The Determinants of Credit Spreads

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1. Introduction

While many studies concentrate on theoretical models for the pricing of corporate bonds and credit risk, there has been much less empirical testing of these models. Yet, there are several reasons for investigating the determinants and behaviour of credit spreads. First, both the US and Euro corporate bond markets have grown rapidly in recent years. The Euro market, which lags its US counterpart, has become broader and more liquid, and the number and the market value of Euro corporate bonds have more than doubled over the last five years.

These developments have potentially affected financial stability. The growth of the corporate bond markets has significantly influenced the composition of portfolios held by financial institutions, industrial firms, trusts, and private investors. It is likely that the portfolios of these investors have become more (geographically) diversified. Investors can also construct portfolios that better fit their needs and expectations of return and risk, which will improve the allocation of capital. On the other hand, the increased reliance by corporates and households on financial market instruments such as corporate bonds has also increased the dependence of these investors and borrowers on financial market prices.

A second reason for studying the determinants of credit spreads is that the credit derivatives market, including structured finance products such as collateralized debt obligations (CDO) and asset-backed securities (ABS), has experienced considerable growth over the last two decades and is expected to grow strongly in the coming years. Some structured products such as collateralized bond obligations (CBO) are backed by a large pool of corporate bonds. This implies that the cash flows (coupon and principal) of the underlying bonds determine the profitability of these structured products; therefore, the creditworthiness of corporate bonds is important for the analysis of these products.

Finally, central bankers use credit spreads to assess (extract) default probabilities of firms and to assess the general functioning of financial markets (credit rationing and sectoral versus macroeconomic effects). In addition, the credit spread is often used as a business cycle indicator. Having a better understanding of credit spreads will help central bankers to extract more precise information from bond prices/spreads.

The contributions of this article are threefold. First, we present an empirical analysis of the determinants of credit spread changes on Euro corporate bonds between 1998 and 2002. This is one of the first analyses of the determinants for different types of Euro corporate bonds based on rating and maturity. In choosing the determinants, we are led by the structural credit risk models pioneered by Black and Scholes (1973) and Merton (1974). Our results show that factors suggested by the structural credit risk models, such as the level and the slope of the default-free term structure, the stock price, and the stock price volatility significantly affect credit spreads on Euro corporate bonds. An important result is that the sensitivities of credit spreads strongly depend on the rating and the maturity of the bonds. Furthermore, liquidity risk is an important determinant of credit spreads, especially those on lower rated bonds. Second, we compare the sensitivities of credit spreads on US and European corporate bonds to financial and macro-economic variables. A review of the existing literature on US and European credit spreads shows that no more than 45 p.c. of the dynamics of credit spreads can be explained. Furthermore, although the US and the European corporate bond markets differ significantly in terms of market value and number of bonds, empirical results for bond markets in both regions are very similar; i.e. the impact of financial and macro-economic news on credit spreads is similar in the US and in Europe. We find that credit spread changes depend more on bond characteristics such as rating and maturity than on country or currency of issuance.

Several possible explanations have been put forward to explain the gap between observed credit spreads and estimated spreads from existing empirical models. These explanations include liquidity risk, taxation, systematic shocks, and diversification risk (see Collin-Dufresne et al. (2001), Elton et al. (2001), Delianedis and Geske (2002), Driessen (2003), Houweling et al. (2004), D'Amato and Remolona (2003), Van Landschoot (2004), and Perraudin and Taylor (2004)). Although there is no consensus on the relative importance of each of these factors, most studies conclude that liquidity risk and systematic shocks significantly influence credit spread changes. D'Amato and Remolona (2003) are the first to suggest that the unexplained portion of the dynamics of credit spreads is actually a premium for diversification risk. According to these authors, investors would need a much larger number of bonds in order to have a well-diversified portfolio than the number of stocks necessary for diversification.

Along these lines, a third contribution of this article is a comparison of the simulated loss distributions of bond, stock, and mixed (made up of bonds and stocks) portfolios. Our simulations suggest that the distribution of bond portfolios is more skewed to the left than is the distribution of equity portfolios for the same firms. This suggests that an investor may well need more bonds than stocks in order to have a well-diversified portfolio. However, the skewness of mixed portfolios is very similar to that of stock portfolios. This calls into question the importance of skewness of the distribution of bond portfolios for large investors, such as financial institutions with large portfolios of bonds and stocks. Furthermore, this analysis does not give any indication of the importance of diversification risk as compared with other factors discussed in the literature such as liquidity risk and systematic shocks.

The remainder of this article is organized as follows. Section 2 gives an overview of the developments in the US and Euro corporate bond markets and briefly discusses some well-known measures of credit risk. In Section 3, we discuss the theoretical determinants of credit risk, i.e. the determinants that follow from structural credit risk models. Section 4 reports the results of an empirical analysis of the determinants of Euro credit spreads for bonds with different ratings and maturity (1998-2003). Section 5 reviews the empirical literature and compares results for European and US credit spreads. In Section 6, we discuss other potential factors that could influence credit spreads and present the (simulated) loss distributions of hypothetical portfolios of stocks and bonds. Section 7 concludes.

2. Corporate Bond Market

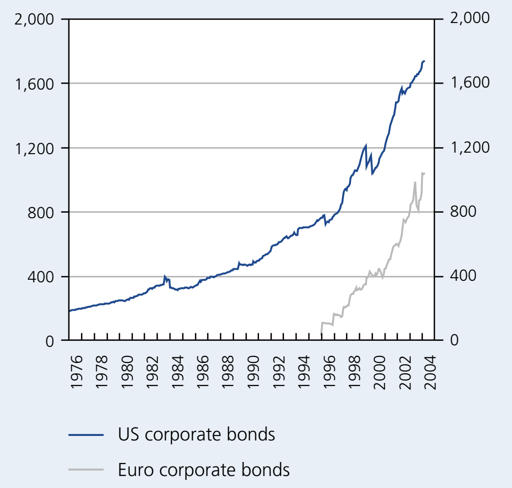
2.1 Market Developments

Before discussing some measures of credit risk and the determinants of credit risk, we briefly describe developments in the Euro and US corporate bond markets over the last three decades.[1] These developments explain why the US corporate bond market has been studied much more than the Euro corporate bond market (see Section 4.2).

Chart 1 presents the outstanding amounts of US and Euro investment grade corporate bonds.[2] While the US investment grade corporate bond market had an average outstanding amount of 200 billion dollars in the 1970s, the Euro corporate bond market did not exist. Over the

CHART 1 OUTSTANDING AMOUNT OF INVESTMENT GRADE US AND EURO CORPORATE BONDS

(Billions of US dollars)



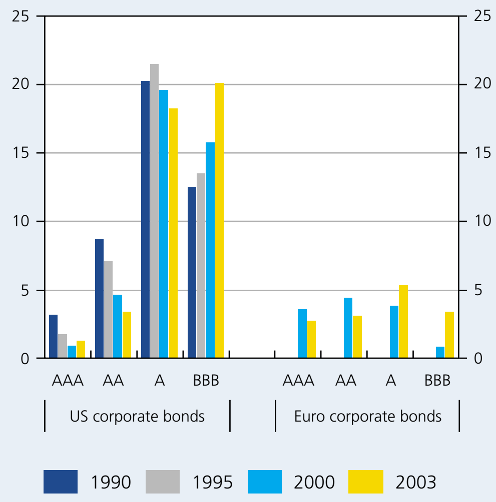
Source: Bloomberg (Merrill Lynch).

(1) In what follows, the Euro corporate bond market is defined as Euro-denominated bonds issued by EMU countries.

(2) Chart 1 presents the outstanding amount of the Merrill Lynch US and Euro corporate bond index. See Section 4.2 for a more detailed discussion of the data. Although the US and Euro high yield corporate bond markets are much smaller than their investment grade counterparts (between 15 and 30 p.c.), they show a similar evolution. In what follows, we will focus on the investment grade markets.

CHART 2 AVERAGE MONTHLY NUMBER OF US AND EURO CORPORATE BONDS ISSUED

(Thousands of unit)



Source : Bloomberg (Merrill Lynch).

last decade the outstanding amounts of both markets have sharply increased. In January 2004, however, the outstanding amount of the US corporate bond market was still much higher than the figure for the Euro corporate bond market.

One source of growth in corporate bond markets has come from reactions to the low-interest-rate environment by investors such as financial institutions looking for higher returns. These investors are moving away from cash, government bonds, and other lower return liquid investments in favour of investment grade corporate bonds. This has boosted corporate bond issuance. Another source of corporate issuance is the wave of merger and acquisition activities. Although the Euro corporate bond market has grown significantly, the average number of US corporate bonds issued on a monthly basis is still five times higher (see Chart 2).

For the US corporate bond market and the Euro corporate bond market respectively, the composition of the issuance has shifted from higher rated bonds to lower rated bonds, especially BBB rated bonds. This increase is mainly led by the higher returns that investors can earn on BBB rated bonds compared to AAA rated bonds (see Section 5). Chart 2 shows that this is not only a temporary shift over the last three years. From 1990 to 2003, the composition of the issuance of US corporate bonds has continuously shifted in favor of lower rated bonds. In 2003, the issuance of BBB rated bonds was five times as high as the issuance of higher rated bonds (AAA and AA rated bonds). Much of this shift is demand driven. Furthermore, mature markets seem to be better suited than less developed markets for issuing lower rated bonds because they are more transparent and liquid.

