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Explaining the Bond-CDS Basis – The Role of Credit Risk and Liquidity

ABSTRACT

We explore the relationship between CDS premia and bond asset swap spreads on the same reference entity. As Duffie (1999) shows, there is a clear theoretical link between CDS premia and bond prices if the two quantities are viewed as a pure measure of credit risk. However, many studies provide evidence that factors other than credit risk seem to affect bond prices and CDS premia, and these factors may partially obscure the relationship. We focus on the difference between the yield spread and the CDS premium, the bond-CDS basis, and show that the basis is highly sensitive to firm-specific and market wide credit risk and liquidity. If CDS and bonds are used in a dynamic hedging strategy or in a basis trading strategy that depends on the convergence of CDS and bond markets, it is necessary to correctly quantify the associated risks of these strategies.

I. Introduction

The purpose of this paper is to explore the relationship between CDS premia and bond yield spreads on the same reference entity. As Duffie (1999) shows, there is a clear theoretical link between CDS premia and yield spreads if the two quantities are viewed as a pure measure of credit risk. If they are affected by additional risk sources - such as liquidity - these risk sources may partially obscure the relationship. Many studies provide evidence that factors other than credit risk seem to affect yield spreads and CDS premia. As an extreme case for the corporate bond sector, Elton et al. (2001) find that only 25% of the yield spread can be attributed to default risk. Collin-Dufresne et al. (2001) analyze corporate yield spread changes and show that these are closely associated with measures of aggregate bond market liquidity. For the CDS market, Aunon-Nerin et al. (2002) and Tang and Yan (2007) provide studies exploring the determinants of corporate CDS premia other than default risk. While the former authors claim that liquidity measured as market capitalization does not matter, the latter study finds a liquidity premium in CDS transaction premia that accounts for approximately 26% of the entire CDS premium.

In this study, we focus on the difference between the yield spread and the CDS premium, known as the *basis*. We explore three potential reasons why the *basis* may deviate from 0. First, we determine whether the issuer-specific credit risk has an effect on the *basis*. If different default events or, in the terms prevalent in the CDS market, credit events are priced in bonds and CDS, the *basis* may well exhibit a sensitivity to measures of firm-specific credit risk. In this respect, we extend the empirical results by Packer and Zhu (2005) who show that CDS with broader credit event definitions trade at higher premia. Second, we analyze to which extent bond and CDS liquidity affect the *basis*. By simultaneously considering the impact of measures from the bond and the CDS market on the basis, we thus extend the evidence by Longstaff et al. (2005) who only analyze the impact of bond-specific variables on the non-default component of bond yield spreads. Third, we explore whether aggregate market conditions affect the *basis*. In contrast to Zhu (2004) who focuses on interest rate levels and stock market data, we use interest rate levels, aggregate bond market index yield spreads, and a broad financial market liquidity indicator, and document a significant impact of the aggregate market conditions in addition to the firm-specific variables.

Due to our large data set, we are able to analyze financial and non-financial firms from 8 different industry sectors and partition the sample into investment and subinvestment grade firms. A stratification of our sample according to the two main rating classes is obvious as there is a large difference in bond spreads between BBB and BB rated bonds. For CDS data, none of the above cited studies also consider subinvestment grade instruments as data on lower grade debt has traditionally been scarce. An exception is the study by Ericsson et al. (2005), but the authors do not differentiate by industry sectors.

Whereas the majority of studies that analyze the consequences of credit risk on bond yield spreads and CDS premia do not discriminate between the financial and non-financial sector, we believe that such a distinction is relevant since financial firms are the major counterparties in the CDS market. Acharya and Johnson (2007) show that there is evidence of informed trading of banks in the CDS market. Because the trader's information regarding a financial underlying is better than for a non-financial one, CDS premia from the two sectors are likely to behave differently. Düllmann and Sosinska (2007) explore this hypothesis and find evidence for a weak link between CDS-implied default probabilities and expected default frequencies for banks. In their cross-sectional analysis, Longstaff et al. (2005) also document that the non-default component in bond yield spreads for financial firms is significantly larger than for non-financial firms.

