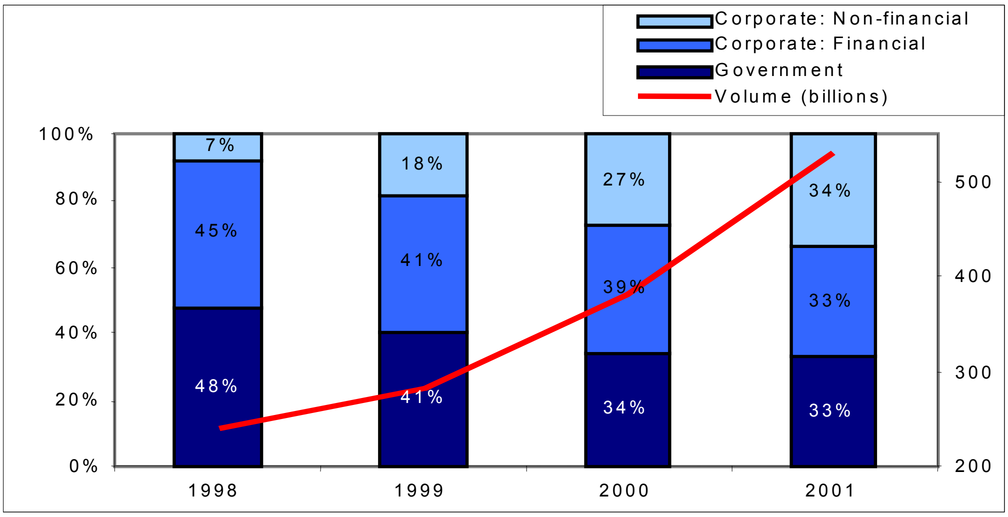


*Figure 1-1:Composition of the Euro debt capital market I. Eurobonds to issuer 1998 – 2001(in billions of Euro).*

*(Source: ECB / Lehman Euro Corporate Index)*

3. In the third place, not only the scale but also the scope of credit risky debt has increased. Banks as traditional potential debt issuers face competition from non-bank financial intermediaries such as institutional investors and mutual funds (ECB (1999) and ECB (2000))9 and from privatised, formerly state-owned non-financial companies.10 Overall this has led to an increase in market activity, and to a diverse Euro debt capital market providing a wide range of credit classes, finance sources and geographical distribution. The differentiation over credit classes is reflected in the growing of non-investment grade issuance (Figure 1-2) and has resulted in a higher average credit risk in the Euro debt capital market (Galati and Tsatsaronis (2001)).

[9] As a consequence of the deregulation of pension systems (from pay-as-you-go to funding and from defined benefits to defined contribution), regulatory restrictions on institutional investments are eased. Hence, investments will be diversified over different areas and credit classes throughout Europe.

[10] Examples of the last decade can be found in telecommunication, utilities, insurance, transport and postal services (D'Souza and Megginson (1999) and OECD (2000)).

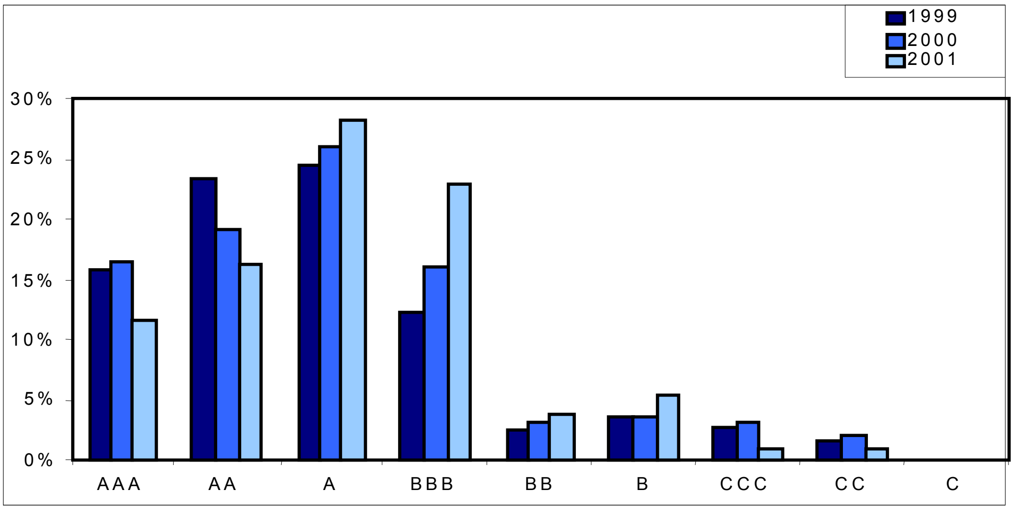


*Figure 1-2: Composition of the Euro debt capital market II. Eurobonds to credit class (S&P) 1999 – 2001.*

*(Source: Reuters)*

Obviously, the developments described above and in particular the average increase of credit risk in Euro debt capital markets have major consequences for investment policies and hence for the management of assets and liabilities within insurance companies (Friedel (2002)). This paper aims to provide an introduction to credit risk and related issues for the insurance industry.

## 2 Theory on yield spreads on corporate bonds

This section provides a theoretical description of the determinants of yield spreads on corporate bonds based on existing literature. We generally define the yield spread or excess return on a corporate bond as the difference between the yield-to-maturity on the bond and the yield-to-maturity on a risk-free benchmark. Typically the risk-free benchmark is a government bond or a swap rate with corresponding time to maturity or duration.

Already Fisher (1959) studied the determinants of yield spreads on corporate bonds and argued that firm statistics like earnings variability, period of solvency, leverage and amount of debt outstanding play an important role in public bond pricing. Merton (1974) divided the total return on corporate bonds into three components: a required rate of return on risk-less debt, an excess return due to bond provisions contained in the contract and an excess return due to default risk. He especially focuses on the last component and uses option theory to price it. In particular, Merton points out that corporate bonds can be interpreted as contingent claims on a firm's assets. The price of the bond can then be expressed as a relative simple function of firm asset volatility, leverage and the risk-free market rate.

Fama and French (1993) identify common risk factors that affect both the returns on bonds as on stocks. They argue in favour of a five-factor model to explain asset returns. In particular, they employ three stock market factors viz. firm size, book-to-market ratio and an overall stock market factor. Furthermore, they employ two bond market factors viz. a term premium reflecting the debt maturity and a default premium reflecting the probability of default.

In a recent paper, Elton et al. (2001) distinguish between three factors to account for the yield spreads on corporate bonds:

1. Expected default: a firm-specific and non-systematic risk factor.
2. Tax premium: in some countries interest payments on corporate bonds are taxed differently than interest payments on government bonds.
3. Risk premium: in addition to non-systematic default risk, corporate bonds may be subject to general market risk factors.

Using empirical analysis, they quantify the relative impact of the three factors on the size of the spread. They find that the expected default accounts only for a small fraction of the spread. While taxes explain a substantial portion, the remaining, and largest, part is explained by the systematic risk factors of the market. Two arguments are provided why corporate bonds may be subject to systematic risk: firstly, it seems reasonable to assume default probabilities to be correlated with equity prices. Secondly, the general compensation for risk-bearing in capital markets changes over time and is expected to move in one and the same direction across different financial markets.

Blume et al. (1991) examined risk-returns relations for low-grade bonds. They find that non-investment grade bonds realise higher returns than investment-grade bonds but lower returns than common stocks. Furthermore, they find that cyclical factors, in particular interest rates, largely explain the observed yield spreads.