2.2 Measures of Credit Risk

Investors should be aware that shifting from government bonds to corporate bonds involves credit risk. Credit risk mainly covers two components: (i) default risk and (ii) recovery risk. Default risk reflects the fact that the counterparty in a financial contract (e.g. bond issuer) may not be able or willing to repay the contractual coupon and face value.[3] The recovery risk captures the uncertainty about the proportion of the loss that will be recovered if, e.g., bondholders default.

The credit spread gives an indication of the market's assessment of credit risk. The literature presents two well-known measures for credit risk: (1) **bond yield spreads**, and (2) **credit default swaps (CDS) spreads**.[4] Another measure, which will not be discussed in detail here, is a firm's credit rating. The latter measure primarily reflects the likelihood of default and does not necessarily provide the most adequate assessment of the debt's credit quality. Even if credit ratings predict a substantial part of credit spreads, they do not tell us what information is relevant for credit spreads. Furthermore, changes in the firm's credit quality, especially credit deteriorations, do not always result in immediate rating changes because of a "through-the-cycle" rating methodology (see, e.g., Holthausen and Leftwich (1986), Crouhy et al. (2001), Altman and Rijken (2003)).[5]

2.2.1 Bond Yield Spreads

The difference between the yield on a risky asset and an equivalent risk-free asset is often referred to as the bond yield spread. The risk-free rate is often proxied by the yield on a government bond or a swap contract. In the literature, it is standard to consider government bonds as default-free assets, given their relatively high liquidity and given that governments can in principle raise income by taxing their citizens, thereby avoiding default.

(3) In this paper we consider rating migration risk, which represents the risk of an upgrading or downgrading of the rating of a financial asset, as a part of default risk.

(4) In what follows, the term "credit spread" covers bond yield spreads as well as CDS spreads.

(5) The critique of rating agencies is mainly focused on the timeliness properties of agency ratings, not on the accuracy level itself.

The bond yield spread compensates the investor for the expected default losses on the risky bond. No investor would be willing to buy a risky corporate bond, if he could buy a risk-free bond at the same price, ceteris paribus. Corporate bonds will trade at a lower price ceteris paribus and, hence, at a higher yield, since there is the risk of losing (part of) the invested funds. The spread also consists of a risk premium to reward the risk-averse investor for the risk of possibly higher than expected losses. As an illustration, consider the following example. Suppose that we have a risk-free bond with a price of 100 and a risky bond with exactly the same characteristics, except that it has a default probability of 10 p.c. A risk-neutral investor will pay 100 for the risk-free bond and 90 for the risky bond. A risk-averse investor will pay 100 for the risk-free bond but only less than 90 for the risky bond. The stronger the risk-aversion of an investor, the lower the price he is willing to pay (or the higher the premium) for the risky bond.

Finally, it is very likely that the spread between default-risky and default-free yields also includes a premium for other factors such as liquidity risk, differences in tax treatments between government and corporate bonds, contingent contract specifications (e.g. call features) and systematics shocks.

2.2.2 Credit Default Swap (CDS) Spread

CDS is the most used credit derivative and can be viewed as default insurance on loans or bonds. The buyer of a CDS makes periodic payments to the seller of the CDS and in return obtains the right to sell to the CDS seller a bond issued by the reference entity (company or sovereign) for its face value if default or another credit event occurs. Using CDS data to mesure spreads has two major advantages (see Hull et al. (2002) and Cossin et al. (2002)). First, CDS spread data provided by a broker consist of firm bid and offer quotes from dealers. Once a quote has been made, the dealer is committed to trading a minimum principal (usually 10 million dollars) at the quoted price. However, bond yield data available to researchers usually consist of indications from dealers. So, there is no commitment from the dealer to trade at the specified price. Second, since CDS spreads are already credit spreads, there is no default-free benchmark needed to calculate the spreads. The main disadvantages of CDSs are their lack of liquidity and the absence of a (liquid) secondary market.

2.2.3 Relationship between CDS Spread and Bond Yield Spread

In theory, bond yield spreads should be closely related to CDS spreads. This is because of an arbitrage relationship that exists between credit default swap spreads and credit spreads for a given reference entity (see Duffie (1999), O'Kane and McAdie (2001), and Hull et al. (2002)). Suppose that an investor buys a T-year par bond with yield to maturity y issued by the reference entity. The investor can eliminate most of the default risk associated with the bond by buying a CDS at a spread (or rate) of y_{CDS}. By arbitrage, $y - y_{CDS}$ should approximately equal the risk-free rate, r_f. For $y - y_{CDS} < r_f$, shorting a risky bond, writing protection in the CDS market, and buying a risk-free bond would be profitable. Thus, this suggests that the credit spread should be equal to the CDS spread. The results of the empirical studies on the relationship between CDS spreads and bond yield depend on the choice of the default-free benchmark (see, e.g., Blanco et al. (2003), Longstaff et al. (2003) and Houweling and Vorst (2005)). Studies that use the swap rate as the default-free benchmark find bond yield spreads to be quite close to CDS spreads (Blanco et al. (2003)). Derivatives traders tend to work with the LIBOR zero curve (also called swap zero curve) as the benchmark because the LIBOR or swap rates closely correspond to the cost of capital of financial institutions. However, studies that use the Treasury rate as the default-free benchmark find significant differences.

3. Determinants of Credit Spreads

3.1 Theoretical Framework

Credit risk models generally boil down to one of two distinct approaches: *structural, contingent-claim or firm-value models* and *reduced-form models*. The **structural models,** initiated by Black and Scholes (1973) and Merton (1974), relate credit events to the firm's value and capital structure. Default occurs if the value of the firm falls below a barrier. In these models, credit events are endogenous. In contrast, the **reduced-form models** specify the credit event as an exogenous, unpredictable, statistical event, governed by some hazard-rate process. Although the latter category of models is used more often in pricing derivatives for reasons of mathematical tractability, structural credit risk models yield more insight into the determinants of credit spreads. Since the Merton model (see Box 1: Merton model) is one of the first structural credit risk models, the literature often refers to it as the representative of the structural models. [6]

(6) The Merton model has been extended in several ways by relaxing some restrictive assumptions such as a deterministic risk-free term structure, zero-coupon debt as the only source of debt, and frictionless markets. However, the main conclusions are not altered by these extensions.

Box 1 – Merton model

In the structural models, default occurs when the firm's asset value, V_T, falls below a specified critical value at maturity T. In the Merton model (1974), the critical value is given by the face value of the firm's zerobond debt, L, which is by assumption the only source of debt. In case of default, debt holders receive the amount V_T. The value of a default-risky zero-coupon bond at time T can be written as

Eq 1 $$D_T = \min(L, V_T) = L - \max(0, L - V_T)$$

The value of a default-risky zero-coupon bond equals the difference of the value of a default-free zero-coupon bond with face value L and the value of European put option written on the firm's asset value, with strike price L and exercise date T.(1) The payoff, L - V_T, is often called the put-to-default.

In the Merton model, the dynamics of the asset value of the firm can be described as

Eq 2 $$\frac{dV_t}{V_t} = r dt + \sigma_V dZ_t,$$

where r is the instantaneous expected rate of return, the variance of the return σ_V the underlying assets, and Zt a standard Wiener process.(2)

Since the sum of the firm's debt value and equity value equals V_T, the equity value at time T equals

Eq 3 $$E_T = V_T - \min(V_T, L) = \max(0, V_T - L) = C_T$$

The stockholders receive the difference between V_T and L in the case of no default and zero in the case of default. The firm's equity value can thus be seen as the value of a call option on the firm's assets. Issuing debt is similar to selling the firm's asset value to the bondholders while the stockholders keep a call option to buy back the assets. Using the put-call parity, this is equivalent to saying that the stockholders own the firm's asset value and buy a put option from the bondholders.

Merton (1974) derived a closed-form solution for the price/yield of a defaultable zero-coupon bond by combining equation (1) with the Black and Scholes formula for a European put option. The credit spread on a defaultable bond with maturity T, CR(t,T) is calculated as the difference between the yield on a defaultable zero-coupon bond with maturity T, Y^d(t, T) and the yield on risk-free zero-coupon bond with maturity T, Y(t, T)

Eq 4 $$CR(t,T) = Y^d(t,T) - Y(t,T) = -\frac{\ln(l_t^{-1} N(-h_1) + N(h_2))}{T-t},$$

with $$h_{1,2} = \frac{-\ln l_t \pm 0.5\sigma_V^2 (T-t)}{\sigma_V (T-t)},$$

and $$l_t = \frac{LB(t,T)}{V_t} = \frac{L \exp^{-r(T-t)}}{V_t}.$$

(1) The bondholder has written a put option from the equity holders, agreeing to accept the assets in settlement of the payment if the value of the firm falls below the face value of the debt.

(2) A Wiener process Z has the following properties: (1) Z has uncorrelated and unpredictable increments, (2) Z has zero mean and variance t, and (3) the process Z is continuous.

N denotes the cumulative probability distribution function of a standard normal. $L_t = LB(t, T)$ is the present value of the promised claim (the face value) at the maturity of the bond and $B(t, T)$ presents the value of a unit default-free zero-coupon bond. l is the leverage ratio, r the continuously compounded risk-free rate and σ_V the volatility of the firm's asset value. For simplicity, we assume that the payout or dividend ratio equals zero.

Equation (4) shows that the credit spread is a function of the risk-free interest rate, the firm's asset value, and the volatility of the firm's asset value. These factors will be discussed in more detail in Section 3.2.