Our results extend the existing literature by showing that the *basis* is highly sensitive to firm-specific and market-wide risk factors and that this sensitivity differs for investment and subinvestment grade as well as for financial and non-financial firms. Overall, we obtain three main results. First, we document an on average positive *basis* which implies that credit risk cannot be the only priced factor in CDS premia and bond yield spreads. The differences between yield spreads and CDS premia are smaller in the subinvestment grade segment which we take as a first indication that a higher firm-specific credit risk leads to an increasing convergence of the bond and the CDS market.

Second, we study whether this cross-sectional observation also holds in a time-series analysis. The results of a vector error correction analysis show that the *basis* depends on different time-varying factors. For one third of the sample, in particular for financial and investment grade firms, this impact is large enough to obscure the credit-risk induced comovement of yield spreads and CDS premia. This result stands in contrast to the finding by Blanco et al. (2005) who find a stable cointegration relation between the bond and the CDS market.

Our third contribution is the attribution of the *basis* variation to firm-specific and market-wide risk measures. In a firm-specific fixed-effects analysis, we document that the way in which firm-specific credit risk is measured leads to different sensitivities of the *basis*. Market-implied measures have a stronger impact on the CDS market while the more easily available rating information affects the bond market more strongly. Both the bond- and the CDS-specific liquidity have a significant impact on the *basis*, thus extending the evidence on illiquidity premia in the CDS market by Tang and Yan (2007) and Bühler and Trapp (2008). For non-financial firms, the *basis* is more sensitive towards the firm-specific explanatory variables, suggesting that financial firms are more strongly affected by aggregate market conditions.

Through extending the fixed-effects analysis to market-wide explanatory variables, we demonstrate that more adverse market conditions lead to a decreasing *basis* and thus to converging yield spreads and CDS premia. We also find that the *basis* of financial firms is much more sensitive to interest rate levels than that for non-financials. This effect is of particular interest since economically, two contrary effects prevail: First, interest rates decrease in recessions and increase in boom phases. Therefore, higher interest rates indicate more favourable economic conditions and lower overall default risk. On the other hand, higher interest rates signify higher refinancing costs which may lead to an increase in default risk. Since these effects pertain at the firm-specific level, we would expect that yield spreads and CDS premia exhibit a similar sensitivity and that the basis is only marginally affected by interest rates. In our empirical analysis, we document that CDS premia are consistently negatively related to interest rate levels. The interest rate sensitivity of bond yield spreads, on the other hand, depends on the industry segment. For non-financial firms, yield spreads also depend negatively on interest rates while yield spreads for financial firms *increase* for higher interest rates. This puzzling difference between the interest rate sensitivity of yield spreads and CDS premia for financial firms is a factor that can drive the two markets apart which makes an effective hedging strategy between bonds and CDS impossible.

II. Data

A. Bond Yield Spreads and CDS Premia

All CDS and bond data is obtained from Bloomberg. CDS bid and ask premia were made available to us by a large international bank. Mid bond prices were taken directly from Bloomberg. We focus on CDS contracts and bonds that are denominated in Euro in order to obtain a longer time series. Especially in the early phase of the CDS market, Euro denominated CDS contracts are much more widely available: between June 2001 and October 2001, we observe 119 Euro denominated CDS contracts versus 16 US-Dollar denominated CDS contracts. As the starting and end point, we use June 1, 2001 (there were no CDS quotes available prior to this date) and June 30, 2007 which yields a total of 1,548 trading days. Therefore, we exclude the turbulent market phase related to the subprime crisis.

We only choose CDS quotes with a 5-year maturity in order to obtain a sample which is homogenous with regard to liquidity as discussed by Meng and ap Gwilym (2006) and Gündüz et al. (2007).

The default-free term structure of interest rates is provided by the Deutsche Bundesbank on a daily basis. The estimates are determined by the Nelson-Siegel-Svensson method from prices of German Government Bonds which represent the benchmark bonds in the Euro area for most maturities.