Some recent research focuses on the particular effect of interest rate movements on yield spreads. Duffee (1998), for example, shows that the yield spread on investment-grade corporate bonds decreases when (the term premium of) interest rates rise. The size of the change in the yield spread depends on the maturity and the credit-quality of the bond. The effect is even larger for callable bonds.

Longstaff and Schwartz (1995) confirm that changes in interest rates account for the majority of the variation in yield spreads. They argue that this holds in particular true for investment-grade bonds for which changes in default rates are relatively small. Furthermore, they find a negative relation between maturity and yield spreads. This means that low-rated firms typically issue short-term debt, while high-rated firms issue longer-term debt. Furthermore, they argue that high-rated firms typically face upward-sloping yield curves and low-rated firms face downward-sloping yield curves (or at least hump-shaped; see e.g. Sarig and Warga (1989) and Jarrow et al. (1997)[11]). The underlying reasoning here may be that for low-rated firms a longer maturity will provide a longer time and a higher probability to recover. However, the empirical research of Helwege and Turner (1999) shows also upward-sloping yield curves for bonds with different maturities issued by the same non-investment grade firm.

[11] As a critical assumption, the authors assume independence between changes in yield spreads and interest rates, which is typically not true.

# 3 The influence of interest rate movements on Eurobond yield spreads

This section provides an empirical analysis of the effect of interest rate movements on the yield spreads of Eurobonds. In particular, we will analyse the effect of changes in the level and the term structure of the Euro swap rate on the size of Eurobond yield spreads. As described in the previous section it is well known that yield spreads on bonds are sensible to shifts in interest rates.

Figure 3-1 provides an explicit illustration hereof, decomposing the yield-to-maturity of a corporate bond in its components.[12]

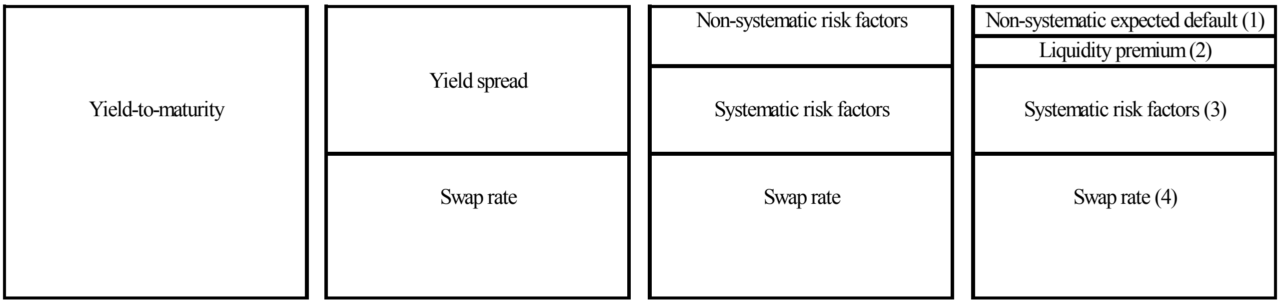


*Figure 3-1: Decomposition of the yield-to-maturity*

Note that we employ the swap rate as the (approximately) risk-free benchmark. Obviously, changes in the swap rate curvature are systematic in nature since they are directly related to market developments. Indeed, swap rate movements constitute an important part of the systematic risk factors (component 3). Hence, changes in the swap rate will not only lead to changes in component 4, but will also affect the yield spread and in particular component 3. Note that the yield spread also contains a liquidity premium and a non-systematic expected default premium, reflecting the individual default risk. This last risk factor is uncorrelated with general market factors and forms an important diversifying element in portfolio management.

## 3.1 Data

Our database contains data on all plain vanilla Eurobonds that were issued on the public capital market between January 1999 (the introduction of the Euro) and January 2002.[13] The basic bond characteristics, in particular coupon payments, issue date, time to maturity and rating class were collected from Reuters 3000 Fixed Income. The ratings were downloaded on January 2002 and are assumed to be constant during the sample period.[14] By making use of the International Security Identification Number (ISIN) codes, we were able to download the other necessary bond

[12] In contrast to Elton *et al.* (2001) we do not distinguish a separate tax premium since we argue that the effect of taxes is negligible in Eurobond markets.
[13] We do not consider Eurobonds with any callable, put-able, extendible, refundable, sinkable, convertible, index-linked, floating rate-linked, multiple-coupon or dual currency-coupon features.
[14] In fact, few credit class migrations have taken place within the sample period.

characteristics from Bloomberg, in particular daily closing bid prices, issue sizes and industry classes. The total number of Eurobonds in the sample period equals 2702. From those Eurobonds, 1628 were not priced because of direct private placement at institutional investors. Another 20 bonds were deleted from the sample because of lacking data. The remaining 1054 constitute the sample used for the empirical analysis.

As an –approximately risk-free– benchmark we use the Euro swap term structure, which reflects the common funding costs of the financial market. Data were extracted from Bloomberg. The main advantage of the Euro swap-curve over a constructed government curve is its direct availability from the interest markets. Although the Euro swap may not be completely free of credit risk, it does incorporate all current market conditions.

To calculate daily bond yield spreads we subtract the Euro swap-rate with corresponding duration from the bid yield-to-maturity of the Eurobonds.[15] In this way we capture the effect of a (different) coupon payment structure in comparison with the benchmark. To construct weekly bond yield spreads for each rating class $i \in \{AAA, AA, A, BBB, < BBB\}$ we determine the average weekly yield spread for all quoted bonds in the rating class and denote it by $s_{t,i}$. Furthermore, we denote weekly differences in the average weekly yield spread by $\Delta s_{t,i}$. Table 3-1 provides descriptive statistics on the yield spreads.

| Rating class | Observa tions | mean# / wk | Average spread | St. dev. spread | Minimum spread | Maximum spread | AverageD-spread | St.Dev. Dspread | Mean Maturity | Mean issue size (M) |
|---|---|---|---|---|---|---|---|---|---|---|
| AAA | 139 | 78 | -0.02 | 4.59 | -9.50 | 11.02 | 0.05 | 1.67 | 7.23 | 845 |
| AA | 136 | 108 | 19.33 | 6.36 | 5.96 | 37.27 | 0.07 | 1.97 | 7.32 | 620 |
| A | 265 | 139 | 51.33 | 13.73 | 20.36 | 87.81 | 0.33 | 2.71 | 7.26 | 656 |
| BBB | 169 | 66 | 80.70 | 38.38 | 18.76 | 171.73 | 0.68 | 4.78 | 5.66 | 748 |
| <BBB | 85 | 37 | 512.76 | 266.90 | 19.54 | 1470.88 | 3.87 | 60.70 | 5.70 | 352 |

*Table 3-1: Descriptive statistics Eurobonds per rating class*

The sample range of the data is January 1999-December 2001. Observations are defined as the maximum number of quoted bonds in a week.[16] Mean #/ wk is the average number of quoted bonds per week. Average spread resp. St.dev. spread is the average resp. the standard deviation of the weekly bid yield spread in basis points. Minimum spread resp. Maximum spread is the minimum observed resp. the maximum observed weekly bid yield spread in basis points within the particular rating class. AverageDspread and St.dev. Dspread is the average resp. the standard deviation of the contemporaneous changes in the average weekly bid yield spread in basis points. Mean maturity is the average maturity at issue. Mean issue size is the average size of a bond issue in millions of euro.

[15] Intermediate swap-rates are constructed from the available month-rates (money market) and year-rates (capital market) by linear interpolation.