The Merton model, which is discussed in more detail in the Box, and the structural credit risk models in general, provide a framework which identifies some important determinants of credit spreads, which include the risk-free interest rate, the asset value, and asset volatility. These variables are discussed in more detail below. In addition, we also discuss the slope of the default-free term structure, as this variable is implied by the structural models because it is closely related to the risk-free interest rate. Finally, we discuss two additional variables that do not come from the existing structural credit risk models but which are often mentioned in the literature on credit spreads: liquidity risk and taxation.

3.2 Factors Implied by Structural Credit Risk Models

3.2.1 Default-free Interest Rate

According to the structural credit risk models, we expect a negative relation between the (instantaneous) nominal risk-free rate and the credit spread. [7] The drift of the risk-neutral process of the value of the assets (see equation (2)), which is the expected growth of the firm's value, equals the risk-free interest rate. An increase in the interest rate implies an increase in the expected growth rate of the firm value. This will in turn lower the probability of default and the credit spread. Structural credit risk models show that for firms with moderate and high (low) debt levels, the effect of an interest rate change decreases (increases) with the term to maturity. However, the interest rate effect always remains stronger for firms with higher debt levels. Since firms with a higher debt level often have a lower rating, we expect that the interest rate effect is stronger for lower rated firms.

Furthermore, lower interest rates are usually associated with a weakening economy and higher credit spreads. In the long run, however, low interest rates might stimulate investment and thus economic growth. This reasoning would lead, in contrast to what was said above, to a positive relation between the risk-free rate and credit spreads. Box 2 discusses which relation arises empirically.

3.2.2 Slope of Default-free Term Structure

The interpretation of the effect of the slope of the default-free term structure on credit spreads is similar to that of the effect of the default-free rate. The expectations hypothesis of the term structure implies that the spread between the long-term and the short-term rate, which is often called the slope, is an optimal predictor of future changes in short-term rates over the life of the long-term bond. As such, an increase in the slope implies an increase in the expected short-term interest rates. As in the case of the motivation for the risk-free interest rate above, an increase in the slope is expected to lower the price of the put option and reduce a firm's default risk. Furthermore, the slope of the term structure is often related to future business cycle conditions. A decrease in the slope is considered to be an indication of a weakening economy. Estrella and Hardouvelis (1991) and Estrella and Mishkin (1995, 1998) conclude that the yield curve is a good predictor of future economic activity and the probability of recession. A positively sloped yield curve is associated with improving economic activity, which might in turn increase a firm's growth rate and reduce its default probability. Therefore, we also expect a negative dependence between changes in the slope of the default-free term structure and credit spread changes.

3.2.3 Asset Price

Equation (4) includes the leverage ratio or the pseudo debt-to-assets ratio, namely l. [8] Firms with a low leverage ratio, where the asset value can easily cover the debt value, are unlikely to default. An increase in the leverage ratio increases the value of the put option and thus the credit spread. An increase in the firm's asset value, V, (for a given debt value) reduces the leverage ratio and the value of the put option. Therefore, we expect a negative relation between the firm's asset value and the credit spread. The effect of an asset price change is stronger for

(7) The risk-free rate that is referred to in the structural credit risk models is the nominal rate. In the remainder, we drop "nominal".

(8) Structural credit risk models often refer to the distance-to-default ratio, which is (1/l) (with l the leverage ratio).

bonds with a short to medium term to maturity and for firms with a high leverage ratio.

Structural models typically assume that the assets of the firm are tradable securities. In practice, however, the asset value has to be deduced from the balance sheet and is updated only on an infrequent basis. Therefore, the value of the assets is usually replaced by the equity value/returns for publicly traded companies. Studies that consider portfolios of bonds try to mimic the average stock return of the issuing firms by including the value (return) of a stock index that is related to the portfolio. For a portfolio of, e.g., Euro bonds issued by the financial sector, the average asset value is often proxied by the return of a Euro financial index.

3.2.4 Asset Volatility

Equation (4) shows that credit spreads are affected by the volatility of the firm's asset value. High asset volatility corresponds with a high probability that the firm's asset value will fall below the value of its debt. In that case, it is more likely that the put option will be exercised and thus, credit spreads will be higher. The effect of a volatility increase is larger for bonds with a high leverage ratio compared to bonds whose debt value is far below the asset value. Furthermore, the effect decreases with the time to maturity for bonds with a high leverage ratio. For bonds with a low leverage ratio, the effect first increases slightly and then remains constant.

Since the asset value, and thus asset volatility, is only updated on an infrequent basis, asset volatility is often replaced by equity volatility. As with asset volatility, an increase in equity volatility increases the probability that the put option will be exercised and therefore credit spreads will increase. Studies that analyse portfolios of bonds often use the volatility of a stock index that is related to the portfolio.

3.3 Other Factors

3.3.1 Liquidity Risk

Option models typically used in the structural approach assume perfect and complete markets where trading takes place continuously. These assumptions imply no differences in liquidity between bonds. However, in practice markets are not perfectly liquid, and liquidity may be an important determinant of credit spreads. Indeed, Collin-Dufresne et al. (2001), Elton et al. (2001), Houweling et al. (2004), and Perraudin and Taylor (2004) find evidence that liquidity significantly influences credit spreads. Investors require a premium for investing in less liquid assets. If liquidity risk were similar for government and corporate bonds, the liquidity premium should be cancelled out when taking the difference between the two yields. However, since government bond markets are larger and more liquid than corporate bond markets, an investor may expect an additional premium for lower liquidity in corporate bond markets. Hence, we expect a positive relationship between liquidity risk and credit spreads. Measures that are often used as proxies for liquidity risk are the bid-ask spread, trading volume, age, and bond issue size.

3.3.2 Taxation Differences

If taxation differences exist between corporate and government bonds or corporate bonds and swap contracts, bond yield spreads are likely to reflect these differences. It is well known that US municipal bonds have had a negative credit spread for the last 50 years, despite their lower liquidity and higher default risk in comparison with government bonds. The reason is that municipal bond interest payments are exempt from US federal income taxes. Even though part of the level of credit spreads might reflect the tax effect, it is very unlikely that the tax effect has a significant impact on changes in credit spreads given the rigid nature of taxation rates.

4. Detailed Empirical Analysis of Euro Credit Spreads

4.1 Introduction

This study, which is based on a Van Landschoot (2004), analyses the determinants of credit spread changes for different types of Euro corporate bonds between 1998 and 2002. More specifically, we investigate the relationship between credit spread changes and financial and economic factors for bonds with different maturities and investment grade rating categories. The main question is whether credit spread changes on bonds with different characteristics (rating and/or maturity) are differently affected by the various determinants of credit spreads. To our knowledge, this is the first paper on credit spreads that tests these differences for a wide range of maturities and rating categories with a data set of individual Euro corporate bonds.

4.2 Data Description

The analysis uses individual weekly bond data of the EMU Broad Market indices from January 1998 until December 2002 constructed by Merrill Lynch. The data set consists of 1577 corporate bonds issued by 448 firms and 250 AAA rated government bonds. The former are used to estimate the term structure of risky assets, whereas the latter are used to estimate the risk-free term structure. The EMU Broad Market indices are based on secondary market prices of bonds issued in the EMU bond market or in EMU-zone domestic markets and denominated in Euro or one of the currencies that joined the EMU. Besides bond prices, the data set contains data on the coupon rate, the time to maturity, the rating, the industry classification, and the amount issued. Ratings are composite Moody's and Standard & Poors ratings. The Merrill Lynch Broad Market index covers investment-grade firms. Hence the analysis is restricted to corporate bonds rated BBB and higher. Further, all bonds have a fixed rate coupon and pay annual coupons. To be included in the Merrill Lynch index, bonds should have a minimum size of 100 million euro for corporate bonds and 1 billion euro for government bonds. Because the EMU Broad Market index has relatively low minimum size requirements, it provides a broad coverage of the underlying markets.

4.3 Term Structure of Credit Spreads

In accordance with the structural credit risk models, we expect that the relation between credit spreads and macro-economic and financial variables depends on the leverage ratio (creditworthiness) of the issuer and the maturity of the bonds. In accordance with the existing empirical literature on credit spreads, we use credit ratings as a proxy for the leverage of the issuing firm. In order to obtain and easily compare credit spreads for a broad range of maturities and ratings, we estimate the term structure of credit spreads for four groups of bonds, namely AAA, AA, A, and BBB rated bonds. The term structure of credit spreads is calculated as the difference between the term structure of spot rates on corporate and government bonds. [9] The term structure gives the evolution of credit spreads as a function of the remaining time to maturity of the bonds. Since spot rates are not observable, we use an extension of the parametric model introduced by Nelson and Siegel (1987). This Nelson-Siegel (NS) model offers a conceptually simple and parsimonious description of the term structure of interest rates. It avoids over-parameterisation while it allows for monotonically increasing or decreasing yield curves and hump shaped yield curves. Diebold and Li (2002) conclude that the NS method produces one-year-ahead forecasts that are strikingly more accurate than standard benchmarks such as linear interpolation.

We add four additional factors to the original NS model in order to capture differences in liquidity, taxation, and subrating categories. First, if liquidity decreases, bid-ask spreads tend to widen and hence spot rates might go up. Second, to capture part of the taxation effect, we include the difference between the coupon of a bond and the

(9) There are a number of reasons for using the spot rates instead of yields to maturity. The yield to maturity depends on the coupon rate. The yield to maturity of bonds with the same maturity but different coupons may vary considerably. As such, the credit spread will depend on the coupon rate. Furthermore, if we use yields to maturity to calculate the credit spread, we compare bonds with different duration and convexity.

