The determinants of credit spread changes in the euro area

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1. Introduction

In recent years investors, central bankers, regulators and academics have been studying the markets in default-risky instruments such as corporate bonds, loans or credit derivatives with growing attention. The interest in credit products has increased for a number of reasons. First, credit markets are representative of important structural developments in financial markets. In the United States the shrinking supply of government bonds due to the fiscal surplus has motivated investors to consider alternative assets among fixed income products. In Europe the process of monetary union has increased the pace of integration in the capital markets. Credit markets in the euro area have grown quickly, as the increasing euro-denominated issuance by non-sovereign borrowers indicates. These developments have widened the investment universe and therefore reinforced the importance of analysing corporate bond markets. Furthermore, the changing regulatory framework and the development of new products have generally strengthened the focus on modelling default-risky assets. In particular, the ongoing Basel II process and the rapid development of credit derivatives have motivated researchers to undertake theoretical as well as empirical work on instruments with credit risk.

For a central bank, there are three perspectives on credit markets, based on its activities in setting monetary policy, conserving financial stability and asset management. In the context of monetary stability, credits are studied due to their role in the transmission mechanism. In order to understand the functioning of monetary policy measures, monetary authorities analyse the interdependence between corporate bonds, government bonds and money markets. Thus, they can obtain an insight into how the impulses of monetary policy action are transmitted across financial markets and on towards the real economy. Furthermore, there is evidence that corporate bonds possess leading indicator properties for the economic climate in aggregate. So, the information content of credit spreads makes them useful as indicators for monetary policy. Since the crisis in August 1998, central banks have been increasing their monitoring of potential sources of instability in financial markets. In this context, the systemic risk in the banking sector is regularly observed. This key risk category is heavily influenced by the development of aggregate credit risk among banks and financial institutions. Despite the increasing importance of financial markets, credit risk is still the major component of most banks' activities. Here, corporate bond markets are an important data source, because data on bank loans are difficult to collect. Finally, central banks are active as asset managers, for example when they invest foreign exchange reserves. So, from a treasury perspective, central bankers are interested in determinants of risk factors for portfolio management and hedging.

The purpose of our paper is to study the functioning and the determinants of the pricing process in corporate bond markets. Our study focuses on the euro area. Due to monetary union, the importance of the markets for default-risky assets has grown relative to the historically dominating government bonds. For comparative purposes we include US bond markets, which have been studied in some detail. The markets in the euro area are still at an early stage of development and therefore evidence from the more mature markets in the United States can complement the European perspective.

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As regards related literature, a number of studies are of interest. The comprehensive theoretical literature on the valuation of default-risky assets is surveyed by Nandi (1998), Saunders (1999) and Crouhy et al (2000). Evidence for European credit markets is so far rather limited. Düllmann et al (1998) study DM-denominated debt of a variety of issuers. They analyse the term structures of the spreads and observe a significant influence of interest rates on the spreads. Annaert and De Ceuster (1999) analyse spreads of euro area bond indices with a focus on the behaviour of spreads in different credit quality or maturity categories. Finally, Houweling et al (2001) focus on constructing credit curves. In contrast to the euro area, the US markets for investment grade and high yield debt have been analysed by a number of authors. Closely related to our methodology is the study by Collin-Dufresne et al (2001). This paper studies which factors determine the first differences of credit spreads of individual industrial bonds. Their main finding is that the spreads are mostly determined by a single common factor, which is not related to pricing theory. Another recent study on US credits is Elton et al (2001). The market for US high-yield debt is studied by Cooper et al (2001) or Barnhill et al (2000).

In order to shed some light on the mechanisms in the euro credit market, we analyse three time series of credit spreads. The spreads which we study are the distances between yields of corporate bonds from industrials, financials and plain vanilla interest rate swaps and default-free yields, ie from government bonds. The difference between two categories of yields is a key variable, because it reflects the market's assessment of default risk. Hence, differences between the spreads of different borrowers can indicate the relative riskiness of various categories of debt. In this context, an important caveat is that the spread is not a pure measure of credit risk, because liquidity risk is a potential additional component. By means of econometric techniques we model the determinants of these three spreads and so we can examine the importance of a variety of risk factors. Our approach is to model the spreads in linear regressions with a comprehensive set of variables. We include variables based on theoretical valuation models, a variety of variables related to default-free interest rates and proxies for market liquidity. We distinguish between statistical and economic significance of the estimates. The results provide some insight into the pricing process of default-risky instruments. Hence we can illustrate to what extent spreads are influenced by eg other interest rates, measures of market liquidity or stock prices. Our framework for the interpretation of the econometric results consists of the three central bank perspectives outlined above.

Our principal results are as follows. First, we observe that factors based on yields of German government bonds play an important role in explaining the movements of euro credit spreads. Second, we find a sizeable unobserved component, which may be linked to market-specific factors that are not captured by our model. The comparison of the estimates for the euro area with the US bond markets documents some differences, though overall the results are quite similar, supporting the robustness of our findings.

The rest of this paper is organised as follows. Section 2 describes the methodology and Section 3 our sample. Section 4 summarises our empirical results. Section 5 concludes.

2. Methodology

Our analysis of European credit markets is based on three time series, namely the yields on the Euro Credit Index Industrials and Euro Credit Index Financials, both provided by JP Morgan (JPM), and the 10-year swap rate, which we obtain from Datastream. By means of Ordinary Least Squares (OLS) regression we try to extract the factors that determine the weekly changes in spreads between the yields on the credit indices, or the swap rate, and the yield on risk-free debt, for which we use the yield on 10-year German government benchmark bond (Bunds). For purposes of comparison we investigate the weekly changes in credit spread according to the difference between the yield on the Merrill Lynch Bond Index for US industrials and the yield on the 10-year US Treasury benchmark bond. The following table summarises the variables which we try to explain by means of linear regressions.

Table 1

Dependent variables

Var	Description
Δs_{eu}^{i}	Weekly changes in the spread between the yield on the JPM Euro Credit Index Industrials and the yield on the 10-year German government benchmark bond.
Δs_{eu}^{f}	Weekly changes in the spread between the yield on the JPM Euro Credit Index Financials and the yield on the 10-year German government benchmark bond.
Δs_{eu}^{s}	Weekly changes in the spread between the 10-year swap rate according to Datastream and the yield on the 10-year German government benchmark bond.
Δs_{us}^{i}	Weekly changes in the spread between the yield on the Merrill Lynch Bond Index for US industrials and the yield on the 10-year US Treasury benchmark bond.

The factors which we include in our regression equations are partly motivated by theoretical arguments according to the class of structural models of credit risk. In addition, we include factors which are based on empirical observations and economic reasoning. In the following - after a brief introduction to structural models of default risk - the factors that we use in our estimations will be described in detail.

2.1 Structural models of default risk

The class of structural models of default risk was introduced by Merton as early as 1974 and since then numerous extensions and refinements of Merton's basic formulation have been presented.[3] It has been pointed out by Merton (1974) that issuing a default-risky (zero coupon) bond has the same payoff structure as a risk-free bond plus writing a put option on the firm's value with strike price equal to the face value of the debt. Structural models of the default risk specify a continuous stochastic process for the value of the bond-issuing firm, where default is assumed to occur when the firm's value falls below some threshold, which in the simplest case equals the face value of the outstanding debt. This framework permits the application of standard option pricing theory - like the well known Black-Scholes equation in the basic framework presented by Merton (1974) - to the pricing of a default-risky bond. Its price is simply the price of a risk-free bond with the same face value as the risky debt minus the price of - or plus the value of a short position in - a put option on the firm's value with strike price equal to the face value of the risky bond .