[16] Remark that there has not been a week in which all 1054 Eurobonds were quoted.

In correspondence with the literature described in the previous section, low-rated bonds are characterised by a relatively high average yield spread and standard deviation. Furthermore, indeed low-rated firms issue debt with relatively short maturity. For an illustration of the movements of weekly yield spreads and the weekly swap rates through time we refer to Figure 3-2 and Figure 3-3.

To capture changes in the swap rate term structure, we distinguish between changes in the level and in changes in the slope of the term structure. More specifically, we introduce a variable $\Delta r_t^{6m}$ denoting the contemporaneous weekly changes in the six-month swap rate. Furthermore, we introduce a variable $\Delta d_t^{6m,10y} = \Delta(r_t^{10y} - r_t^{6m})$ denoting the contemporaneous weekly change in the slope of the swap rate term structure as measured by the difference between the short-term six-month swap rate and the long-term ten-year swap rate. Obviously, this decomposition of the term structure is arbitrary because the level of the term structure could be measured at any point of the term structure. Furthermore, the slope of the term structure could be measured between any short-term and long-term yield.

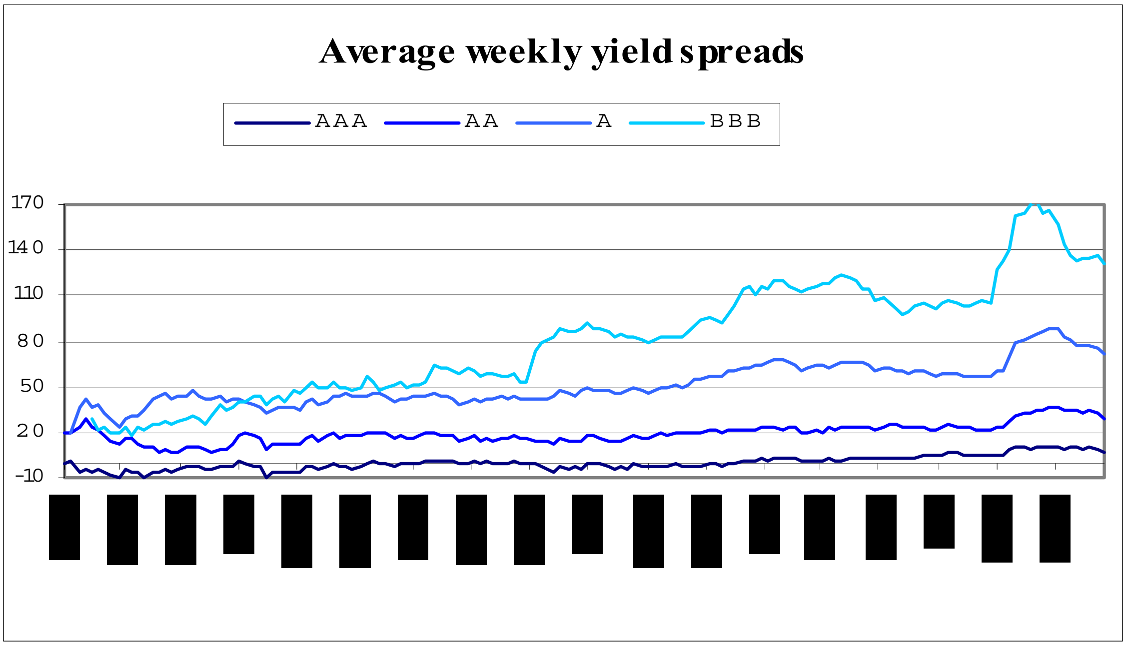


*Figure 3-2: Average weekly credit spreads*

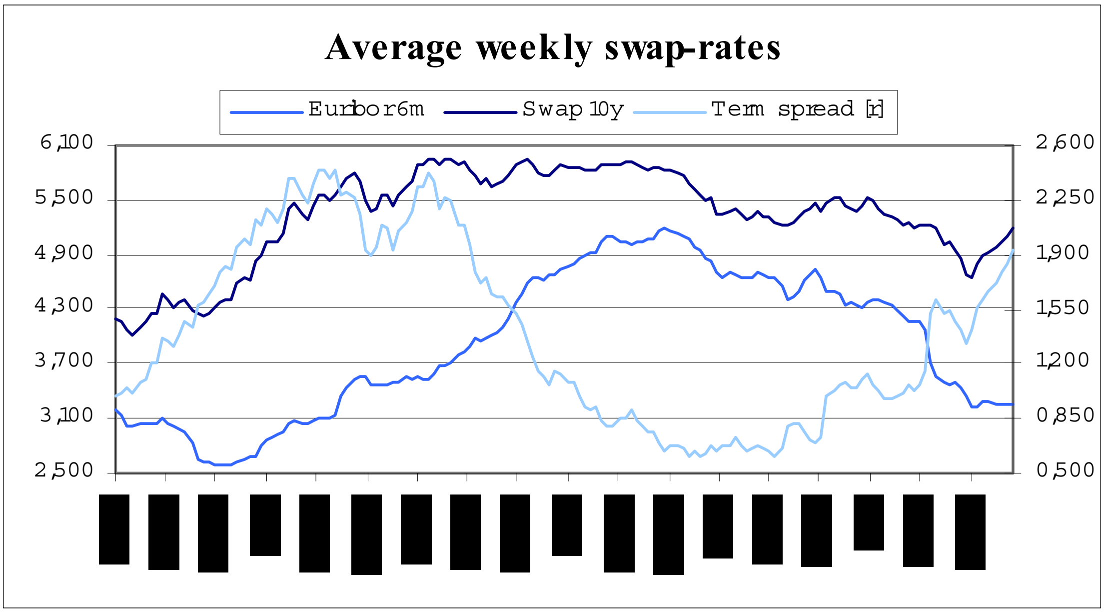


*Figure 3-3: Average weekly swap spreads*

### 3.2 Empirical results

Ordinary Least Squares estimates of the equation below describes the relation between the yield spreads and the swap-rate curve for the various rating classes are reported in Table 3-2.

$$\Delta s_{t,i} = \beta_{0i} + \beta_{1i}\Delta r_t^{6m} + \beta_{2i}\Delta d_t^{6m,10y} + \varepsilon_{t,i}$$

| | $\beta_1$ | St.dev. | Prob. | $\beta_2$ | St.dev. | Prob. | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|
| AAA | -0.0207 | 0.0051 | 0.0001 | 0.0068 | 0.0051 | 0.4569 | 0.2074 |
| AA | -0.0805 | 0.0318 | 0.0123 | -0.0614 | 0.0248 | 0.0143 | 0.0813 |
| A | -0.1889 | 0.0513 | 0.0003 | -0.0990 | 0.0354 | 0.0059 | 0.1620 |
| BBB | -0.1344 | 0.0605 | 0.0279 | -0.0782 | 0.0525 | 0.1386 | 0.0617 |
| <BBB | -1.6197 | 0.7748 | 0.0383 | -0.6271 | 0.4785 | 0.1921 | 0.0847 |

*Table 3-2: Regression results*

Because of the relative low number of observations, we grouped the non-investment grade Eurobonds.

The columns $\beta_1$ and $\beta_2$ report the estimated value of the coefficients for the level-factor and the slope-factor. The second and third columns report the standard deviation respectively the probability that the hypothesis saying that the coefficient is equal to zero holds true. The parameter estimates indicate that changes in the swap rate level have a significant effect on the yield spreads on Eurobonds. In particular, the yield spread decreases when the level of the swap rate curve increases. As reflected in the size of the estimated coefficients, low-rated firms are more sensitive to such changes in the swap rate level than high-rated firms.