TABLE 1 AVERAGE CREDIT SPREADS ON BONDS WITH DIFFERENT RATINGS AND MATURITIES

Rating	Years to maturity			
	3y	5y	7y	10y
AAA	17.0 (3.4)	18.3 (6.7)	22.0 (9.0)	26.0 (11.0)
AA+	22.6 (4.3)	27.2 (7.7)	32.8 (10.2)	38.6 (11.6)
AA	27.0 (4.8)	31.6 (8.6)	37.2 (11.3)	43.0 (12.9)
AA–	37.1 (8.5)	41.7 (12.4)	47.3 (14.9)	53.1 (16.6)
A+	41.6 (9.9)	50.9 (15.1)	59.0 (18.1)	67.5 (20.4)
A	57.4 (17.6)	66.8 (22.8)	74.9 (25.4)	83.4 (27.4)
A–	80.6 (32.0)	89.9 (36.7)	98.0 (38.8)	106.5 (40.5)
BBB+	104.1 (27.0)	117.8 (31.2)	135.7 (30.4)	162.9 (31.1)
BBB / BBB–	154.2 (38.6)	167.9 (43.1)	185.8 (42.2)	213.0 (41.9)

Note : The table presents average and standard deviation (between brackets) of credit spreads on AAA, AA, A, and BBB rated bonds with different maturities. We use a data set of weekly data from January 1998 until December 2002.

average coupon rate of the sample. The underlying idea is that holders of high-coupon bonds need to pay more taxes compared to holders of low-coupon bonds. Finally, another reason why bonds might have different yields within a rating category is that they are not viewed as equally risky. Moody's and Standard and Poor's (S&P) both introduced subcategories within a rating category. While S&P add a plus (+) or a minus (–) sign, Moody's adds a number (1, 2 or 3) to show the standing within the major rating categories. Bonds that are rated with a plus (1) or a minus (3) might be considered as having a different probability of default compared to the flat letter rating (2). Therefore, we include a dummy for the plus subcategory and a dummy for the minus subcategory.[10]

Table 1 presents the summary statistics (average and standard deviation) of credit spreads on bonds with different ratings and maturities. The results show the well-known fact that credit spreads increase as the creditworthiness of the issuer decreases. Furthermore, credit spread volatility (standard deviation) is higher for bonds with lower ratings. Finally, credit spreads are higher for bonds with longer maturities.

4.4 Model Specification

We investigate the main factors driving credit spread changes on bonds with different characteristics, in particular ratings and maturities. The structural models provide guidance on identification of the main factors, namely the level and the slope of the default-free term structure, the stock return, and the volatility of stock prices. Furthermore, we also consider liquidity risk, measured as the bid-ask spread, and mean-reverting properties of credit spreads.

In order to analyse the main determinants of credit spread changes of bonds in rating category *j* and with years to maturity *m*, we estimate the following equation

Eq 5

$$\Delta CR_t = \alpha_0 + \alpha_1 \Delta i_{3,t} + \alpha_2 \Delta slope_t + \alpha_3 R^m{}_{t-1} + \alpha_4 \Delta volp_t + \alpha_5 \Delta voln_t + \alpha_6 liq_{t-1} + \alpha_7 \Delta liq_t + \alpha_6 (CR_{t-1} - \overline{CR}) + \nu_t$$

where CR is the estimated credit spread for a rating group (AAA, AA, A, and BBB).[11] The variables i_3 and $slope$ are the level and the slope of the default-free term structure, respectively. The former is defined as the 3-month euro rate and the latter as the spread between the 10-year constant maturity euro government bond yield minus the 3-month euro rate. R^m and vol are the market return and volatility of the DJ Euro Stoxx. These variables should proxy the asset value of the issuing firm and its volatility (see Section 3.1.1). In a manner similar to Bekaert and Wu (2000) and Collin-Dufresne et al. (2001), we test whether the impact of volatility is asymmetric. Therefore, we make a distinction between positive *(volp)* and negative changes in the volatility *(voln)*. The variable liq is a proxy for liquidity risk, namely the average bid-ask spread of the bonds in our sample. We include the lagged level and the change in the bid-ask spread. Given the fact that bid-ask spreads are very small, the level might be more important than a change.

TABLE 2 EXPLANATORY VARIABLES AND EXPECTED SIGNS ON THE COEFFICIENTS IN THE EMPIRICAL ANALYSIS

Variable	Description	Expected sign
$\Delta i_{3,t}$	Change in 3 month euro rate	–
$\Delta slope_t$	Change in slope, i.e. 10 year minus 3 month euro rate	–
$R^m{}_{t-1}$	Weekly return on DJ Euro Stoxx, lagged one week	–
$\Delta volp_t$	Positive change in volatility of DJ Euro Stoxx	+
$\Delta voln_t$	Negative change in volatility of DJ Euro Stoxx	+
liq_{t-1}	Bid-ask spread, lagged one period	+
Δliq_t	Change in bid-ask spread	+
$CR_{t-1} - \overline{CR} = MR$	Credit spread minus average credit spread (mean reversion term)	–

Finally, $CR_{t-1} - \overline{CR} = MR$ is the deviation of the credit spread from its mean. This factor should capture the mean-reversion of credit spreads. If credit spreads fluctuate around a long-term average (equilibrium), the sensitivity to the lagged credit spread should be negative. Table 2 gives an overview of the explanatory variables and the expected signs on the coefficients.

Weekly data on the explanatory variables are obtained from Datastream and Bloomberg. We estimate the credit spread model using seemingly unrelated regression (SUR) methodology. This methodology has the advantage that it accounts for heteroskedasticity, and contemporaneous correlation in the errors across equations. Furthermore, we are able to test for significant differences in sensitivity coefficients for bonds with different maturities.

(10) For simplicity, we assume that the additional factors only affect the level of the term structure and not the slope.

(11) CR is the credit spread that results from the term structure estimation. It can be considered as an weighted average of the credit spreads in that rating category.

4.5 Empirical Results

Panels A, B, C, and D of Table 3 present the estimation results for bonds with different rating categories (AAA, AA, A, and BBB) and different maturities (3, 5, 7, and 10 years to maturity). The sensitivities of credit spreads on bonds with similar rating, e.g. AA, but different subrating, e.g. AA+, AA, and AA–, are very similar. Therefore, we focus on different ratings and not subratings. We perform Wald tests to analyse whether bonds with different maturities and/or ratings react in significantly different ways to changes in financial and macro-economic variables.(12)

The results show that changes in the level and the slope of the default-free term structure are two important determinants of credit spread changes. Consistent with the findings of Longstaff and Schwartz (1995), Duffee (1998), and Collin-Dufresne (2001) for the US and for Boss and Scheicher (2002) and Leake (2003) for Europe, we find a negative relation between changes in the level and the slope of the default-free term structure and credit spread changes. For AAA and AA bonds, the null hypothesis that the sensitivities in credit spread changes are similar for different maturities is rejected for both the level and the slope. The effects first increase with the time to maturity and then decrease. However, for A and BBB rated bonds the effects do not significantly depend on the maturity. Furthermore, the level effect is stronger for bonds with a lower rating or high leverage ratios. This is in accordance with the implications of structural credit risk models (see Section 3.1.1). However, the slope effect is very similar for AAA, AA, and A rated bonds. For BBB rated bonds, the slope effect is substantially larger. If we compare the level effect on credit spreads of, e.g., AAA and BBB rated bonds with 7 years to maturity, we find that a 100 basis point increase in the 3-month risk-free rate causes a 5.6 basis point decrease in the AAA credit spread and a 32.4 basis point decrease in the BBB credit spread.

The return and the implied volatility of DJ Euro Stoxx significantly influence credit spread changes. According to the structural credit risk models, the effects of the return and volatility should be larger for bonds with a higher leverage. The results indeed indicate that the sensitivity coefficients are higher for BBB rated bonds compared to AAA rated bonds. A 100 basis point increase of the weekly market return reduces the credit spread on AAA and BBB rated bonds with 7 years to maturity by 0.08 and 0.7 basis points respectively. The return effect is relatively weak compared to the effect of the level and the slope of the default-free term structure. For AA, A, and BBB rated bonds, we find that positive changes in the volatility significantly influence credit spread changes whereas negative changes do not. This is in accordance with the hypothesis that the effect of the volatility is asymmetric. For AAA, the results are less clear. Furthermore, Wald tests show that the effect of the return and the volatility do not depend on the maturity of the bonds. This can not be explained by the theoretical models that predict a stronger effect for bonds with a shorter maturity.

For AAA, AA, and A rated bonds, we find that the bid-ask spread significantly influences credit spread changes. However, changes in the bid-ask spread do not have a significant influence. This shows that the credit spread changes are more affected by the bid-ask spread itself than a change in the bid-ask spread. For BBB rated bonds, the level as well as the changes in the bid-ask spread significantly affect credit spread changes. In general, the effect of the bid-ask spread becomes stronger for bonds with a lower rating. An increase of 100 basis points in the bid-ask spread increases the credit spread on AAA (BBB) rated corporate bonds with 7 years to maturity by 23 (164) basis points. For AAA and AA rated bonds, the effect of the bid-ask spread becomes stronger for bonds with longer maturities. For higher rating categories, liquidity changes do not significantly affect credit spread changes. This might be due to the fact that these bonds are more liquid than BBB rated bonds and are not immediately affected by a change.

Finally, our results indicate that credit spreads are mean reverting. This means that if credit spreads are high, the changes are smaller or even negative such that the credit spread converges to its long-run average.