The factors affecting the price of a default-risky bond in a structural model differ for the various variants and extensions of Merton's basic model. They are determined by the respective specification of the firm value process, the definition of the threshold for the default event and other modelling issues like consideration of bankruptcy costs or stochastic interest rates.[4] However, the set of factors which determine the price of a default-risky bond according to Merton's basic specification is common to all of its variants. In Merton's model the price of the put option on the firm's value is given by the well known Black-Scholes formula and hence the factors are the ratio of debt to the value of the firm, ie the leverage ratio, the volatility of the firm value and the risk-free interest rate.

If structural models of the default risk are of empirical relevance, we would expect that the price-determining factors used in this class of models can be used to explain the changes in credit spreads we observe in the corporate bond market. Hence, we include those variables which represent the firm-specific factors on an aggregate level. This is necessary because our estimations do not rely on firm-

3 Shimko et al (1993), Leland (1994) and Longstaff and Schwartz (1995) are some of the more prominent examples.

4 A good introduction to Merton's model and its various extensions and variations can be found in Cossin and Pirotte (2001).

specific data as we try to explain credit spreads implied by the JP Morgan Euro Credit Indices and the 10-year swap rate.

Besides the factors implied by Merton's model, we include additional factors which are motivated by extensions of the basic framework, like the structural model of default risk with stochastic interest rates by Longstaff and Schwartz (1995), as well as variables motivated by empirical evidence such as measures for liquidity risk.

The factors which we use as explanatory variables in our estimations can be divided into three categories: interest rate sensitive variables, variables measuring market liquidity and equity related variables. To some extent, these three categories correspond to the different types of risk which account for the spreads between the yield of corporate bonds, on swap rates, and the yield on government bonds, namely interest rate risk, liquidity risk and credit risk.[5] While the first two of these types of risk apply to all bonds and swaps, government bonds are usually considered to be free of credit risk, and therefore they are called (default)[6] risk-free bonds. In contrast, corporate bonds and swaps are also subject to credit risk and hence they are named (default-) risky assets. However, it should be noted that the sensitivities of corporate bond and swap prices with respect to interest rate and liquidity risk may be different to that of government bonds. Taking this into account, we do not only include variables which refer to credit risk, but consider also interest rate and liquidity risk relevant factors when we try to explain the spread between the yields of default-risky and default risk-free assets. In the following the set of variables which we use in our estimations is described. All changes, returns and volatilities are relative to the frequency on which we base our estimations, namely one week.

2.2 Interest rate sensitive variables

(a) Changes in the 10-year government benchmark bond yield

According to structural models of the credit risk the risk-free spot rate is a relevant factor for the pricing of risky debt. In accordance with Collin-Dufresne et al (2001), who examined the determinants of credit spread changes for the US market, we use changes in the yield of the 10-year government benchmark bond as a proxy for the risk-free spot rate. As has been pointed out above, in Merton's basic framework the price of the put option on the firm value, which determines the price of the risky debt, equals the well known Black-Scholes formula. The risk-free rate enters the Black-Scholes formula as the rate at which the expected payoff of the option at maturity is discounted to the present value. Under the assumption that the average maturity of the corporate bonds in the indices under consideration is about 10 years, it is reasonable to use the 10-year government bond yield as a proxy for the risk-free spot rate.

Changes in the risk-free rate have an inverse effect on the credit spread, ie an increase in the risk-free spot rate leads to a decrease in the credit spread. The reasoning behind this is less obvious than with the other factors that affect the credit spread within Merton's framework: First, if the interest rate increases, the present value of the expected future cash flows, ie the price of the option, decreases. Second, increasing interest rates tend to raise the expected growth rate of the firm value[7] and hence a higher firm value becomes more likely. As has been pointed out above, this implies a lower price of the put option on the firm value. Hence both effects of increasing interest rates decrease the costs of insurance against default, ie the price of the put option on the firm value, which implies a smaller credit spread.

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[5] The correspondence between the different categories of variables and the three types of risk that account for the spread between risky and risk less debt is not an exact one. For example, potential changes in the risk-free interest rate will usually be interpreted as interest rate risk, but the risk-free rate is also a relevant factor in structural models for the credit risk.

[6] Note that in this context the term "default" is sometimes omitted, which can be somewhat misleading in the case of government bonds, because they are still exposed to interest rate and liquidity risk and hence are not entirely risk-free.

[7] A higher interest rate leads to an higher expected growth rate of the firm value because in Merton's setup the drift of the risk-neutral process (ie the expected growth rate) of the firm value is equal to the risk-free interest rate.

For the euro market the time series of weekly changes in the yield of the 10-year benchmark bond was constructed on the basis of the most recent issues of German 10-year bonds (bunds), and for the US market the latest issues of 10-year Treasury bonds were used. The yields of the individual on-the-run benchmark bonds were obtained from Datastream on a weekly basis and linked in order to get a continuous series of benchmark bond yields, from which weekly changes were calculated.[8]

(b) Changes in the volatility of the 10-year government benchmark bond yield

Apart from changes in the level of the risk-free interest rate, we also include its volatility. From a theoretical perspective this factor is motivated by Longstaff and Schwartz (1995), who introduced stochastic interest rates to Merton's basic setup. Furthermore, Collin-Dufresne et al (2001) report that squared changes of the yields of 10-year government bonds add significant explanatory power to their models of credit spread changes in the US market. As we do not have data available on the implied volatility of the risk-free rate, we estimate the historical volatility on the basis of a GARCH(1,1) model. In order to do this, for both markets we first construct a time series of relative weekly changes of 10-year benchmark yields.[9] Then we fit a GARCH(1,1) process to these data, which in turn we use to calculate a time series of weekly volatilities. Finally we take the first differences of this time series and obtain weekly changes of weekly volatilities of the relative changes of the 10-year government benchmark yields.

The influence of volatility can be interpreted as a quantification of convexity, ie the curvature in the interdependence between bond yields and bond prices. Concerning the sign of the respective coefficient, it is not a priori clear if it should be positive or negative, ie if the credit spread falls or rises as the yield volatility increases. Collin-Dufresne et al (2001) report with regard to the squared yield of the 10-year government bonds negative coefficients for high-rated corporate bonds with short maturities and positive coefficients for low-rated short term and all long-term bonds. This result is consistent with respect to the structural model of default risk with stochastic interest rates by Longstaff and Schwartz, where the impact of a change in the yield volatility on the credit spread can be positive or negative.

2.3 Changes in the slope of the government yield curve

The third variable in the category of interest rate related factors is the weekly change in the slope of the term structure. We define the slope as the difference between the yields of 10-year and two-year benchmark government bonds. The continuous time series of benchmark bond yields was constructed as described above on the basis of the yields of individual bund and US Treasury benchmark bonds, which we obtained from Datastream.

The interpretation of the slope of the riskless term structure is twofold: first, in the context of the Longstaff and Schwartz (1995) structural model with stochastic interest rate, in the long run the short rate is expected to converge to the long interest rate. Hence an increase in the slope of the term structure should lead to an increase in the expected future spot rate. This in turn will decrease the credit spread, as has been pointed out above. Second, from a more general perspective, a decreasing slope of the term structure may imply a weakening economy, which in turn may lower the expected growth rate of the firm value and lead to higher credit spreads. Thus both arguments predict an inverse effect of changes in the slope of the yield curve on changes in the credit spread.

(a) Liquidity-measuring variables

Liquidity is without doubt an important source of risk, but its measurement is not an easy task. Theobald et al (1999) argue that measuring liquidity by traditional means like bid/ask spreads and traded volumes may not be adequate in all situations. We will therefore use two different measures of

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8 Although Datastream provides a continuous time series for the yield of the 10-year government benchmark bond, we constructed the time series by ourselves, because Datastream updates the used benchmark bonds only once a month and hence it can happen that an off-the-run benchmark bond is included in the time series instead of the latest issued benchmark bond.