A decrease of 10 basis points in the 6-month swap rate implies a rise of respectively 0.2, 0.8, 1.9, 1.3 and 16.2 basis points for the given rating classes. A similar interpretation holds for a change in the slope of the swap rate term structure. Furthermore, the parameter estimates indicate that a rise in the slope of the swap rate term structure causes a decrease in the yield spread. However, the effect is not significant across all rating classes.

### 3.3 Conclusions and Implications from Asset and Liability Management Perspective

We found that swap rate movements significantly influence the yield spreads on Eurobonds. In particular, a negative relation between the yield spread and both the level and the slope of the swap rate curve exists. The size of the effect of swap rate movements on yield spreads is larger for low-rated firms than for high-rated firms.

Obviously, this effect has serious implications for investment policies and hence for the management of assets and liabilities within insurance companies. We have seen above that the share of risk-free government debt in Euro debt capital markets has decreased while the scale and the scope of credit risky debt has increased. This has led to an average increase in credit risk in Euro debt capital markets. Consequently institutional investors will be forced to bear credit risk on their bond investments.

Naturally, diversification opportunities may be exploited to have the credit risk exposure partly disappear. However, an important systematic risk will still remain. From an asset and liability management perspective, the presence of a remaining systematic risk will not necessarily be unattractive as long as its sensitivity to the underlying systematic risk factors is in line with the sensitivity of the liabilities to systematic risk factors.

In this section we analysed the influence of a particular systematic risk factor viz. swap rate movements on the yield spread on corporate bonds. The empirically found negative relation implies that the effect of a rise in the swap rate level on the price of a corporate bond is twofold[17]: firstly, the present value of the coupon payments will decrease as an immediate result of the rise in the swap rate level. Secondly, the present value of the coupon payments will increase as a result of the decrease in the yield spread. Consequently, the total effect of a rise in the swap rate level on the price of corporate bonds is ambiguous. Based on to the empirical results reported in table 5, the price of investment grade bonds is expected to decrease while the price of non-investment grade bonds is expected to increase.

We remark that for risk-free government debt the price effect of a rise in the swap rate level is unambiguous. Furthermore, we remark that the present value of insurance liabilities is typically expected to decrease in case of a rise in the swap rate level. Hence, risk assessment of the debt portfolio has become more indispensable than ever to guarantee a proper matching policy between debt and insurance liabilities.

[17] A similar reasoning holds for the effect of a rise in the slope of the swap rate term structure.

# 4 Credit risk models

In this part, the following models will be described: CreditMetrics from J.P. Morgan, CreditRisk+ from Credit Suisse First Boston and the KMV model[18]. In 4.4, we recap these models and try to identify possible differences between credit risk for banks and insurance companies.

All three models determine an expected loss (EL), which represents the cost of doing business and an unexpected loss (UL), representing the expected deviation around the EL. To determine these quantities, assumptions need to be made with respect to, for example, the transition probability of going from one rating category to another, the residual value of the bond at default, etc.

The principles behind the three models are reasonably comparable. The differences mainly lie in exactly how the input with respect to the different model parameters is derived and the credit event taken into account. (A credit event can be actual default but also simply an overdue interest payment. Here we will refer to credit events as actual defaults and transitions into another rating categories)

In all models the EL is basically build up from the following components:

1. The chance of counter party default over the chosen horizon (= Expected Default Frequency or EDF)
2. The size of the amount outstanding at the moment the credit event takes place (= Loss In the Event of Default or LIED), and
3. The estimate of the size of the loss, taking into account the seniority of the loan and possible collateral (= Potential Credit Exposure or PCE).

Hence, the EL per bond is equal to $EL = \overline{PCE} \times \overline{EDF} \times \overline{LIED}$, and the EL of a portfolio containing n bonds is given by

$$EL_p = \sum_{i=1}^{n} EL_i$$

The EDF is –in principle– treated as exogenously given in CreditMetrics and CreditRisk+. This information needs to be available as input and can be obtained from several sources (e.g. from

[18] This paper will focus on the treatment of individual investments. For more details on the use of these models to determine credit risk for portfolios, the reader is referred to the original documents describing the different models or the more comprehensive description of these models also made by the working group.

rating agencies). The KMV model derives the EDF itself from the input with respect to the share price development, i.e. an implied EDF is calculated.

Something similar is the case with respect to the dependencies between different assets of the investment portfolio as reflected in the correlation matrices. The KMV model derives these itself from the stock price information, while the other two models require the matrices as external input. In the latter case, historic observations are used to estimate the expected correlation.

With respect to the credit event taken into account, it is worth mentioning that the CreditRisk+ model is a default-mode model. In general, credit risk can be split into:

1. Risk related to credit spread changes, impacting the market value of the bonds (see section 2),
2. Risk resulting from the possibility of going into default and not receiving the full amount outstanding.

CreditRisk+ only captures the second part of the risk, assuming the first part is captured in Value-at-Risk models. It is therefore of particular use for hold-to-maturity assets and called a default-mode model.

CreditMetrics is essentially a marked-to-market model that quantifies both above-mentioned risks over a pre-chosen horizon. Clearly, if that horizon would equal the length of the asset with the highest maturity, a default-mode model would result. However, in general the chosen horizon is considerably shorter. The KMV can be both a marked-to-market and default-mode model as well depending on the chosen horizon.

### 4.1 CreditMetrics

CreditMetrics is a trademark of J.P. Morgan. This description of the model is mainly based on "CreditMetrics$^{TM}$ – Technical Document" (G.M. Gupton, C.C. Finger and M. Bhatia (1997)). For further details with respect to CreditMetrics the reader is referred to the original document.

CreditMetrics estimates the value of an individual bond or portfolio of bonds at the end of a pre-chosen horizon by combining transition probabilities with forward bond values. Comparison of the thus obtained amount to the current market value of the bond or the portfolio, yields the expected loss. CreditMetrics is a marked-to-market model as it takes into account changes in market values. The model is only considered for a single bond assuming a horizon of 1- year.

This model is very much 'rating driven': generally, a transition matrix for a single bond can be derived using data that can be obtained through rating agencies. A typical data set will show the rating history per issuer over the years. Using this information one can derive transition probabilities for the desired horizon. EDF's are then linked to the ratings of the investments that are being assessed.

We consider a bond and assume it has a BB rating. Based on historical data it is possible to estimate the probability of default, the probability of going from one rating category to another or staying in the current rating category, i.e. that no 'credit event' takes place. Table 4-1 presents the 1-year transition matrix, describing all relevant probabilities (the BB-line describes the transition probabilities of the BB bond).

| Initial Rating | Rating at year-end | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | AAA | AA | A | BBB | BB | B | CCC | Default |
| AAA | 90.81 | 8.33 | 0.68 | 0.06 | 0.12 | 0.00 | 0.00 | 0.00 |
| AA | 0.70 | 90.65 | 7.79 | 0.64 | 0.06 | 0.14 | 0.02 | 0.00 |
| A | 0.09 | 2.27 | 91.05 | 5.52 | 0.74 | 0.26 | 0.01 | 0.06 |
| BBB | 0.02 | 0.33 | 5.95 | 86.93 | 5.30 | 1.17 | 0.12 | 0.18 |
| BB | 0.03 | 0.14 | 0.67 | 7.73 | 80.53 | 8.84 | 1.00 | 1.06 |
| B | 0.00 | 0.11 | 0.24 | 0.43 | 6.48 | 83.46 | 4.07 | 5.20 |
| CCC | 0.22 | 0.00 | 0.22 | 1.30 | 2.38 | 11.24 | 64.86 | 19.79 |

*Table 4-1: One-year transition matrix*

*(Source: "CreditMetrics – Technical Document", chap 1, page 20)*

In order to determine the expected value of the BB-bond one-year from now, the individual bond forward values need to be estimated, one for each of the 8 possible outcomes. In case of default, the bond value will equal the outstanding amount (LIED) multiplied by the recovery rate (= 1 - PCE). The value in each of the 7 non-default categories is determined using 7 different 1-year forward interest rate curves, one for each category.