The factors suggested by the structural credit risk models explain between 10 p.c. and 39 p.c. of the evolution of credit spread changes, depending on the rating category and the maturity of the bond. The economic and financial variables included in our model (see Equation 5) have the highest explanatory power for BBB rated bonds. Furthermore, our model explains most of the variation of credit spreads on bonds with medium maturities. The adjusted R^2 is on average 19 p.c. for bonds with 3 and 10 years to maturity and 24 p.c. for bonds with 5 and 7 years to maturity. Our results indicate that bonds with different ratings and maturities behave differently.

(12) The results of the Wald test and a more detailed discussion of the results can be found in Van Landschoot (2004).

TABLE 3 DETERMINANTS OF CREDIT SPREAD CHANGES : ESTIMATION RESULTS

	Δi_3	$\Delta slope$	R_m	$\Delta volp$	$\Delta voln$	liq	Δliq	MR	R^2
Panel A : AAA rated bonds									
3 yr	–6.29	–6.80	–0.04	0.05	0.00	0.16	0.21	–0.11	24.4
	(0.00)	(0.00)	(0.13)	(0.25)	(0.91)	(0.01)	(0.57)	(0.00)	
5 yr	–8.31	–9.04	–0.06	0.08	–0.02	0.25	0.39	–0.10	33.7
	(0.00)	(0.00)	(0.01)	(0.05)	(0.66)	(0.00)	(0.24)	(0.00)	
7 yr	–5.98	–8.15	–0.08	0.08	0.04	0.23	0.31	–0.09	24.3
	(0.00)	(0.00)	(0.00)	(0.06)	(0.41)	(0.00)	(0.38)	(0.00)	
10 yr	0.53	–4.99	–0.10	0.06	0.14	0.18	–0.05	–0.08	11.4
	(0.79)	(0.00)	(0.00)	(0.29)	(0.01)	(0.03)	(0.91)	(0.00)	
Panel B : AA rated bonds									
3 yr	–5.86	–6.11	–0.04	0.13	0.02	0.45	0.99	–0.11	21.7
	(0.00)	(0.00)	(0.24)	(0.02)	(0.74)	(0.00)	(0.04)	(0.00)	
5 yr	–5.04	–6.65	–0.09	0.15	0.03	0.48	0.77	–0.10	25.1
	(0.00)	(0.00)	(0.00)	(0.00)	(0.53)	(0.00)	(0.07)	(0.00)	
7 yr	–2.79	–5.68	–0.13	0.16	0.04	0.43	0.52	–0.10	20.3
	(0.11)	(0.00)	(0.00)	(0.00)	(0.36)	(0.00)	(0.21)	(0.00)	
10 yr	1.25	–3.15	–0.18	0.13	0.04	0.41	0.49	–0.10	10.2
	(0.56)	(0.03)	(0.00)	(0.03)	(0.52)	(0.00)	(0.35)	(0.00)	
Panel C : A rated bonds									
3 yr	–10.60	–5.34	–0.14	0.31	0.07	0.91	1.04	–0.10	13.6
	(0.00)	(0.03)	(0.03)	(0.00)	(0.47)	(0.00)	(0.27)	(0.00)	
5 yr	–12.62	–9.61	–0.13	0.29	0.10	0.95	1.64	–0.09	15.2
	(0.00)	(0.00)	(0.06)	(0.01)	(0.37)	(0.00)	(0.11)	(0.00)	
7 yr	–10.67	–9.50	–0.19	0.29	0.07	0.80	1.64	–0.08	15.1
	(0.00)	(0.00)	(0.00)	(0.00)	(0.48)	(0.00)	(0.09)	(0.00)	
10 yr	–4.89	–5.18	–0.33	0.41	0.02	0.60	1.06	–0.07	17.4
	(0.17)	(0.03)	(0.00)	(0.00)	(0.85)	(0.00)	(0.25)	(0.00)	
Panel D : BBB rated bonds									
3 yr	–14.54	–14.24	–0.67	0.59	–0.22	1.85	4.33	–0.18	17.4
	(0.21)	(0.08)	(0.00)	(0.02)	(0.40)	(0.00)	(0.00)	(0.00)	
5 yr	–23.05	–21.39	–0.67	0.82	–0.38	1.97	5.56	–0.18	20.1
	(0.05)	(0.01)	(0.00)	(0.00)	(0.14)	(0.00)	(0.00)	(0.00)	
7 yr	–33.07	–32.27	–0.74	1.08	0.00	1.64	8.43	–0.17	32.5
	(0.02)	(0.00)	(0.00)	(0.00)	(0.99)	(0.00)	(0.00)	(0.00)	
10 yr	–52.42	–44.30	–0.88	1.62	0.71	0.89	11.57	–0.16	38.9
	(0.02)	(0.00)	(0.02)	(0.00)	(0.15)	(0.12)	(0.00)	(0.00)	

Note : Panel A, B, C, and D present the estimation results for credit spreads on respectively AAA, AA, A, and BBB rated bonds. The data set consists of weekly data from January 1998 until December 2002. The explanatory variables are briefly explained in Table 2. The model is estimated using Seemingly Unrelated Regressions (SUR). p-values are given between brackets. Coefficients that are significant at 5 p.c. level are in bold. The adjusted R^2 in the final column are given in p.c.

5. Comparison of European Versus Us Credit Spreads

As the US has a large and mature corporate bond market, most empirical studies on corporate credit spreads have concentrated on US data (Duffee (1998), Collin-Dufresne et al. (2001), Cossin et al. (2002), Elton et al (2001), and others). Empirical studies on the determinants of European credit spreads are rather limited (Boss and Scheicher (2002), Leake (2003), and Van Landschoot (2004)). An issue of interest is whether credit spreads on US corporate bonds are affected by the same factors and in a similar way as those on European corporate bonds. Chart 1 shows that the size of the Euro corporate bond market has become large enough (over the last decade) to make a comparison.[13] Furthermore, we consider whether bond characteristics such as maturity and leverage influence the relation between credit spreads and macro-economic and

(13) Before the EMU, the Euro corporate bond market was very small and illiquid. Therefore, it is very difficult (if not impossible) to investigate the effect of the formation of the EMU on the relation between credit spreads and macro-economic and financial variables.

financial variables in a similar way for the US and Europe. The leverage is often proxied by the rating.

In this section, we review studies that proxy the credit spread by the bond yield spread and not the CDS spread.[14] The reason is that the CDS market is much less developed than the corporate bond market. Furthermore, we focus on studies that analyse the determinants of credit spread changes instead of levels. The reason is threefold. First, even though it seems implausible that any credit spread would actually explode, as a unit root process could, credit spreads are highly persistent. This may result in biased estimates (see Ferson et al. (2003) for a detailed analysis of spurious regression bias). Second, the holder of a default-risky asset is mainly interested in the changes in the credit spread. Third, focusing only on credit spread changes makes it easier to compare the magnitude of the sensitivity coefficients.

5.1 Empirical Evidence on the Determinants of Credit Spreads

For the US, we briefly discuss and compare the results of Longstaff and Schwartz (1996), Duffee (1998), and Collin-Dufresne (2001). For Europe, we briefly discuss and compare the results of Boss and Scheicher (2002), Leake (2002), and Van Landschoot (2004). Longstaff and Schwartz (1996), Duffee (1998), and Leake (2002) mainly focus on the relation between the risk-free term structure and credit spreads, whereas the others attempt to explain as much as possible of the variation of credit spreads. Table 4 gives an overview of the main variables that are included in the different studies and the sign of the sensitivity coefficients.

Longstaff and Schwartz (1995) investigate the relationship between interest rate changes and credit spread changes on investment grade US indices for different sectors (utilities, industrials, and railroads) and investment grade ratings between 1977 and 1992. The authors do not make a distinction between bonds with different maturities. The results show a significant negative relation between credit spread changes and 30-year Treasury yield changes for all sectors. The effect is stronger for industrials and railroads compared to utilities. Although the authors do not discuss this issue, the results seem to indicate that the effect is stronger for lower rated bonds. Furthermore, they find a significant negative relation between credit spread changes and the return on the corresponding S&P stock index. The latter effect monotonically declines with the credit rating for utilities and industrials. The regression results show that a 100 basis point increase in the 30-year

(14) Cossin et al. (2002) is one of the few studies analysing the determinants of CDS spreads.

TABLE 4 OVERVIEW OF THE DETERMINANTS OF CREDIT SPREAD CHANGES

	Δi	$(\Delta i)^2$	$\Delta slope$	Δvol_{int}	R^m	Δvol	liq	SMB	HML	MR	R^2
Panel A : US data											
Longstaff & Schwartz (1995)	(–)				(+)						41
Duffee (1998)	(–)		(–)								42
Morris et al. (1998)	(–)										30
Joutz et al. (2002) . .	(–)		(–)		(–)			(–)	(–)		29
Collin-Dufresne et al. (2001)	(–)	(–)	(–)		(–)	(+)	(+)	(–)	(–)	(–)	25
Panel B : European data											
Boss & Scheicher (2002)	(–)		(–)	(+)	(–)	(+)[1]	(+)				40
Leake (2003)	(–)		(–)								7
Van Landschoot (2003)	(–)		(–)		(–)	(+)	(+)			(–)	23

Note : This table presents an overview of the determinants (see below) of credit spread changes i = interest rate; slope = slope of the default-free term structure; vol_{int} = interest rate volatility; R^m = market return; vol = equity volatility; liq = proxy for liquidity; SMB = Small minus Big (Fama-French factor); HML = High minus Low (Fama-French factor); MR = mean reversion (lagged level). We mention the sign of the coefficient : positive (+), negative (–) or zero (0). If the coefficient is significant at the 5 p.c. level, it is presented in bold. All studies in Table 5, except Longstaff and Schwartz (1995), include R^ml lagged one period instead of R^m. The adjusted R^2 in the final column is given in p.c.