9 We calculate the volatility of relative yield changes, because this makes the bond volatility comparable to equity volatility.

liquidity, which are both based on the spread between more and less actively traded securities in the government bond market. The liquidity measures can be based on the government bond market, because the liquidity premium is highly correlated across markets as has been found by Theobald et al (1999) in their study on valuing market liquidity in US, German and UK bond and swap markets. They conclude that the liquidity conditions in the government markets proxy for the liquidity premia reflected in the pricing of corporate bonds and swaps. In our estimations we use the following variables to account for the liquidity risk:

(b) Changes of the liquidity spread of 30-year government benchmark bonds

A measure of liquidity which has become quite common in recent years is the spread between the yields of on-the-run and off-the-run government benchmark bonds for a certain maturity. The actual benchmark bond for a certain maturity, which is usually the most recent issue with this maturity, is called the on-the-run benchmark, while the previous benchmark, which has been substituted by a newer issue, is called the off-the-run benchmark. If the difference in the remaining time to maturity for both bonds is small and other characteristics, like the coupon payments, are the same, the two bonds should trade approximately at the same price. However, the on-the run-benchmark bond is the most actively traded and hence the most liquid bond for the respective maturity and therefore it is subject to less liquidity risk than the off-the-run benchmark bond. In order to compensate for the higher liquidity risk, the latter trades at a yield which is usually a few basis points above the yield of the on-the-run benchmark bond. Thus, if the characteristics of the two bonds are about the same, the spread between the yields of the two bonds can be interpreted as the liquidity premium.

In times when liquidity is high, the liquidity risk accounts only for a few basis points. But as liquidity dries up, liquidity risk increases and traders are willing to pay a higher price for avoiding this risk. Hence the gap between the yield of on-the-run and off-the run benchmark bonds widens, ie the liquidity premium becomes higher. In crisis situations, the “flight to quality” appears in parallel with a “flight to liquidity”, where an increase of the liquidity premium by more than 20 basis points can be observed. As corporate bonds are usually less liquid than the government bond market we would expect that such a “flight to liquidity” weakens demand in the corporate bond market. Hence, the credit spread should increase with the liquidity spread, all else equal.

We use the liquidity spread calculated on the basis of the yields of 30-year bunds and US Treasuries as a proxy for liquidity in the corporate bond and swap markets we investigate. Again, yields of the on-the-run and off-the-run benchmark bonds are taken from Datastream and the respective time series are constructed analogously to the time series of yields of 10-year benchmark bonds. Finally we calculate the weekly changes of the liquidity spread for the respective markets.

(c) Changes in the liquidity spread of the government bond market

The idea on which our second measure of liquidity is based, is taken from Theobald et al (1999) and it is somehow connected to the liquidity spread. However, it does not measure liquidity on the basis of the on-the-run and off-the-run benchmark bonds for a single maturity, but uses the information of the whole term structure by measuring the relative pricing of government bonds versus a model of the government term structure. Such a model uses observed prices of government bonds in order to estimate the discount function, which is implied by these prices. In order to do this, the discount function defined as a function of some free parameters, which are chosen in a way such that the observed prices, or alternatively the corresponding yields, are approximated as closely as possible[10] by the “theoretical” prices, or yields, ie those which are implied by the estimated discount function. For bonds which have the same characteristics, clearly the theoretical yields are the same. For yields implied by observed prices, this is not always the case, but as there is no relevant default risk, differences in observed yields should be due to liquidity risk.[11] Hence the difference between observed

[10] In this context “as closely as possible” means that the free parameters of the discount function are set such that the summed squared differences between observed prices (yields) and the prices (yields) which are implied by the discount function, are minimised ie the parameters are estimated by Non-linear Least Squares (NLS).

[11] Another source of differences in observed prices could be the so-called coupon effect driven by coupon taxes or considerations related to accounting.

and theoretical yields - the "yield error" - can be interpreted as a measure of liquidity risk related to the individual bonds. The liquidity risk with respect to the whole market is measured by the average absolute deviation from the mean yield error.[12] We call this statistic the liquidity spread of the government bond market and, as with the other measure of liquidity risk, it increases as liquidity worsens and we hence expect that the credit spread increases with it.

The daily estimation of the term structure is based on Svensson's method with Datastream prices for German and US government bonds. For each estimate we calculate the liquidity spread of the respective government bond market and finally produce the time series of weekly changes.

2.4 Equity-related variables

(a) Stock returns

As has been outlined above, in structural models of default risk the firm's leverage ratio is a key variable in determining the price of the debt issued by the firm. The leverage is defined as the ratio of the firm's debt to the value of its assets, or the firm value. Within the framework of structural models default is triggered as this ratio approaches unity. Hence the higher the leverage ratio is, the higher is the risk of default and thus the lower is the price of debt. Therefore the credit spread should increase as the leverage ratio increases, all else equal.

With respect to the put option which determines the price of the risky debt, leverage is the ratio of the strike price (the face value of debt) to the price of the underlying (the firm value). This ratio is the inverse of the moneyness of an option. If leverage is high, the put option is said to be in the money, and if it is low, the option is said to be out of the money. The more the option is in the money, the higher is its price and consequently the higher is the credit spread.[13] More intuitively speaking, the higher the leverage ratio is, or the lower the value of the firm - given a fixed level of debt - is, the more likely it is that the firm will default and hence the more costly the insurance against default should be. The cost of this insurance, which is simply the price of the put option, is reflected by a higher credit spread.

However, in this study we do not analyse credit spreads on a firm-specific level but on the basis of indices for corporate bonds and hence we cannot use the leverage ratio itself as a factor in our estimations. In practice it is quite common to examine the relationship between credit spreads and leverage in terms of changes in equity level, or equity returns. Given a certain level of debt leverage increases as the firm value decreases, this leads to an inverse relationship between firm value and credit spread: the less the firm is worth, the higher the credit spread should be. In the reverse case, we expect that a positive return on the equity index decreases the credit spread.

Besides the theoretical reasoning according to the structural approach, there is another motivation for using the equity return as an explanatory factor of credit spreads. Collin-Dufresne et al (2001) argue that changes in the business climate can have an effect on credit spreads even if the probability of default remains constant over time through changes in the expected recovery rate. One would expect that recovery rates are higher when the economy expands than in times of recession. The return on a representative equity index is commonly used as a proxy for the overall state of the economy, and therefore - analogously to the theoretical argument - we would expect that a positive return on the equity index leads to a decrease in the credit spread.

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[12] Note that Theobald et al (1999) use a different statistic, namely the standard deviation of the yield errors, in order to measure liquidity risk. We prefer to base the summary statistic on absolute deviations, because this seems to be a more natural measure of liquidity risk. In fact it is quite similar to the liquidity spread for a single benchmark bond with a certain maturity. There are two differences: first, liquidity risk is measured with respect to the whole term structure instead of a single maturity, and second, this measure is based on the spread to an average yield, which is given by the theoretical yield implied by the estimated term structure, and not on the spread to the on-the-run benchmark bond. A possible improvement of the presented method could perhaps be achieved if the term structure estimation were based on benchmark bonds only instead of all bonds.

[13] The price of a default-risky bond equals the price of a risk-free bond minus the value of a put option on the firm value and hence a lower absolute price of the put option leads to a higher overall price of the risky bond, which in turn corresponds to a lower yield and a lower credit spread.

The equity index used in the estimations should be in a way representative of the firms that are included in the respective JP Morgan Credit Index. We decided to calculate the weekly returns for the euro area on the basis of the Dow Jones (DJ) STOXX Index family for European equities,[14] because these indices are based on a wide range of liquid European equities and sub-indices are available for various regions and market sectors. In order to account for the different market sectors, to which the three credit spreads under consideration refer, the estimations for the JPM Credit Index Financials, and the swap rates, and those for the JPM Credit Index Industrials are based on different sub-indices of the DJ EURO STOXX Total Market Index (TMI). This index covers 95% of the free floating market capitalisation in the euro area and it is calculated as a price and as a total return index on the basis of US dollars and on the basis of the euro, where we choose the euro denominated price indices[15] of the respective sub-indices for 18 different market sectors.