The 1-year forward value of a bond equals the present value (PV) of the cash flows after year 1, discounted at the 1-year forward rates (i.e. it equals the 'market estimate' of the value of the bond one year from now, given that it be in a certain rating category). For each rating category a different forward curve is derived. The weighted average of the 8 outcomes equals the expected value (EV) of the bond at the end of the horizon:

$$EV = \sum_{i=1}^{8} p_i * PV_i$$

Thus the EL can be determined as EL = current value -/- expected value and the variance ($UL^2$) calculated as:

$$UL^2 = \sum_{i=1}^{8} p_i * PV_i^2 - EV^2$$

The determination of the credit risk of a portfolio is more complicated since rating transitions will not be independent. Companies that operate within the same industry in the same region will be susceptible to the same economic factors and therefore show a certain correlation. For instance, all coffee companies will be sensitive to changes in coffee prices and are exposed to the same economic cycles. As the correlation between individual bonds will be below 1, the standard deviation of a portfolio will be lower than that of the sum of the individual standard deviations.

Using historical data, one could directly derive 'joint probability transition matrices' that reflect the correlation between the creditworthiness of different counterparties. Even for small portfolios this will be an almost impossible task.

Alternatively, one can set assumptions with respect to the correlations between assets or asset classes and then calculate 'joint probabilities' based on the correlation assumptions and the individual transition probabilities. Clearly, these assumptions with respect to the correlations (correlation matrix) would be based on historic material as well.

The rating at the end of the year of an individual bond would first be 'linked' or 'mapped' to the outcome of a drawing from a normal distribution. Taking these individual normal distributions together with the correlation matrix would produce a joint distribution from which random drawings can be taken. These drawings are then 'translated' into scenarios that link each current bond rating to an expected rating at the end of the year. Final step would be to determine the relevant forward values as described above and add them all up.

### 4.2 KMV model

The KMV model was founded in 1989 by Kealhofer, McQuown and Vasicek and was developed for credit risk measurement.

The principle of the KMV model is that the probability of default of a specific company can be calculated based on market information, information from financial statements and (subjective) perceptions of outlooks and risks of the particular company. Next to company dependent information, a database with historical defaults is used.

To calculate a single firm's probability of default, the Expected Loss and Unexpected Loss, the KMV model takes a three steps approach:

1. Estimate the asset's volatility
2. Calculate the "distance to default"
3. Calculate probability of default

*Ad 1.* In 1973 Black & Scholes already explained that a company's equity can be regarded as a call option on the firm's assets (See Figure 4-1).

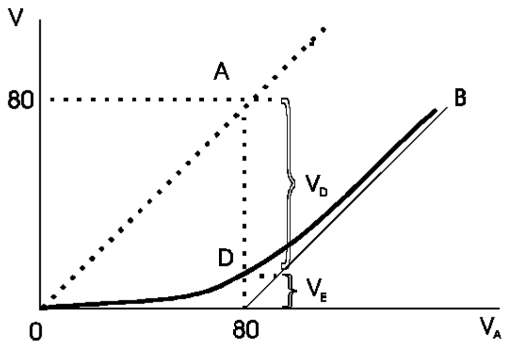


*Figure 4-1: Equity as option on asset value*

*(Source: KMV – Modelling Default Risk)*

Based on this concept the underlying formula is used to define the value of the equity. A similar formula is used for the volatility of equity ($EQ_{volatility}$)

$$EQ_{value} = OptionFormula\begin{pmatrix} Asset\ Value, \\ Asset\ Vol, \\ Capital\ Structure, \\ Interest\ Rate \end{pmatrix}$$

Since the value of equity, interest rates and equity volatility is calculated and the company's capital structure is known, the asset value and the asset volatility can be calculated by solving the two formulas simultaneously.

*Ad 2.* A company's point of default is where the value of the assets is approximately the book value of short-term liabilities. Net Worth of the company is the difference between the Asset Values and its default point, so when the Net Worth drops below zero, the company goes into default.

It is important to recognize that two companies with the same Net Worth do not have similar default probabilities, since the probability is also influenced by the volatility of the asset values.

Distance-to-Default combines the company's Net Worth with its business risk, and is therefore a normalized measure for the determination of default probability

$$Distance - to - Default = \frac{Net\ Worth}{Market\ Value\ of\ \ Assets \times Asset\ Volatility}$$

The relation between Distance-to-default (DD) and probability of default (EDF) is summarized in Figure 4-2.

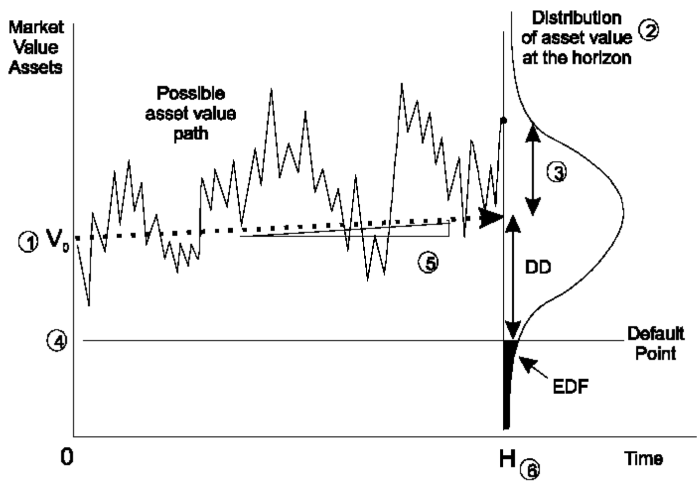


*Figure 4-2: Relation between Distance-to-Default (DD) and probability of default (EDF)*

*(Source: KMV – Modeling Default Risk)*

*Ad 3.* Now the firm's Distance-to-Default is known, the probability of default can be determined by using KMV's database, containing Distance-to-Default information of over 250,000 company'-years, including approx. 5000 defaults.

For using the KMV model in a portfolio context, the same challenge exists as for the CreditMetrics-model: determination appropriate default correlations. These default correlations cannot be measured directly, so an indirect method should be used.

In de document “Equity Correlations Are Not Enough”, KMV analyses the possibilities whether default correlations can calculated using equity correlations or whether asset correlations should be used as input for default correlations. Conclusion of this article is that default correlations will be underestimated when equity correlations are used. To overcome this problem, asset correlations should be used when estimating the default correlations.