(1) Only financials.

Treasury yield and a 100 basis points return reduces Baa rated utility credit spreads by 18 basis points and 1.6 basis points respectively. The paper does not test whether the sensitivity coefficients differ significantly between different types of bonds. Their two-factor model explains on average 41 p.c. of the variation in credit spreads, with a minimum of 1.1 p.c. for Baa utilities and a maximum of 74 p.c. for Baa railroads.

Duffee (1998) analyses the relationship between changes in corporate bond yield spreads and changes in the Treasury yields. This study uses a data set of monthly US callable and noncallable investment grade corporate bonds (1973-1995) and constructs indices for different rating categories and three maturity ranges. The results provide evidence that changes in the level and the slope of the term structure are negatively related to credit spread changes. The magnitude of the latter coefficient becomes larger for lower rated bonds and longer maturities. The regression results show that an increase of 100 basis points in the 3-month risk-free rate and the slope (10-year minus 3-month risk-free rate) reduce the AA long maturity credit spread by 29 basis points. However, the results do not show whether the maturity significantly affects the relation. The authors also conclude that there is no compelling evidence that yield spreads for different business sectors react differently to Treasury yields and that the inverse relationship between corporate bond yields and the Treasury bill yield is much stronger for callable bonds. Duffee's two-factor model is able to explain 42 p.c. of the variation in credit spreads.

Collin-Dufresne et al. (2001) analyse the determinants of credit spread changes using a panel data set of individual monthly US industrial bond data (1988-1997) for rating categories (AAA to B) and two maturity categories. The sensitivity coefficients to changes in the level and the slope of the default-free term structure, the S&P return, changes in the S&P volatility, and liquidity proxies all have the expected sign and are significant. Although they do not find significant differences between bonds with different ratings and maturities, their model performs worst when explaining variations in long-term, high-leveraged bonds. Including other financial and economic variables such as liquidity proxies, Fama-French factors (small-minus-big (SMB) and high-minus-low (HML)), and leverage provide only limited additional explanatory power.[15] Furthermore, they find that, contrary to the predictions of the structural models, aggregate factors are much more important than firm-specific factors.

Boss and Scheicher (2002) analyse the determinants of credit spread changes on Euro corporate bonds (financials and industrials) and on US corporate bonds (industrials). They find that the level and the slope of the default-free term structure are the most important determinants of credit spread changes. In addition, stock returns and implied volatility of stock returns have the expected sign and significantly affect credit spread changes for industrials. Liquidity proxies are not significant at a 5 p.c. level. The results for US credit spread changes are very similar to those for Euro credit spread changes, except that the former are also affected by liquidity changes. The model explains on average 35 p.c of the variation in credit spread changes.

Leake (2003) analyses the relation between credit spread changes on sterling corporate bonds and the term structure of UK interest rates. Using weekly data, they find a significant negative relation between changes in the level and the slope of the risk-free UK term structure and credit spread changes. Credit spreads fall by between 5 and 16 basis points for a 100 basis points rise in the level or the slope (over a period of one week). Their model explains on average 7 p.c. of the variation in credit spread changes.

(15) Fama and French (1993) find that HML and SMB, which are also called Fama-French factors, significantly affect stock returns. HML is the return on high minus low capitalization portfolios and SMB is the return on small minus big book-to-market portfolios. HML and SMB are assumed to capture the risk related to size and book-to-market ratio. See Fama and French (1993) for a detailed overview.

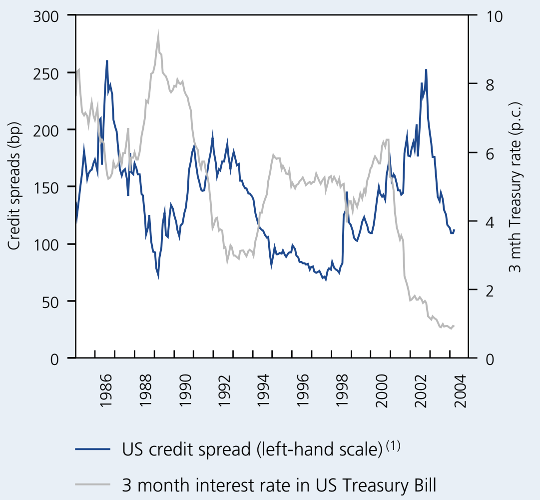
Box 2 – Relation between Credit Spreads and the Risk-Free Interest Rate over Time

Theoretical credit risk models, explicitly or implicitly, include a relation between credit spreads and the risk-free rate. The Merton type credit risk models posit a negative relation between credit spreads and the risk-free rate (see Black and Cox (1976), Leland (1994), Longstaff and Schwartz (1995), Zhou (1997), and others).[1] Recent empirical studies of Longstaff and Schwartz (1995), Duffee (1998), and Collin-Dufresne et al. (2001) also find evidence of a negative relation between credit spread changes and changes in the risk-free rate.

(1) See Sections 3.2.1 and 3.2.2 for a discussion on the relation between credit spreads and the risk-free rate according to the Merton type credit risk models.

Morris et al. (1998) and Joutz et al. (2002) argue that the finding of a negative relation between credit spreads and the risk-free rate is due to the fact that studies analysing credit spread changes automatically focus on the short-term relation. Both studies use a data set of US corporate bonds and apply a cointegration approach to model the long run and short-run relations between credit spreads and Treasury rates. They find that, initially, an increase in the Treasury rate causes credit spreads to narrow, which is in accordance with the structural credit risk models. However, this effect is reversed in the long run with higher rates causing increasing credit spreads. In the short run, a decrease of the risk-free interest rate is usually associated with a weakening economy and thus high credit spreads. However, a low-interest rate-environment is likely to stimulate investment and economic growth and to lower credit spreads after some time. Morris et al. (1998) only focus on the risk-free rate as an explanatory variable and find that their model explains on average 30 p.c. of the variation in credit spreads on Moody's investment grade bond indices (Jan. 1960 - Dec. 1997). Joutz et al. (2002) also find that credit spread changes are significantly negatively related to changes in the level and the slope of the default-free term structure. Furthermore, they find that the market return, small-minus-big (SMB), and high-minus-low (HML) are significantly negatively related to credit spread changes. Similar studies for the Euro corporate bond market have not been undertaken because the latter has a much shorter history compared to the US corporate bond market.

CHART 1 US CREDIT SPREADS AND SHORT TERM INTERREST RATE



Source : Bloomberg (Merrill Lynch) and Datastream.

(1) Calculated as the difference beween the US corporate and governement bond yield (all maturities).

Chart 1 presents the credit spread on US corporate bonds and US 3 months Treasury Rate. It shows that the US credit spread often lags the US Treasury rate, which is in accordance with the long-run relation discussed in Morris et al. (1998) and Joutz et al. (2002). Decreases in the Treasury rate at the end of 1980, the beginning of 1990, and the beginning of 2000 are followed by decreases in the credit spread (with a lag of one year). However, an increase in the Treasury rate in 1994 was not followed by an increase in the credit spreads. Chart 1 also shows that in the short run an increase in the Treasury rate often coincides with a decrease in the credit spread. For the Euro area, the history of the Euro corporate bond market is too short to draw (strong) conclusions, especially for the long run relation.

5.2 Comparison of European and US Credit Spreads

We now compare findings for the US and Europe based on the empirical results in Longstaff and Schwartz (1995), Duffee (1998), and Collin-Dufresne et al. (2001) for the US and Boss and Scheicher (2002), Leake (2003), and Van Landschoot (2004) for Europe. Notice that not all studies focus on the same variables. Therefore, "all studies" means those studies that focus on a particular variable or relation.

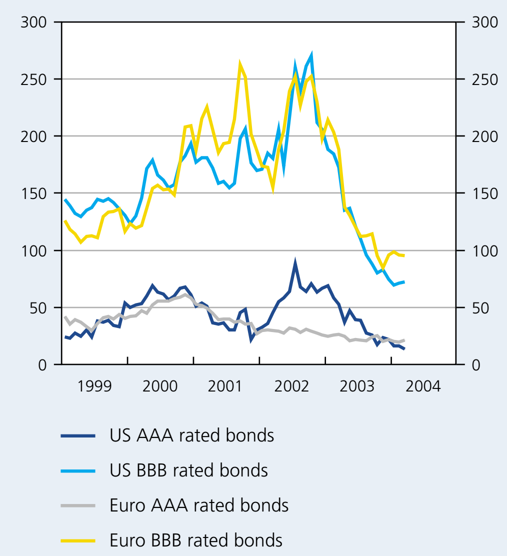
1. There is a significant negative relation between credit spread changes on European and US corporate bonds and changes in the European and US risk-free rate, respectively. In general, the effect becomes stronger for bonds with a lower rating (higher leverage).
2. For the slope effect, all studies find a significant negative relation between credit spread changes and changes in the slope of the default-free term structure. Most studies provide evidence that the slope effect slightly increases for lower ratings.
3. It is unclear whether the effect of changes in the risk-free rate and the slope of the default-free term structure depend on the maturity of the bonds. Duffee (1998) and Van Landschoot (2004) find that the effects are smaller for bonds with shorter maturities, whereas Collin-Dufresne et al. (2001) do not find different sensitivity coefficients for bonds with short and long term maturities.
4. In general, the sensitivity of credit spreads to changes in the level and the slope of the default-free term structure do not differ significantly between studies on US and European credit spreads, i.e. the sensitivity coefficients are not persistently different.
5. There is a significant negative relation between US and European credit spread changes and the US and European market return respectively. The sensitivity coefficients for the US and the European are similar. Finally, there is no clear evidence that the effect depends on the rating.
6. A change in the risk-free rate is economically much more important than the market return. The effect of a change in the risk-free rate on credit spread changes is much stronger than the effect of the market return. Furthermore, Collin-Dufresne et al. (2001) find that the market return, which is an aggregated return, has a much larger impact than the firm-specific equity return.
7. There is a significant positive relation between credit spread changes and changes in the volatility of the market. The impact of volatility is similar for US and Euro credit spread changes. Collin-Dufresne (2001) and Van Landschoot (2004) find that the effect of the volatility is asymmetric, i.e. positive changes in the volatility have a much larger impact than negative changes.
8. Liquidity proxies have a significant impact on credit spread changes in Collin-Dufresne et al. (2001) and Van Landschoot (2004). In both studies, the effect becomes stronger for lower rated bonds.