In particular, we use the DJ EURO STOXX TMI Banks to calculate equity returns for the JPM Credit Index Financials and the swap rates, because most bonds included in this credit index are issued by banks and swaps are usually traded by banks too. In the following we refer to this index as the EURO STOXX JPM Banks Index. Regarding the JPM Credit Index Industrials there is no DJ EURO STOXX Index which is representative for the respective bond issuers. Hence we had to calculate a representative equity index, which was done in the following way. First we calculated weights for the market sectors according to the firms in the JPM Credit Index Industrials on the basis of the overall nominal volume issued by the firms in the respective sectors. Second, these weights were used to construct a new index on the basis of the DJ EURO STOXX Sub-Indices for the respective market sectors. The resulting index will be called the EURO STOXX JPM Industrials Index in the following and should be a representative index for the composition of the JPM Credit Index Industrials.

For the United States we use the Wilshire 5000 Index, which is a much broader index than the Standard & Poor's and should therefore be more representative of the composition of the Merrill Lynch Bond Index for US industrials.

Returns are calculated from the indices by taking the difference of the logarithm of the current index value and the logarithm of the last period's (previous week's) index value. Additionally, we include the equity returns on these indices lagged by one week in the respective estimations, as for US markets it has been reported that lagged values of equity returns do have an impact on changes in bond yields and credit spreads.[16]

(b) Changes in the implied volatility of the return on the equity index

Another factor that affects the credit spread according to the structural approach is the volatility of the firm value. The price of an option increases with the volatility of the underlying, because increasing volatility makes it more likely that the put option will be exercised. In the present context a higher volatility implies that large changes of the leverage become more likely. Hence the probability that the leverage ratio approaches unity, or that the firm value falls below the face value of the debt and the firm defaults, increases. Again, the analysis is not done on the basis of the leverage ratio, but we use the volatility of an appropriate equity index, where we expect that a rise leads to an increase of the credit spread.

In order to obtain the market expectation of variance, we use the volatility, which is extracted from option prices. Unfortunately we do not have data for the implied volatility based on the EURO STOXX and the Wilshire 5000 indices, which we use to calculate equity returns. Instead we use the best substitutes available, namely the VDAX for the euro area and VIX for the US. The VDAX is a DAX-based constant maturity volatility index calculated on the basis of near the money DAX options traded at the Eurex, while the VIX is a volatility index of near the money options on the S&P 100 equity index and is provided by the Chicago Board of Exchange on a daily basis.

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[14] See STOXX Limited (2001) for a detailed description of this index family. The data are available on the internet at http://www.stoxx.com.

[15] The price index includes only dividend payments larger than 10% of the equity price and special dividends from non-operating income, in contrast to the total return index, which includes all dividend payments.

[16] See for example Kwan (1996).

Table 2 summarises the factors which we use in our estimations and the corresponding signs that we expect for the respective estimates of the parameters.

Table 2

Explanatory variables and expected signs for parameter estimates

Var	Description	Sign
Δy_c^{10}	Weekly change in the yield of 10-year government benchmark bond	-
$\Delta \sigma_c^y$	Weekly change in the one-week volatility of the 10-year government benchmark bond yield obtained from estimated GARCH(1,1) model	~
Δsl_c	Weekly change in the slope of the government yield curve according to the spread between the 10 and the two-year government benchmark yield	-
$\Delta \ell_c^{30}$	Weekly change in the liquidity spread of the 30-year government benchmark bonds according to the difference between the respective on-the-run and off-the-run bonds	+
$\Delta \ell_c$	Weekly change in the liquidity spread of the government bond market according to the average absolute deviation from the mean yield error obtained from daily term structure estimates using Svensson's model	+
$r_{c,e}$	Weekly equity return based on the EURO STOXX JPM Banks Index ($e = b$) for $c = eu$ and estimation of Δs_{eu}^f, Δs_{eu}^s, based on the EURO STOXX JPM Industrials Index ($e = i$) for $c = eu$ and estimation of Δs_{eu}^i and based on the Wilshire 5000 Index ($e = i$) for $c = us$	-
$r_{c,e}^{t-1}$	Weekly return as defined by $r_{c,s}$ in the previous period/week	-
$\Delta \sigma_c$	Weekly change in the one-week implied volatility according to the VDAX for $c = eu$, and according to the VIX for $c = us$	+

Note: The interest sensitive variables and those measuring liquidity are all based on German bunds for $c = eu$ and on US Treasuries for $c = us$. The equity returns for $c = eu$ are calculated on the basis of the EURO STOXX TMI Sub-Indices for different market sectors in order to match the composition of the credit spreads regarding the market sectors of the respective firms.

2.5 Description of the data

Before outlining our sample, we provide a brief overview on the corporate bond markets in the euro area. The market size at the end of 2000 was \$4 trillion for non-government bonds in the euro area and \$13.2 trillion for US dollar credits.[17] In contrast to these considerable differences in market capitalisation, the levels of new issuance were quite similar in both regions in 1999 and 2000. For the bond markets of the euro area JP Morgan offers the representative JP Morgan Aggregate Index Euro.[18] The volume in this index separates into 64.5% for governments, 11.6% Pfandbriefe, 6.3% financial institutions, 9.4% corporates and 8.2% supranational or sovereign non-EMU borrowers.

17 See ECB (2001) and BIS (2001).

18 See JP Morgan (2001).

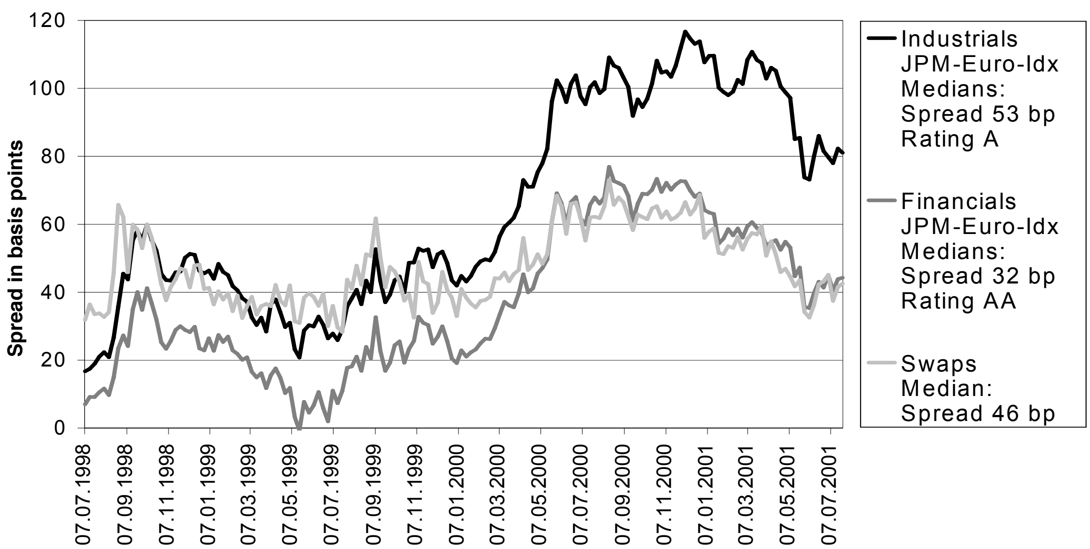
Our study is based on the Euro Credit Index Industrials and Euro Credit Index Financials. In addition to these two categories of corporate debt, we include the spread relative to 10-year interest rate swaps. This distance is frequently interpreted as an indicator of default risk on the interbank market and is therefore used for monetary policy analysis (ECB, (2000)). We compute three spreads relative to the yield on the 10-year bund benchmark.

Our sample comprises the period from 14 July 1998 to 24 July 2001. In order to obtain a reasonably large sample, we begin before the official start of EMU. However, in July 1998 uncertainty about the process was already quite low and therefore we can assume this period to be homogeneous.