### 4.3 CreditRisk+

The CreditRisk+ model was developed in 1997 by Credit Suisse First Boston (CSFB). In contrast to the CreditMetrics model, CreditRisk+ is based on continuous default rates and default rate volatility, to model the uncertainty of default rates. Where CreditMetrics measures the expected change in value of the portfolio (i.e. credit spread risk), CreditRisk+ (like KMV) focuses on the calculation of expected loss and unexpected loss due to default (i.e. credit default risk). Since CreditRisk+ assumes only two states of a bond (default and non-default), CreditRsk+ can be regarded as a default mode model and is therefore developed to measure credit risk of hold-to-maturity portfolios.

CreditRisk+ is a statistical model of credit default risk, that models default rates as continuous random variables incorporating the volatility to capture the uncertainty of the default rate. CreditRisk+ makes use of mathematical techniques and models that are used in the insurance industry to calculate the impact of catastrophes (similar to a default); it is therefore sometimes referred to as the actuarial model.

Credit risks are time-dependent: the longer the time horizon, the more credit risk will be borne. CreditRisk+ identifies two ways to define the time horizon: a constant time horizon, e.g. one year in which it is possible to take measures to mitigate credit risk, and a hold-to-maturity time horizon that allows the full term structure of default rates to be recognised over the lifetime of the exposure.

The CreditRisk+-model is a 2-stage process:

1. Determination of the frequency of defaults and the severity of losses
2. Combining the frequency and severity of losses into a distribution of default losses.

Creditrisk+ assumes that the frequency of defaults can be captured in a Poisson distribution, since it is neither possible to forecast the exact time of default nor the total number of defaults. In case of a default, the severity of losses is calculated as Exposure * (1- recovery rate). The recovery rates are subject to seniority of the exposure and the collateral held.

In order to generate the overall distribution of default losses in the second stage the default probability is first calculated per range of losses or Loss Given Default band (LGD band). The portfolio is grouped into bands, that –given default- would generate the same default loss (see Figure 4-3).

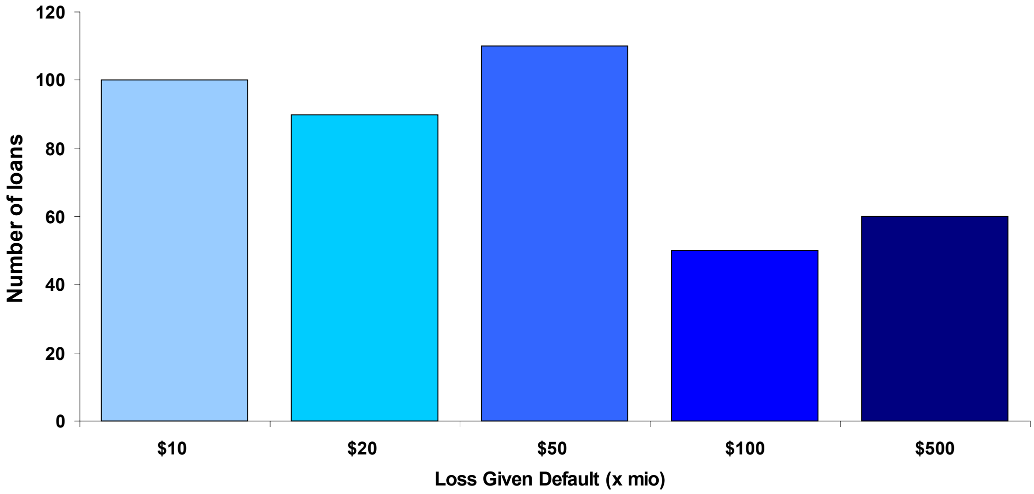


*Figure 4-3 Division of LGD-bands*

Within such a group the number of defaults will assumed to be Poisson distributed. By making use of the credit ratings of counter parties and the link with expected future default rates, an average default rate can be determined for the different LGD bands. This average rate multiplied by the number of assets generates the expected number of defaults in the portfolio and defines the distribution. An example is presented in Figure 4-4 for a LCD band of $10 mln.

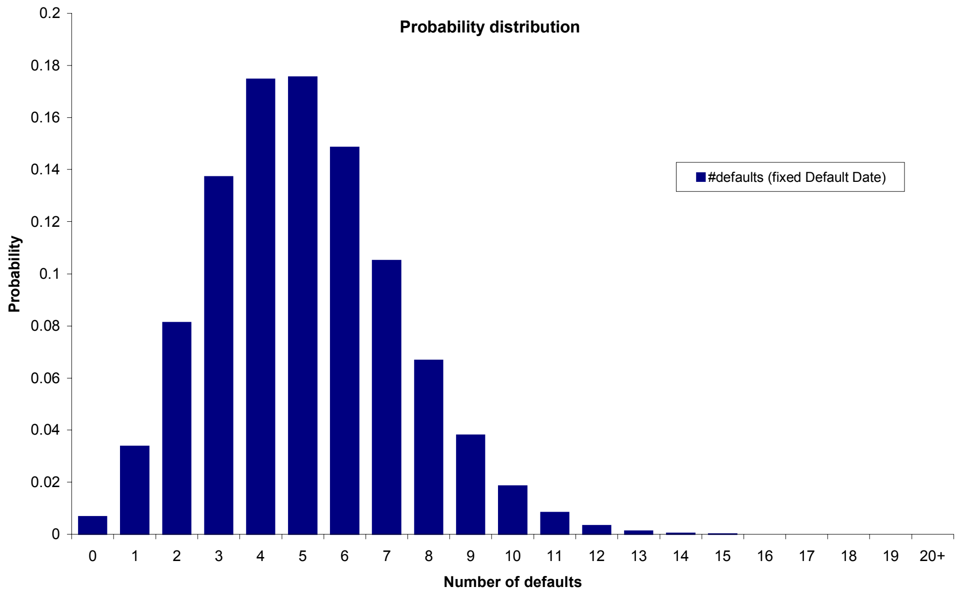


*Figure 4-4: Probability distribution of number of defaults for LDG band of $10 mln*

When the severity of losses in a LGD band is fixed (in this example at $10 mln), the probability distribution of losses (in that particular LGD band) is similar to the figure above, where the x-axis represents the possible loss. When introducing default rate uncertainty and volatility of severity in the LGD bands, the probability distribution changes compared to the one above: the tail will increase.

For an entire portfolio, the default risk can be determined by aggregating these distributions functions taking into account the possible default correlation between the LGD bands.

### 4.4 Comparative analysis

Banks have been using the three described models for quite some time now. When opting for one or the other one must take into account the specific advantages and disadvantages of each of the models and possible differences between banking and insurance.

A common disadvantage of all models is that a considerable amount of data is required as input, some of which may only be available for larger companies: ratings, stock information, etc. Several studies exist that compare the output of these models. In general, the models are able to produce comparable outcomes when fed with consistent input, although the sensitivity of the tail of the distribution to the different parameters and thus the required amount of capital is relatively large. Gordy (2002) compared CreditMetrics and CreditRisk+ by adjusting the models. Conclusions of Gordy are that models perform similarly on an average quality loan portfolio when the volatility of default rates is kept low. CreditRisk+ demands somewhat higher capital in case of low quality portfolio than CreditMetrics. Although the two models perform similar on the average loan quality, these models diverge on the calculation of Unexpected Loss. Also, the models are highly sensitive to the volatility of default probability and default correlation. Finally, especially CreditRisk+ is highly sensitive to the volatility of the default rate, which determines the kurtosis (and not the mean and standard deviation) of the distribution of loss.