The empirical results in Section 3 and the overview of the literature suggest that the determinants of credit spread changes on US and European corporate bonds are very similar. Although the Euro corporate bond market is less liquid and smaller than the US corporate bond market (see Chart 1), the conclusions are very similar.

The magnitude of the effects depends more on the leverage or rating of the issuing firm and the maturity of the bond than on the country or currency of issuance. To illustrate these findings, we plot the credit spreads on AAA and BBB rated US and Euro corporate bonds with 7 to 10 years to maturity (see Chart 3). The credit spreads on bonds with a similar rating but issued in different regions (US and Euro area) behave in a much more similar way than the credit spreads on corporate bonds with different ratings (AAA and BBB) but issued in the same region. Credit spreads on BBB rated bonds are higher and more volatile than credit spreads on AAA rated bonds, regardless of the country or currency of issuance. We find similar results for bonds with different maturities. Credit spreads on US and Euro corporate bonds with 1-3 (or 7-10) years

CHART 3 CREDIT SPREADS ON US AND EMU AAA AND BBB RATED CORPORATE BONDS WITH 7 TO 10 YEARS TO MATURITY

(Basis points)



Source : Bloomberg (Merrill Lynch).

to maturity behave much more similarly than do credit spreads on Euro (US) corporate bonds with 1-3 and 7-10 years to maturity.

The creation of a Euro corporate bond market has improved (reduced) the diversification (concentration) of credit risk (by definition) because investors have the opportunity to invest in more regions. However, one should not exaggerate this effect. Credit spreads and thus market prices of US and Euro corporate bonds behave in very similar ways. Although we do not perform a detailed analysis of credit risk diversification, Chart 3 seems to indicate that investors should diversify their portfolio by investing in bonds with different ratings and/or maturities.

Empirical studies for both regions are unable to explain more than 45 p.c. of the variation of credit spread changes. This suggests that we still have limited knowledge about the determinants of credit spread changes. Interestingly, it does not appear as if the residual component of the credit spread changes, i.e. the component that remains unexplained by credit risk models, can be considered as idiosyncratic risk. Along these lines, Collin-Dufresne et al. (2001) perform a factor analysis and find that the residual component is mainly driven by one systematic component. We expect that a similar result would be obtained if such an exercise were to be undertaken for Europe.

6. Additional Factors to Explain Credit Spreads

6.1 Components of Credit Spreads

As suggested above, a question that is still unresolved in the literature is why a large part of the dynamics of credit spreads remains unexplained. In order to address this question, several studies (Elton et al. (2001), Delianedis and Geske (2002), Driessen (2003), D'Amato and Remolona (2003), and Perraudin and Taylor (2004)) attempt to decompose the credit spread into several factors such as expected loss, tax effect, liquidity risk, and a risk premium. The risk premium is often defined as an additional premium for risk-averse investors. [16]

Elton et al. (2001) decompose the credit spread into three components, namely expected loss, tax effect, and a risk premium. They find that the taxation difference between corporate and government bonds have a larger impact on credit spreads than expected loss. Furthermore, they conclude that the part of credit spreads that is not accounted for by taxes and expected default (85 p.c.), can be explained as a reward for bearing systematic risk. Driessen (2003) decompose the credit spread into four components, namely expected loss, tax effect, liquidity, and a risk premium. The author describes the risk premium as a premium for the risk associated with changes in credit spreads (if no default occurs) and the risk of the default event. The latter is associated with the jump in prices in case of a default event (default jump risk). [17] The empirical results seem to imply that the default jump risk is not fully diversifiable. Expected loss explains only between 3.5 to 34.7 percent of the credit spreads. Furthermore, the importance of taxes, the risk premium, and the liquidity premium depend on the rating and maturity of the bond. Perraudin and Taylor (2004) find that liquidity significantly influences credit spreads. Making a distinction between low and high liquid bonds according to various liquidity proxies results in spread differences of 10 to 28 basis points for AAA to A grade bonds.

D'Amato and Remolona (2003) argue that credit spreads are largely a compensation for the difficulty of diversifying credit risk *(diversification risk)*. They argue that the assumption that investors can diversify away unexpected losses (which are any losses different from the mean) of default risk by holding a large enough portfolio does not hold in practice. The nature of default risk is such that the distribution of returns on corporate bonds is highly negatively skewed, i.e. the distribution has a long left tail.

As an illustration of skewness, consider the following example. Suppose that we have a portfolio of assets with an average return of 5 p.c. and a standard deviation of 2 p.c. If the distribution of the portfolio returns is strongly negatively skewed, investors have a higher probability of earning returns that are far below the average return of 5 p.c. (extreme losses) than earning returns much above 5 p.c. Investors want to be compensated for this risk unless it can be diversified away. D'Amato and Remolona (2003) conclude that skewness in returns is a critical factor that stands in the way of diversification.

Another factor that may also explain the poor results of previous empirical analyses of credit spreads is recovery risk. The expected loss on a bond depends on the probability of default and the loss given default (or recovery rate). It is very likely that bonds with a high recovery rate will have lower credit spreads. However, individual data on recovery rates are not readily available. Therefore, most empirical studies assume a constant recovery rate, which is similar across assets.

(16) Note that there is no unique definition of "the risk premium". Different studies often have different definitions.

(17) Elton et al. (2001) only consider the risk associated with changes in credit spreads.

6.1 Distribution of Stock and Bond Portfolios

Empirical studies show that credit risk loss distributions have thick tails, i.e. are skewed. However, the prominence of these properties seems to depend on the composition of the specific portfolio under consideration (see Lucas et al. 2001). D'Amato and Remolona (2003) argue that the distributions of bond and stock portfolios are significantly different; bond returns are much more negatively skewed to the left. D'Amato and Remolona (2003) illustrate the difficulty of diversifying credit risk by presenting the loss distribution of two hypothetical bond portfolios.

Similar to D'Amato and Remolona (2003), we perform simulations to obtain the loss distributions of hypothetical portfolios. However, we simulate the loss distributions of bond and stock portfolios in a Merton framework. The aim is to analyse how the loss distribution depends on the composition of the portfolios, the size of the portfolios, the assumptions about the leverage of the firms, the correlation of the assets in the portfolios, and the risk-free rate.

6.1.1 Simulation Exercise: Assumptions

Suppose that we have three portfolios, one of 100 p.c. bonds (bond portfolio), one of 100 p.c. stocks (stock portfolio), one of 50 p.c. bonds and 50 p.c. stocks (mixed portfolio). To analyse whether the size of the portfolio influences the results, we consider portfolios with 50, 100, and 300 assets. We assume that each firm's asset value equals 100 at the start ($t = 0$). In order to evaluate the value of the portfolio after one period, say one year ($t = 1$), we need to make assumptions on how the asset value of the firms evolve. We assume that the average growth rate of the asset value equals 5 p.c., the asset volatility equals 3 p.c., and that the value can make jumps (see jump-diffusion process, i.e. a process that allows for sudden jumps in the asset value).[18] At time $t = 1$, we need to evaluate whether a firm has defaulted or not. In accordance with the Merton model, we assume that a firm has defaulted when the value of the assets falls below the value of the debt. We assume that a firm's balance sheet consists of 50 p.c. debt at time $t = 1$. This implies that a firm defaults if its asset value is smaller than 50 after one year. If default occurs, bondholders will recover the 'residual' asset value. So, the recovery rate is not fixed but depends on the asset value in the case of default. Stockholders lose everything in the case of default. We allow for a correlation of 0.1 between the asset value of the firms issuing bonds and/or stocks. The risk-free interest rate equals 4 p.c.

6.1.2 Simulation Exercise: Results

Table 5 shows the summary statistics of the simulated loss distribution of 9 portfolios: 3 stock portfolios (50, 100, and 300 stocks), 3 bond portfolios (50, 100, and 300 bonds), and 3 mixed portfolios (50, 100, and 300 assets). If we compare the loss distribution of the 100 p.c. bond portfolios and the 100 p.c. stock portfolios, we find that the average loss and the standard deviation of the stock portfolios are much larger compared to the bond portfolios. This is in accordance with our expectations,

(18) In the extreme case of no default, the loss distribution will be a flat line with a probability of one having zero loss. In order to have an "interesting" case study with some defaults, we allow for negative jumps in the asset value. There will be more defaults if we allow for larger negative jumps in the asset value.