Graph 1 depicts the three spread series and Table 3 summarises some details. As regards the credit quality of the issuers in the two index series, median Industrials are rated A and median Financials are rated AA.[19] The median spread is 53 bp (Industrials), 32 bp (Financials) and 45 bp (Swaps). In general, spreads fluctuate with a weekly standard deviation of 10-30 basis points. In the graph, the rise of the swap spread during the LTCM crisis in August 1998 is notable. The maximum was achieved for all spreads in the second half of 2000, namely for Industrials on 12 December 2000 with 120 bp, for Financials on 15 August 2000 with 80 bp and for Swaps on 15 August 2000 with 73 bp. The second half of 2000 was characterised by two major developments. Market participants focused with growing concern on the financial situation of debtors from the telecommunications sector and, simultaneously, the economic climate in the United States began to deteriorate.

Graph 1

Time series of euro credit spreads



Sources: JP Morgan, Datastream.

Given that the levels of dependent and independent variables possess unit roots, the first differences form the basis for our estimations. Our sample comprises 159 data points. Table 4 in the Appendix presents some descriptive statistics about the weekly changes of the spreads and the explanatory variables, measured in percentage points. The mean of the weekly changes of our variables is close to zero in most cases. For the interest rate variables in particular, the Jarque-Bera statistics indicate that the empirical distribution deviates strongly from the normal. In the lower half of Table 4 in the Appendix, the correlations between dependent and independent variables are provided. We observe correlations of more than 0.7 between the three spread changes. Given our common set of

19 Average cumulative default rates for 10-years (Crouhy et al, (2000)): AA (1.29), A (2.17), BBB (4.34).

explanatory variables, we would expect that, to some degree, the correlations are accounted for by these factors. When we evaluate the interaction between independent and dependent variables, the first differences of government yields and the slope show the highest correlations. Among the set of independent variables, the strongest linkage exists between stock returns and volatility, with a value of around –0.6. Furthermore, the three variables based on bund yields are correlated with values below 0.3. The remaining correlations are all less than 0.15 and hence evidence for multicollinearity is weak.

Table 3
Euro credit spreads

	Number of bonds	Distribution according to rating in %						Descriptive statistics of credit spread in %			
		AAA	AA	A	BBB	High-yield	Not rated	Median	Max	Min	Std Dev
Industrials	473	7.3	14.9	41.6	25.1	3.2	7.9	0.53	1.17	0.17	0.30
Financials	505	19.5	43.8	31.3	0.8	0.8	3.8	0.32	0.77	-0.01	0.21
Swaps								0.46	0.73	0.28	0.11

Sources: JP Morgan, Datastream.

2.6 Model estimation and model selection

As has been mentioned already, we use OLS regressions to explain the three credit spreads for the euro area and the spread for the US corporate bond market. For each series we perform two regressions. First we estimate an equation in which all explaining factors according to Table 2 are included; formally we estimate

$$\Delta s_c^m = \beta_1 \Delta y_c^{10} + \beta_2 \Delta \sigma_c^y + \beta_3 \Delta sl_c + \beta_4 \Delta \ell_c^{30} + \beta_5 \Delta \ell_c + \beta_6 \Delta r_{c,e} + \beta_7 \Delta r_{c,e}^{t-1} + \beta_8 \Delta \sigma_c^r + \varepsilon_c^m ,$$

with $e = b$ and $m = f, s$, $e = i$ and $m = i$ for $c = eu$ respectively $m = i$ and $e = i$ for $c = us$. This results in four equations, three for the spreads $s_{eu}^i, s_{eu}^f, s_{eu}^s$ which we analyse for the euro area and one spread s_{us}^i for the US corporate bond market. The residuals are assumed to have an expected value $E(\varepsilon_c^m) = 0$, variance $Var(\varepsilon_c^m) = \sigma_{c,m}^2$ and to be uncorrelated $E(\varepsilon_{c_1}^{m_1} \varepsilon_{c_2}^{m_2}) = 0$ for $m_1 \neq m_2$ and $c_1 \neq c_2$.

Typically, not all of the estimated parameters are statistically significant. However, the objective of our analysis is not only to determine the factors which explain the various credit spreads under consideration, but in addition we want to analyse how - in particular large - changes in the explanatory variables affect the credit spreads. Because a model that contains insignificant variables would not be very helpful with respect to this task, a second model is estimated for each credit spread.

In order to find an appropriate model for each credit spread, we do not simply remove the variables with statistically insignificant parameter estimates, because this can affect the estimates for the parameters of the other factors and the respective statistical significance. Instead we use a heuristic model selection procedure in order to find a model, which will be referred to as the "parsimonious model" in contrast to the "complete model" which includes all factors listed in Table 2. This procedure works as follows: first, for every possible combination of factors to be included in the regression equation we estimate the respective parameters by OLS.[20] From this set of models, we select those

[20] For the Euro spreads an additional moving average term is included in the regression equation due to serial correlation in the residuals.

which have statistically significant parameter estimates given a significance level of 90% and for which the signs correspond to what we expect from theory, as summarised in Table 2. The remaining models are then sorted according to the Akaike Information Criterion (AIC) and the model with the lowest AIC is selected as the "parsimonious model". Hence, in the following for each credit spread we describe two estimated models, namely the complete and the parsimonious model.

3. Results

In the following we first present the estimates regarding the European credit spreads. We discuss our estimation results using the entire set of explanatory variables and the results from our model selection procedure, where we evaluate the explanatory value of the individual variables. In this context we also evaluate the economic significance of our results, which means that we also look at the size of changes in the credit spreads as a result of changes in a specific factor, given a statistically significant parameter estimate for this factor. We continue by comparing the regressions for the US and euro series. Finally, the results for the inclusion of some additional variables in our regression equations will be discussed.

3.1 Results for European credit markets

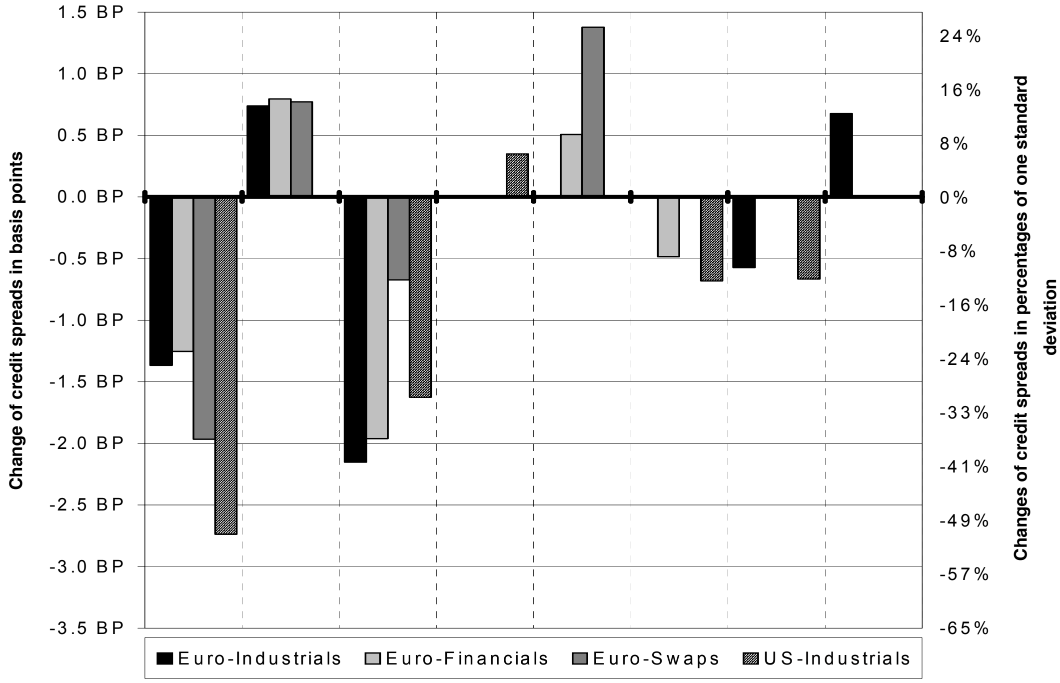
Table 6 in the Appendix shows the estimates for Industrials, Financials and Swaps with the common set of explanatory variables. Our first observation is that variables based on bund yields play a very important role as determinants of credit spreads. With respect to the European credit markets, with one exception all interest rate sensitive variables show statistical significance and all of them are included in the models which were found by our model selection procedure. The exception refers to the volatility of the bund yields, which is not significant in the model for the swap spread with all factors included. However, concerning the parsimonious model, there is some statistical evidence that the bond yield volatility might affect the swap spread, although with a p-value of 0.05 this evidence is not very strong.