The fact that outcomes seem consistent may not be very useful when all models would be consistently wrong. A lack of sufficient data makes (back) testing of the models over a period of several business cycles difficult, especially when models are already calibrated to the historic numbers that are available. This is a serious issue which also somewhat constraints the use of these models by supervisors.

| Model | Advantage | Disadvantage |
|---|---|---|
| CreditMetrics | (1) Given that the ratings are relatively stable, the outcome will be relatively stable;<br><br>(2) Relatively simple methodology<br><br>(3) Marked-to-market model and therefore useful for a market value based credit risk capital | (1) Subjectivity through use of ratings<br><br>(2) Ratings are not up-to-date: a time lag exists between credit event and rating change (which can be months).<br><br>(3) For derivatives certain ‘tricks’ are required in order to make them fit the model |

| | | |
|---|---|---|
| KMV | (1) Internal ratings are up-to-date as they are based on (on-line available) market data.<br><br>(2) Can -easily- be used for derivatives<br><br>(3) Default mode model and marked-to-market model (based on chosen horizon) and therefore useful for a market value based credit risk capital | (1) Relatively complicated and therefore a possible ‘black-box’<br><br>(2) Data problems for all non-listed companies (info with respect to stocks is required)<br><br>(3) Relatively volatile output –as model is based on continuous changing market data- whereas ‘actual’ credit risk might be more stable. |
| CreditRisk+ | (1) CreditRisk+ calculates the explicit expected loss driven by default and leaves changes in credit spreads aside<br><br>(2) A closed formula can be used for calculating expected, unexpected loss and Economic Capital | (1) Default model: can not be used for a market value based credit risk capital<br><br>(2) The model is very sensitive to volatility of default<br><br>(3) Difficult to explain |

# 5 Provisioning for credit risk in a deferral and matching world

In this section we provide an introduction to the current accounting system regarding credit risk, which is based on deferral and matching. In the next section, we briefly discuss the future accounting system, which is based on fair value. Finally, we explicitly focus on the Dutch accounting system regarding credit risk. In the following part an introduction is made for the use of the models of part II within the accounting principles. At first a description follows of accounting according to the deferral and matching system and the fair value system. This will be followed by the accounting rules in the Netherlands. In a deferral and matching world an appropriate credit risk provisioning methodology reflects the credit losses of the portfolio over several years and hence that more accurately presents the true earnings of the business by matching income with losses.

## 5.1 The need for credit provisions

Generally, current accounting and provisioning policies recognise credit income and credit losses at different times, even though the two events are related. Usually, credit loss provisions are made only when exposures have been identified as non-performing. These provisions are often supplemented with other specific and general credit provisions.

In relation to any portfolio of credit exposures, there is a statistical likelihood that credit default losses will occur, even though the obligors are currently performing and it is not possible to identify specifically which obligors will default. The level of expected loss reflects the continuing credit risk associated with the firm’s existing performing portfolio and is one of the costs of doing credit-related business or investing in high yield bonds. This level of expected loss should be taken account of when executing any business that has a credit risk impact.

When default losses are modelled, it can be observed that the most frequent loss amount will be much lower than the average, because, occasionally, extremely large losses are suffered, which have the effect of increasing the average loss. Therefore, a credit provision is required as a means of protecting against distributing excess profits earned during the below average loss years.

The starting point for provisioning is to separate the existing portfolio into a non-performing and a performing portfolio. The non-performing portfolio should be fully provisioned to the expected recovery level available through foreclosure, administration or liquidation. Once fully provisioned, the non-performing portfolio should then be separated out and passed to a specialist team for ongoing management. As for the performing portfolio, since no default has occurred, one needs a forward-looking provisioning methodology.

### 5.2 Annual Credit Provision (ACP)

The Annual Credit Provision ("ACP") represents the future expected credit loss on the performing portfolio, which is calculated as follows:

ACP = Exposure x Default Rate x (100% - Recover Rate)

The ACP should be calculated frequently in order to reflect the changing credit quality of the portfolio. The ACP is the first element of the credit provisioning methodology.

The ACP represents only the expected or average level of credit losses. As experience shows, actual losses that occur in a year may be higher or lower than this amount, depending on the economic environment, interest rates, etc. In fact, a better way of viewing the annual credit loss of the portfolio is as a distribution of possible losses (outcomes), whose average equals the ACP but has a small probability of much larger losses. In order to absorb these variations in credit losses from year to year, a second element of the provisioning methodology, the Incremental Credit Reserve ("ICR"), can be established.

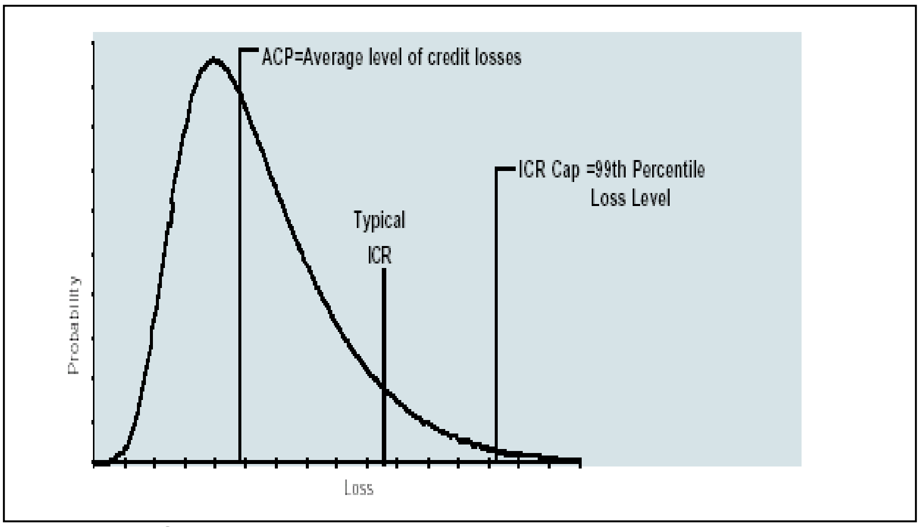


*Figure 5-1: Credit risk provisioning*

*(Source: Credit Suisse First Boston)*

The ICR provides protection against unexpected credit losses (i.e. in excess of the ACP) and is subject to a cap derived from a model (the "ICR Cap"). The ICR Cap represents an extreme case of possible credit losses (e.g. the 99th percentile loss level) on the performing portfolio.

### 5.3 Managing the credit risk provision

As credit defaults occur, loans or exposures are moved from the performing to the non-performing portfolio and hence provisioned to the expected recovery level. This increase in provision is then charged first against the ACP and then, to the extent necessary, against the ICR. To the extent that actual credit losses are less than the ACP within any given year, the balance is credited to the

ICR up to the ICR Cap, beyond which the balance is taken into P&L. This ensures that the ICR is replenished during low loss years following a large unexpected loss, but that the ICR never exceeds the ICR Cap.

| Year | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Assumptions | | | | | |
| Actual loan losses | 500 | 600 | 300 | 300 | 650 |
| ACP | 500 | 525 | 550 | 610 | 625 |
| ICR - Initial level | 1,900 | - | - | - | - |
| ICR Cap | 2,000 | 2,100 | 2,200 | 2,250 | 2,300 |
| Income Statement | | | | | |
| Operating profit | 2,100 | 2,100 | 2,205 | 2,315 | 2,430 |
| Less: ACP | (500) | (525) | (550) | (610) | (625) |
| Add: excess unutilised provision over ICR Cap | 0 | 0 | 0 | 135 | 0 |
| Pre-tax profit | 1,600 | 1,575 | 1,655 | 1,840 | 1,805 |
| ICR (pre cap) | 1,900 | 1,825 | 2,075 | 2,385 | 2,225 |
| ICR Cap (as above) | 2,000 | 2,100 | 2,200 | 2,250 | 2,300 |
| Excess unutilised provision over ICR Cap | 0 | 0 | 0 | 135 | 0 |
| ICR (with cap applied) | 1,900 | 1,825 | 2,075 | 2,250 | 2,225 |

*Table 5-1: Managing Credit Provision*

*(Source: Credit Suisse First Boston, table 7: example of credit risk provisioning*

In other words, the ACP is credited to the ICR and charged against P&L. As credit defaults occur, loans or exposures are moved from the performing to the non-performing portfolio and hence provisioned to the expected recovery level. This increase in provision is charged against the ICR. The remaining ICR may not exceed the ICR Cap. If it does, the balance is taken into P&L. To the extent that actual credit losses are more than the ICR Cap the balance is also taken into P&L.