TABLE 5 SUMMARY STATISTICS OF SIMULATED LOSS DISTRIBUTION
(Mean and standard deviation are given in percentages)

	Mean	Standard deviation	Skewness	Kurtosis
50 stocks	2.34	2.26	1.04	4.19
50 bonds	0.37	0.46	1.69	6.69
25 stocks & 25 bonds	1.35	1.32	1.07	4.29
100 stocks	2.33	1.72	0.95	4.26
100 bonds	0.37	0.35	1.37	5.64
50 stocks & 50 bonds	1.35	1.00	0.98	4.41
300 stocks	2.34	1.18	0.82	4.06
300 bonds	0.37	0.22	0.98	4.35
150 stocks & 150 bonds	1.36	0.69	0.83	4.08

Source: Own calculations based on 10,000 simulations.

namely that stocks are riskier. Mixed portfolios, i.e. portfolios of 50 p.c. bonds and 50 p.c. stocks, have an average loss and standard deviation between the stock and bond portfolios. If the number of assets increases, the volatility of the losses decreases for all portfolios.

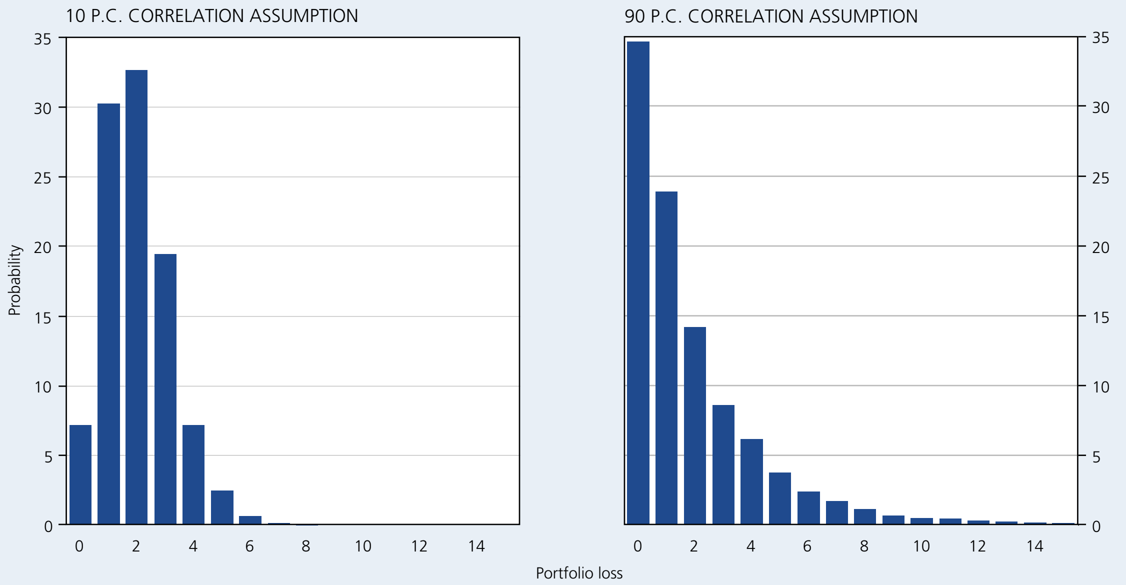
The loss distribution of all portfolios is skewed, which means that the probability of having extremely high losses is higher than having almost no losses. The skewness of the loss distributions of the bond portfolios, is always larger than for the stock portfolios, although the difference in skewness between stock and bond portfolios becomes smaller for larger portfolios. The same holds for the kurtosis, i.e. the peakedness or flatness of the distribution.(19) Our results provide evidence that the loss distributions of bond portfolios are more skewed than stock portfolios and that the composition of portfolios matters. However, if investors hold a mixed portfolio, i.e. a portfolio of stocks and bonds, the skewness and the kurtosis are only slightly higher than for stock portfolios. This result brings into question the importance of the skewness of the loss distribution of bonds compared to stocks for financial institutions that have large mixed portfolios.

To analyse whether assumptions about the correlation between the firms' asset value, the interest rate, the leverage ratio, and the growth rate and the volatility of the firms' asset value influence the results, we change these parameters one by one. First, we change the correlation between the firms' asset value from 0.1 to 0.4 and 0.9. Changing the correlation from 10 p.c. to 40 p.c. does not alter the conclusions. However, if the correlation is extremely high (90 p.c.), the difference between the skewness of the loss distributions of stock and bond portfolios increases for larger portfolios, and diversification becomes more difficult. This result is not surprising, since a high correlation implies that the assets either all survive or default. Chart 4 presents the distribution of portfolios of 300 stocks assuming that the correlation between the firms' value is 10 p.c. and 90 p.c. respectively. Under the assumption of 90 p.c. correlation between the firms' asset values, the loss distribution is much more skewed, i.e. there is a higher probability of experiencing a large number of losses (see right part of chart 4). However, it is very unlikely that the correlation is that high in practice.

Notice that even under the assumption of a high correlation (e.g. 90 p.c.), the skewness of the loss distribution of mixed portfolios is still very similar to that of stock portfolios. This suggests that the 'problem' of the skewness of bond portfolios almost disappears when stocks are added (50 p.c.).

(19) The kurtosis of the normal distribution is 3. If the kurtosis is higher (less) than 3, the distribution is peaked or leptokurtic (flat or platykurtic).

CHART 4 SIMULATED LOSS DISTRIBUTION OF STOCK PORTFOLIO WITH 10 P.C. AND 90 P.C. CORRELATION ASSUMPTION
(Portfolio loss and probability are presented in p.c.)



Source : NBB.

In order to evaluate the effect of the leverage of the firm on our results, we change the composition of the asset value: 70 p.c. debt – 30 p.c. equity and 30 p.c. debt – 70 p.c. equity. Simulations with these new values, however, do not yield qualitatively different results. Furthermore, we find that changing the risk-free rate, the growth rate of the asset value, and the volatility of the asset value influences the results somewhat but does not alter the conclusions.

The main conclusions of the simulation exercise are:

- The skewness of the loss distribution of stock and bond portfolios is lower for larger portfolios (300 assets). This suggests that stockholders as well as bondholders can benefit from having larger portfolios.
- The skewness of the loss distribution of bond portfolios is higher than for stock portfolios. However, the difference significantly decreases for larger portfolios (300 assets) and with a low to moderate level of correlation between firm values (less than 40 p.c.).
- The skewness of the loss distribution of mixed portfolios is only slightly higher than for stock portfolios. Indeed, for large portfolios (300 assets), the skewness of the loss distributions is very similar. Thus, one may question the importance of skewness for institutional investors.
- Although we find that pure bond portfolios are more highly skewed than pure stock portfolios, this analysis does not indicate how important skewness is for credit spreads relative to other factors such as liquidity risk and the systematic shocks.

7. Conclusions

The main focus of this article has been the analysis of the determinants of corporate bond spreads in US and Europe. Structural credit risk models, introduced by Black and Scholes (1973) and Merton (1974), are used to derive determinants of credit spreads such as the risk-free interest rate, the asset value, and asset volatility. Our analysis of Euro corporate bonds (1998-2002), yields results in support of those reported in previous studies. We find a negative relation between changes in the level and the slope of the risk-free term structure and credit spread changes. In addition, we find that high return and a decrease in the volatility of the DJ Euro Stoxx reduces credit spread changes. We also find that credit spread changes significantly increase with liquidity risk. A general conclusion, however, that can be drawn from most empirical studies is that an important portion of the variation in credit spreads remains unexplained.

Our empirical analysis also indicates that the relation between credit spread changes and financial and macroeconomic variables depends on the rating and the maturity of the bonds. Credit spreads on bonds with lower ratings and longer maturities are often more strongly affected by macroeconomic changes than spreads on bonds with higher ratings and shorter maturities.

A comparison of results of empirical studies of US and European credit spreads reveals that the same factors are important for both regions. Even though the US corporate bond market is broader and more liquid, the results for European credit spreads are comparable with those for the US. Examination of the dynamics of credit spreads on different types of corporate bonds, however, suggests that this result should not be surprising. The effect of financial and macro-economic variables on credit spreads appears to depend more on the rating and maturity of the bonds than on the country or currency of issuance. Credit spreads on US and European rated bonds with the same rating exhibit a similar pattern, whereas credit spreads on European corporate bonds with different ratings behave differently.

Empirical studies to date have succeeded in explaining only a small portion of the variation in credit spreads. Several possible explanations for this lack of explanatory power have been put forward, such as liquidity risk, taxation differences, and a risk premium for systematic shocks. Most empirical studies find that liquidity risk and systematic shocks significantly affect credit spreads. Another explanation has been proposed by D'Amato and Remolona (2003), who suggest that diversification risk, i.e. the risk of unexpected losses from default that are present in bond portfolios and cannot be diversified, might explain a substantial portion of credit spread changes. Our simulation analysis has shown that the skewness of the loss distributions of pure bond portfolios is indeed higher than for pure stock portfolios. However, the skewness of mixed portfolios (50 p.c. bonds and 50 p.c. stocks) is very similar to that of pure stock portfolios. This result calls into question the importance of the skewness of pure bond portfolios for explaining credit spread changes. Although these simulations suggest answers to some questions regarding the loss distributions of bond and stock portfolios, it remains an open question as to how important diversification risk is relative to other factors in explaining credit spread changes.

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