The benchmark yield and the slope of the yield curve have a statistically significant influence on all three spreads, with coefficients around 0.1 for the yield and up to -0.28 for the slope. The signs are in accordance with bond pricing theory. As has been pointed out in Section 2.2, according to the Merton model the changes of yields affect spreads in a negative form, ie when the general level of interest rates rises, the spread falls. The negative sign of the parameter for the slope of the term structure is also in line with what we expected. From the theoretical point of view a decrease in the slope should lead to a higher expected future spot rate and hence a rising credit spread. The same is true, when the slope is interpreted as an indicator for future economic growth. The estimated coefficients are large enough for economic significance to be present. Among interest rate variables, apart from the exception mentioned above, the yield volatility to be statistically significant, but its coefficients are rather small in the three series and hence economic significance is ambiguous.

In the literature on determinants of the yields on government bonds (eg Bliss (1997)), three factors are frequently documented: the level, slope and curvature of the yield curve. For the distance between yields on default-risky and default-free assets, we find that the key factors are the level and the slope of the term structure. This result is also confirmed by Graph 2, which shows the impact of a change of one standard deviation on the credit spreads. According to this graph a change of one standard deviation in the yield, or the slope, results in a change of 1.5 to 2.0 basis points in the respective credit spreads, which corresponds to 30-50% of a standard deviation of credit spread changes. Therefore, our first result is that there are considerable similarities between the credit markets and the markets for government securities. With respect to theoretical models this result gives support to extensions of Merton's basic model which explicitly model stochastic interest rates, like the model by Longstaff and Schwartz (1995).

Graph 2

Changes in credit spreads in response to changes in factors by one standard deviation according estimates of parsimonious model



Note: The left-hand scale shows the change of credit spreads in response to a change of one standard deviation in the factors in basis points. The right-hand scale shows this change as a percentage of the average standard deviation of all time series of credit spread changes. As the standard deviations are more or less the same for all credit spreads, this scale measures the responses as (approximate) percentages of credit spread standard deviations.

Besides interest rate risk, the behaviour of market liquidity is a potentially important determinant of the spreads between risky and risk-free debt. As mentioned before, we use two measures, namely the liquidity spread of 30-year government benchmark bonds, ie the difference between the on-the-run and the off-the-run 30-year benchmark bund, and the liquidity spread of the government bond market, which is the average absolute deviation from the mean yield error derived from a term structure estimation according to Svensson's (1994) model. The regression results show that the second measure has a strong impact on the changes of credit spreads. Statistical significance is found only for Financials and Swaps, but not for Industrials. Hence the liquidity spread of the government bond market was included by our model selection procedure in the parsimonious model for the swap and the financial credit spread. However, it should be noted that, while the estimate is highly significant with respect to the first two spreads, this is not the case for the Industrials. In addition economic significance is only evident for the swap market, because a change of one standard deviation in the liquidity spread leads to a change of merely half a basis point in the Financials spread - in contrast to 1.5 basis points with respect to the swap spread, which can be seen in Graph 2. Therefore, we conclude that liquidity risk is priced only in some segments of the credit markets, as there is no evidence for a significant impact of our respective measures on the credit spreads of Industrials and as regards Financials significance is at least doubtful from the economic point of view. However, the impact is positive for all credit spreads, so, based on our construction of the measure, an increase in the average absolute deviation from the mean yield error, ie rising liquidity risk, raises the spread. Again, this is in accordance with what we expected, as a "flight to liquidity" raises demand for highly liquid government securities relative to less liquid corporate bonds.

When we turn to the impact of the equity-related variables on spreads, we can evaluate whether the predictions of the Merton model are validated in European credit markets. We observe that our proxy for equity volatility is significant only for the Industrials spread in the reduced model. Our model selection procedure includes equity volatility in the parsimonious model and with a p-value of 0.02 there is quite strong evidence for statistical significance. According to Graph 2, the impact of a change in volatility by one standard deviation is quite small, but equity volatility can be subject to large changes during a crisis situation. Hence, if there is a change in volatility by several standard deviations, the effect on the credit spread would indeed be economically significant. But, in the case of the yield differential for Financials and Swaps, the VDAX has no measurable impact at all. The positive signs - which we observe for the significant as well as for the insignificant estimates - are in accordance with Merton's model, namely increasing volatility has a positive effect on the spread of default-risky assets. The reason behind this mechanism is that rising variability of future stock returns means more uncertainty about the development of asset values and so the risk premium moves up. One interpretation for the differential impact of volatility comes from the differences in credit quality. From the option pricing perspective, lower credit quality means that the bond is more at the money, ie the strike price of the corresponding option is close to the current price. In this case, the volatility of stock returns has a larger impact on the value of the option. Table 3 shows that the debtors included in the Industrials index on average have a lower credit quality and so the volatility has a stronger impact.

The second equity-related factor with a possibly large influence on spreads is the level of stock prices, or the stock return. According to theory, the stock price has a key role in the financial strength of a firm, because it drives its leverage ratio. The behaviour of stock prices is also frequently used as an indicator of economic sentiment in general. According to Table 6 we find an impact of the current return on Financials and a significant influence of last week's return on the Industrials for both the parsimonious and the reduced models. The negative sign is in accordance with theory: as stock prices rise, risk premia in credit markets fall, because the financial strength of the debtors improves. As with volatility, the size of the respective coefficient is quite small and therefore we find only statistical significance. According to Graph 2, the impact of a change of the current or lagged equity return by one standard deviation on the credit spread of Industrials and Financials is similar to that for for volatility. But again, as equity returns are known to be fat-tailed, large changes with a significant influence on the credit spread are likely to happen sometimes. An explanation for the impact of lagged stock prices on Industrials is based on the fact that some of the information is already captured by equity volatility. The reason for this interdependence is the sizeable leverage effect. The negative correlation between returns and volatility is known as the leverage effect, because of the empirical observation that the standard deviation of a stock increases with the leverage of a firm. For our sample, Table 3 shows that the correlation between stock returns and VDAX is –0.62 for the EURO STOXX JPM Industrials Index and –0.67 for the EURO STOXX JPM Banks Index. Therefore, it seems plausible that the current stock price does not have a strong effect. Instead, the lagged stock price matters in the case of Industrials. As the autocorrelation in index returns is -0.1 at lag one and the effect of the contemporaneous stock price should be negative, the positive sign on last week's return is plausible.

Among the summary statistics of the regressions, all Durbin-Watson statistics are close to two, when we include a moving average with lag one. To judge the overall fit of our set of proxies for interest rate risk, liquidity risk and stock market developments, the R^2s are of particular interest. The measures of determination are between 34% and 41% and indicate that our variables have some information content. Overall, the unexplained fraction of the variability of credit spreads is sizeable. This result is particularly remarkable given the comprehensive set of explanatory variables which we have applied. In this context, we have also computed the correlation of the residuals from the three regressions. From Table 3 we have seen that the interdependence between the first differences of the spreads is sizeable. We would expect the residuals to show a weak correlation, because the common factors are accounted for by the explanatory factors. Therefore, the residuals are a proxy for the idiosyncratic component, which is not captured by our set of explanatory variables. Table 7 shows that the correlations between the residuals are only fractionally smaller than those between the dependent variables. This pronounced interdependence in the residuals indicates the presence of a large unobserved common component, which is not reproduced by our models. A similar result is documented by Collin-Dufresne et al (2001) for US corporate bonds. They show that the residuals from regressions on the spreads of individual bonds are heavily correlated. Their interpretation is that US credit markets are segmented from stock and Treasury markets. Another interpretation of the unobserved component is offered by Elton et al (2001). These authors argue that the US credit spreads are influenced by default risk, fiscal aspects and a risk premium. According to their estimations, the returns on corporate bonds contain a sizeable risk premium due to a systematic source of risk which cannot be diversified.