# 6 Provisioning for credit risk in a fair value world

In a fair value world cash flows and value adjustments of assets and liabilities are recognised in P&L. The difference with deferral and matching accounting is mainly the consequent mark-to-market valuation of all parts of the balance sheet. In the long run the accounted result will not differ in the two methods. However the distribution over the years may differ significantly, as may the split up of net result in organic parts. The net result is more volatile in a fair value world and most of the profit is taken at inception in P&L. Under the new IFRS, credits are generally marked-to-market, where only in a hold-to-maturity strategy, one may use an amortised cost valuation. A separate or additional provision for credit risk is not allowed. For corporate bonds marked-to-market values are often available and besides movements in the yield curve also the changes in credibility (related to the rating of the bond/issuer) are then reflected. These changes in market value should be separately available.

The market value of the assets is at least equal to the market value of the corresponding liabilities, which is equal to the present value of the future cash flows at the risk free rate of return (replicating portfolio). The received interest coupon is accounted for in P&L, so is the credit spread. If interest yields or the credit risk (rating) have not changed over a period, the market value will not have been changed (with exception of zero-bonds). We then conclude that the credit spread is earned. This seems to be right. The investment may be sold at market value at any time.

# 7 Regulations from supervision and statutory rules

Supervisory and legislative bodies have issued regulations for (life-)insurers in terms of investments and the required solvency. Regulations with regard to investments vary from one country to the next within the EU. It can be said that regulations in the UK and in the Netherlands are more lenient than elsewhere in the EU. Minimum solvency requirements are based upon European rules and are uniform in all EU member states. Differences between member states occur in terms of additional regulations by supervisory bodies – in the Netherlands this is the Pensioen- en Verzekeringskamer (PVK) – with regard to the evaluation of the solvency of insurers.

## 7.1 Current situation in the Netherlands

***Investments***

By law, insurers in the Netherlands are in terms of their investments and the valuation thereof subject to the rules of the Dutch Civil Code 2, volume 2, section 15/Directive 605 (reporting by insurers). In addition, there are regulations that have been issued by the PVK on the basis of the Insurance Industry Supervision Act 1993 (WTV '93). The regulations mentioned in the Dutch Civil Code are referring to the valuation of the fixed income investments on the Balance Sheet, the accounts thereof in the Statement of Financial Performance and the options for making provisions in respect of the existing bad debt exposure. The regulations allow the insurers to value their fixed income assets at the purchase price, at redemption value or at market value. Changes in the values may immediately show up in the Statement of Financial Performance or spread over the term of the respective asset. The creation of a revaluation reserve is allowed in the event of valuation at market value. Unrealised results are then booked under this reserve and will not show up in the operational results. Depending on the purpose of assessing at market value, the realised results may also be added to or taken from the revaluation reserve. In all other cases the non-realised changes in values are taken from the revaluation reserve when realised, and added to the results. At this point in time, insurers are also allowed to add the deferred built-up funds in the revaluation reserve to the results. The results are then made up of realised results – direct returns – plus the funds booked from the revaluation reserve – indirect returns.

On the basis of the Insurance Industry Supervision Act 1993 the PVK has issued directives regarding investments that have been allocated to cover assumed obligations. Such directives are aimed in particular to restrict the bad debt exposure by nominating limited allowed investment categories on the one hand, and to prescribe strict limitations to the volume of the investments in each investment category and for each debtor on the other hand (Regulations investment technical provisions in the insurance industry, 1994).

### *Solvency*

In 1994 the PVK has laid down the requirements with regard to the minimum required solvency in the Solvency Margin Insurance Industry Decree by virtue of the Insurance Industry Supervision Act 1993. These requirements are based upon European rules so they apply to all EU Member States. The required solvency amounts to 4% of the available technical provisions for which insurer runs the investment risk, and 1% of the technical provisions for which the policyholder runs the investment risk. In addition, up to 0.3% of the death risk capital plus at least 16% of underwritten premiums for supplementary insurances must be kept as a solvency margin.

Besides the outlined minimum required solvency, the PVK issued actuarial principles in the Netherlands on the basis of the Insurance Industry Supervision Act 1993. These may be regarded as further details of the European directives in terms of supervising insurance companies. Purpose of the actuarial principles is to ensure that the insurer has sufficient assets to also fulfil its obligations under the most unfavourable conditions. They prescribe reductions on the returns of investment depending on the debtor category; at the same time the technical provisions are calculated on a more conservative basis. The further details of the actuarial principles differ from one EU Member State to the next.

## 7.2 Future situation: Fair Value

Starting from the 2005 financial year, all companies listed on the Netherlands stock exchange must present their Annual Reports on the basis of the International Accounting Standards (IAS), meanwhile called “International Financial Reporting Standards” (IFRS). From 2005 the rules for reporting in accordance with the IFRS will apply to all insurers, albeit with possible interim measures with regard to items on the Balance Sheet and the Statement of Financial Performance, for which no detailed rules in accordance with the IFRS are available. More in particular, these may concern the valuation of technical provisions for insurance obligations.

### *Investments*

The IFRS support the idea that all values ought to be based upon their market value (Fair Value). In this event, any changes in the values will immediately show up in the Statement of Financial Performance. An exception to this general rule is the fixed income values that should be held to the final date of the respective values (Hold-to-maturity). These values may be assessed at redemption value. As a result of the assessment at market values and the changes in the values immediately showing up in the operational performance, the company results will be much more volatile than under the current commonly used reporting practices.

Another consequence of assessing interest-bearing assets at market value (real value) is that provisions for bad debt exposure are no longer allowed. After all, such risks and any changes therein are implicitly included in the market value.

***Solvency***

At an international level, such as within the International Actuarial Association (IAA), up-to-date and improved methods for setting the required solvency margins for insurers are being considered for some time. Along the lines of reporting practices with much more emphasis on the real values of investments, the Solvency Working Group is concerned with modernising the current solvency requirements. Point of departure is recognising and naming specific risks and the necessary risk capital that comes with it. This will be an enormous change compared with the current rules.

It follows naturally from this line of argument that the PVK in the Netherlands has also announced it will give a new interpretation to the sufficiency test required under the terms of the actuarial principles. The new test will comprise three tests: the minimum test, the solvency test and the continuity test. The main difference between these tests is the moment or period of time covered. In this respect the minimum test reflects the situation on the Balance Sheet date, the solvency test covers a one-year period, whilst the continuity test refers to a longer period. These tests may be performed using either the PVK-approved in-house developed models or standard models. In line with the new reporting practices, the calculations are based upon the real values of both investments and obligations.

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