Table 7

Correlation of residuals of complete model for the euro area

Variable	ε_{eu}^{i}	ε_{eu}^{f}	ε_{eu}^{s}
ε_{eu}^{i}	1.000		
ε_{eu}^{f}	0.813	1.000	
ε_{eu}^{s}	0.676	0.763	1.000

In this context, the size of the correlation of US dollar and euro swap spreads is of interest. There may be expected to be some commonalties between the spread series. We find that the two series are correlated with a value of -0.02 for the time period from January 1997 to July 2001. This weak interdependence indicates the absence of a common component between US dollar and euro swap spreads.

3.2 Comparative analysis with US evidence

In order to represent the US credit markets, we use the Merrill Lynch Bond Indices for US Industrials with an investment grade rating. This index is representative of the developments in the market for debtors with a rating between AAA and BBB. Given the state of development in this market, we use a longer sample, starting on 8 January 1991 and ending also on 24 July 2001. Our series contains 551 observations. The median spread is 98 bp, the maximum of 223 bp was reached on 26 December 2000 and the minimum of 60 bp on 30 July 1996. These descriptive statistics show that the general level of the spread is higher in the US than in the euro area. One reason for this difference lies in the fact that the US series contains a complete business cycle whereas the euro area index is not available for a period of significant defaults.

The estimation results for the model comprising all variables and the specification chosen by our model selection procedures are presented in Table 6 after the results for the euro area. As in the euro series, the level and the slope of the term structure show very high significance. According to Graph 2 the influence of the interest rate related factors on the credit spread is roughly the same as in the European markets. Thus, in both markets, the proxy for the risk-free rate is of prime importance for determining the changes in credit spreads. The results of the model selection procedure show that the variability of stocks and Treasuries has no significant influence on US credit spreads. So, comparing the US and the euro area results, the main observation is that the volatility only has an impact in the euro markets. In contrast, US spreads are heavily influenced by stock returns.

Regarding the US credit spread for Industrials we can observe from Table 6 that both the current and the lagged return on the Wilshire 5000 are statistically significant, whilst for the euro Financials and Industrials this is only the case with respect to a single return, from the present or past period. Both respective coefficients are around -0.003. In terms of changes by one standard deviation, Graph 2 shows that this corresponds to a change of 0.5 basis points in the credit spread, which is about the same as for the European Industrials. However, Collin-Dufresne et al (2001) report that a change of 1% in the S&P is associated with a credit spread decrease of about 1.6, which is about five times more than what we have found.

With respect to the role of liquidity, some differences emerge. We find that different measures are significant: with regard to the complete model for the US market both measures are significant, though the liquidity spread of the entire government market is only significant at the 90% level and our selection procedure does not include this liquidity measure in the reduced model as was the case for the European model. For the US market however, the liquidity measure according to the spread between on-the-run and off-the-run 30-year benchmark bonds shows high significance with respect to the complete and the reduced model. One explanation for this difference is that, in the German government bond market, the spread between on-the-run and off-the-run issues has a lower information content regarding liquidity risk. The nominal coupons of successively issued 30-year bunds differ strongly and hence the spread between on-the-run and off-the-run benchmark bonds is partly due to this difference.

In general the estimation results for the two areas are quite similar. For example, the euro Industrials estimates show that the level of the term structure has an impact of -0.14. For the corresponding US series, the coefficient is -0.21. The slopes are even almost identical between the two regions. Finally, when we evaluate the R^2s, we find that the measure of determination is higher than in the three euro series. So, our set of variables has a higher explanatory value for the more developed US market. Overall, we can conclude that, despite some differences, there are considerable similarities between the two markets. This result shows that the state of development is not altogether strongly reflected in our estimates.

3.3 Additional variables

As regards other variables which we have not included in our initial set of explanatory factors, we found no factors adding information to our models. We proceeded in three steps. First, we tried various proxies for the short-term spot rate. For the US market we used the three-month Treasury bill rate and for the euro market the three-month Euribor. We also experimented with an estimated instantaneous spot rate, which we obtained from estimates of the entire term structure.[21] None of these proxies for the short-term rate showed a significant impact on the credit spreads. Second, we added price/earnings ratios to the set of variables. With respect to the credit spread of Industrials some evidence of statistical significance was found. However, according to our selection procedure, this factor adds the same information as equity returns because the procedure included price/earnings ratios alternatively to one of these variables. Finally, the influence of the reduced supply of US Treasuries observed since the beginning of 2000, was analysed through inclusion of a dummy variable. However, a significant influence was not found.

4. Conclusion

This paper has examined which factors influence the first differences of credit spreads in the euro area. We evaluate three series, namely the yield distance for Industrials, Financials and for plain vanilla interest rate swaps. By means of linear regressions, we examine the significance of various factors proxying for interest rate, credit and liquidity risk. Our principal result is that interest rates, in particular the level and slope of the risk-free term structure, are the most important determinants of credit spreads. In addition, stock returns, the volatility of stock returns and bond yields and proxies for liquidity risk are significant factors. We examine statistical as well economic significance to quantify the overall effects of the various factors. When we analyse the residual series from the three regressions, we find a sizeable common unobserved component. A comparison of the estimates for the euro area with the established US bond markets shows some differences. However, overall, the results are quite similar and therefore, support the robustness of our findings.

In order to extend the results in this paper we intend to analyse how the credit spreads behave according to our model in a crisis situation like a stock market crash. Another direction seems to be particularly interesting. Instead of relying on aggregate spreads taken from an index, it seems promising to study the euro corporate market on the level of individual issues. On such a disaggregate level, the variation of yields across debtors could increase the information set. In addition, a sample of individual bonds makes it possible to include more elaborate measures of credit risk. One frequently used measure is the expected default frequency (EDF). King (2001) shows that this variable, which combines stock prices and equity volatility in a Merton-type model, has a high explanatory value for the dynamics of yield differences.

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[21] The instantaneous spot rate was obtained from the same Svensson (1994) model from which the liquidity spread of the government bond market was derived. One of the model's parameters can be interpreted as the risk-free instantaneous spot rate - the spot rate with maturity converging to zero - and hence one gets a time series of estimates of the instantaneous spot rate by periodically fitting the discount function according to Svensson to observed market data and collecting the respective parameter estimates.

Appendix

Table 4: Descriptive statistics of variables used in regressions for euro area

	Δs^{i}_{eu}	Δs^{f}_{eu}	Δs^{s}_{eu}	Δy^{10}_{eu}	$\Delta \sigma^{y}_{eu}$	Δsl_{eu}	$\Delta \ell^{30}_{eu}$	$\Delta \ell_{eu}$	$r_{eu,i}$	$r_{eu,b}$	$\Delta \sigma^{r}_{eu}$
Mean	0.004	0.002	0.001	0.002	0.000	0.000	0.000	0.000	0.010	-0.056	-0.001
Median	0.002	0.007	0.002	-0.002	-0.065	-0.004	0.000	0.000	-0.167	-0.036	-0.017
Maximum	0.140	0.121	0.200	0.340	2.713	0.280	0.025	0.019	9.567	11.528	1.202
Minimum	-0.122	-0.116	-0.163	-0.301	-0.943	-0.252	-0.029	-0.012	-11.812	-14.770	-1.383
Std dev	0.045	0.043	0.057	0.098	0.359	0.077	0.008	0.004	3.455	3.199	0.393
Skewness	0.168	0.075	0.345	0.221	2.914	0.129	-0.367	0.654	-0.160	-0.584	0.205
Kurtosis	3.555	3.107	3.874	3.921	22.405	4.377	5.469	6.187	3.494	6.310	4.278
Jarque-Bera	2.8	0.2	8.2	6.9	2719.6	13.0	43.9	78.6	2.297	81.611	11.9
Probability	0.248	0.893	0.016	0.032	0.000	0.002	0.000	0.000	0.317	0.000	0.003
Δs^{i}_{eu}	1.000										Correlation matrix
Δs^{f}_{eu}	0.895	1.000									
Δs^{s}_{eu}	0.697	0.774	1.000								
Δy^{10}_{eu}	-0.441	-0.452	-0.417	1.000							
$\Delta \sigma^{y}_{eu}$	-0.015	0.015	0.095	0.191	1.000						
Δsl_{eu}	-0.481	-0.431	-0.111	0.290	0.303	1.000					
$\Delta \ell^{30}_{eu}$	0.015	-0.025	-0.007	0.123	0.040	-0.040	1.000				
$\Delta \ell_{eu}$	0.026	0.056	0.207	-0.001	0.138	0.089	-0.010	1.000			
$r_{eu,i}$	-0.096	-0.037	-0.023	-0.007	0.014	0.010	-0.045	-0.065	1.000		
$r_{eu,b}$	-0.197	-0.101	-0.100	-0.015	-0.065	-0.014	0.011	0.010	0.640	1.000	
$\Delta \sigma^{r}_{eu}$	0.148	0.088	0.107	-0.085	0.089	0.038	-0.158	0.093	-0.619	-0.672	1.000

Table 5: Descriptive statistics of variables used in regressions for US area

	Δs^{i}_{us}	Δy^{10}_{eu}	$\Delta \sigma^{y}_{us}$	Δsl_{us}	$\Delta \ell^{30}_{us}$	$\Delta \ell_{us}$	$r_{us,i}$	$\Delta \sigma^{r}_{us}$
Mean	0.000	-0.005	0.001	0.000	0.000	0.000	0.227	0.001
Median	-0.002	-0.013	-0.037	0.002	-0.001	0.000	0.399	-0.006
Maximum	0.385	0.505	1.223	0.275	0.094	0.035	7.556	1.518
Minimum	-0.152	-0.440	-0.476	-0.246	-0.051	-0.028	-10.183	-1.514
Std dev	0.045	0.132	0.193	0.063	0.011	0.007	2.088	0.327
Skewness	1.097	0.082	2.373	-0.123	1.986	0.403	-0.513	0.123
Kurtosis	12.971	3.469	13.546	4.743	16.295	5.352	4.790	6.106
Jarque-Bera	2393.2	5.7	3070.1	71.1	4420.4	141.9	97.7	222.8
Probability	0.000	0.058	0.000	0.000	0.000	0.000	0.000	0.000
Δs^{i}_{us}	1.000							Correlation matrix
Δy^{10}_{us}	-0.624	1.000						
$\Delta \sigma^{y}_{us}$	-0.025	0.115	1.000					
Δsl_{us}	-0.392	0.105	0.027	1.000				
$\Delta \ell^{30}_{us}$	0.108	-0.037	0.093	0.006	1.000			
$\Delta \ell_{us}$	0.020	0.119	0.048	-0.048	0.143	1.000		
$r_{us,i}$	0.035	-0.180	-0.073	-0.189	-0.074	-0.044	1.000	
$\Delta \sigma^{r}_{us}$	-0.007	0.072	0.069	0.140	0.071	0.059	-0.722	1.000

Table 6

Results of estimations for credit spread changes

	Euro-industrials: Δs_{eu}^{i}						**Euro-financials: Δs_{eu}^{f}**					
	Complete model			**Parsimonious model**			**Complete model**			**Parsimonious model**		
Var	Coeff	t-Stat	p-Val	Coeff	t-Stat	p-Val	Coeff	t-Stat	p-Val	Coeff	t-Stat	p-Val
Δy_c^{10}	-0.136	-4.453	0.000	-0.140	-4.610	0.000	-0.128	-4.615	0.000	-0.128	-4.756	0.000
$\Delta \sigma_c^{y}$	0.019	2.186	0.030	0.021	2.424	0.017	0.021	2.514	0.013	0.022	2.789	0.006
Δsl_c	-0.283	-7.102	0.000	-0.280	-7.029	0.000	-0.254	-7.048	0.000	-0.255	-7.175	0.000
$\Delta \ell_c^{30}$	0.279	0.781	0.436				0.087	0.258	0.797			
$\Delta \ell_c$	0.639	0.887	0.377				1.226	1.749	0.082	1.220	1.772	0.078
$r_{c,s}$	0.000	0.138	0.890				-0.001	-1.275	0.204	-0.002	-1.902	0.059
$r_{c,s}^{t-1}$	-0.002	-2.182	0.031	-0.002	-2.044	0.043	0.000	-0.222	0.825			
$\Delta \sigma_c^{r}$	0.020	1.976	0.050	0.017	2.296	0.023	-0.001	-0.058	0.953			
MA(1)	-0.170	-2.061	0.041	-0.148	-1.838	0.068	-0.345	-4.304	0.000	-0.344	-4.397	0.000
R^2		0.397			0.387			0.408			0.408	
$\bar{R}^2$		0.365			0.367			0.377			0.388	
DW		1.980			1.961			1.986			1.986	

	Euro-swap: Δs_{eu}^{s}						**US-industrials: Δs_{us}^{i}**					
	Complete model			**Parsimonious model**			**Complete model**			**Parsimonious model**		
Var	Coeff	t-Stat	p-Val	Coeff	t-Stat	p-Val	Coeff	t-Stat	p-Val	Coeff	t-Stat	p-Val
Δy_c^{10}	-0.201	-5.203	0.000	-0.201	-5.427	0.000	-0.211	-12.72	0.000	-0.207	-13.01	0.000
$\Delta \sigma_c^{y}$	0.022	1.815	0.072	0.022	1.974	0.050	0.006	0.591	0.555			
Δsl_c	-0.083	-1.687	0.094	-0.087	-1.805	0.073	-0.255	-9.208	0.000	-0.257	-9.460	0.000
$\Delta \ell_c^{30}$	0.273	0.590	0.556				0.273	2.725	0.007	0.316	2.956	0.003
$\Delta \ell_c$	3.248	3.328	0.001	3.313	3.438	0.001	0.372	1.720	0.086			
$r_{c,s}$	-0.002	-0.997	0.320				-0.003	-2.313	0.021	-0.003	-2.008	0.045
$r_{c,s}^{t-1}$	0.001	0.788	0.432				-0.003	-4.207	0.000	-0.003	-4.436	0.000
$\Delta \sigma_c^{r}$	0.001	0.060	0.952				0.001	0.128	0.898			
MA(1)	-0.382	-4.832	0.000	-0.387	-5.058	0.000						
R^2		0.342			0.332			0.547			0.544	
$\bar{R}^2$		0.307			0.315			0.542			0.540	
DW		2.004			2.002			1.950			1.944	

Note: The R^2 with bar denotes the R^2 adjusted for the number of parameters. *DW* is the Durbin-Watson test statistic for the presence of first order autocorrelation in the residuals. Under the null hypothesis that there is no autocorrelation in the first lag the Durbin-Watson statistic equals two. In addition the Breusch-Godfrey LM Test for serial correlation was performed. The results are the same, ie there is no evidence for autocorrelation. The residuals were also tested for the presence of heteroskedasticity using White's test and an ARCH-LM test. Both tests indicate that there is no heteroskedasticity in the residuals of the European models, but for the US models strong evidence for the presence of heteroskedasticity was found. Hence White's heteroskedasticity-consistent estimator was used to calculate the respective standard errors and covariance.

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