For each firm, we collect the coupon, payment, and maturity dates of all senior unsecured Euro denominated straight bonds which were outstanding between June 1, 2001 and June 30, 2007. We exclude all bonds with more than 10 years to maturity at a given date since the modified-modified restructuring clause which applies to most Euro denominated CDS contracts only allows for delivery of restructured assets with a maturity of up to 5 years in excess of the maturity of the restructured asset. For these bonds, we collect the time series of daily mid price quotes from June 1, 2001 to June 30, 2007.

For each bond, we determine the yield spread over the default-free interest rate and interpolate these to obtain a maturity identical to that of the CDS. We perform the following interpolation scheme: In the first step, we compute the time-t yield spread of each bond by minimizing the squared error of the bond's observed dirty price and its theoretical price. This theoretical price is obtained by discounting each cash flow by the risk-free rate plus the credit spread. In the second step, we perform a linear regression of these yield spreads on the maturity of the bond for each of the trading days. The resulting daily estimates of the intercept and the slope are used to compute the theoretical yield spread of a synthetical bond with the same maturity as the CDS contract. This interpolation produces a more stable time-series of yield spreads than first interpolating the bond yields and then subtracting the yield-to-maturity of a default-free bond.

If the matched time series of yield spreads and CDS premia has less than 20 observations on consecutive trading days, we exclude the firm from the sample. The final sample consists of CDS contracts on 155 firms for which bond mid price quotes are observed. The average length of the observation time series equals 806 trading days with a total of 131,222 CDS ask and bid quotes each and 497,254 bond prices. The distribution of the firms across the different rating classes and industry sectors is displayed in Table I.

Insert Table I about here.

Table I shows that 146 firms have a time-series average investment grade rating; only 9 lie in the subinvestment grade range. Nevertheless, we observe 8,581 CDS mid premia and 22,794 bond yields for these 9 firms. In addition, more than 9 firms exhibit a subinvestment grade rating at some date in the observation interval. The largest industry sector, both regarding the number of firms and the number of observations, is the financial sector with 54 firms and 175,870, respectively 38,046, bond yield and mid CDS premium observations. These numbers amount to 35% of the bond yield observations and 29% of the CDS premium observations. Moreover, financial firms are among the top-rated ones, constituting 34% of the investment grade firms.

B. Firm-Specific Factors

As firm-specific measures of credit risk, the firm's rating and variables derived from traded stocks and stock options are explored. First, we use Standard&Poor's (S&P) and Moody's ratings. In their empirical analysis, Aunon-Nerin et al. (2002) find that the rating is the major determinant of CDS premia. Its explanatory power lies at 40% for their entire sample and increases to 66% for the sovereign sub-sample.

For each of the firms, we collect a complete rating history from Bloomberg between June 1, 2001 and June 30, 2007. We map the daily ratings onto a numerical scale ranging from 1 to 66 where 1 corresponds to the AAA*+ S&P rating (Aaa*+ Moody's rating), and the highest value, 66, corresponds to a D*- S&P rating (for Moody's, C*- is the lowest rating) which marks defaulted firms with a negative outlook. If the numerical rating of the two rating agencies differs on a given day, we assign the average numerical rating to the firm, rounding up to the next integer. The highest resulting numerical rating equals 2 (AAA S&P rating) while the lowest rating in the sample is 50 (CCC+ S&P rating).

However, the use of rating data as a credit risk measure can be problematic. First, rating agencies claim that their ratings are a through-the-cycle evaluation, and second, information on a borrower's creditworthiness may be reflected in CDS premia before the rating is adjusted. An example supporting this concern by Hull et al. (2004) shows that CDS premia anticipate rating changes while only reviews for rating downgrades contain information that significantly affects the CDS market.

As alternative credit risk proxies, we use the option-implied and the historical stock return volatility since these may provide more accurate information on changes in a firm's creditworthiness in the short run. This hypothesis is supported by Cremers et al. (2004) and Benkert (2004) who show that historical and implied volatilities have an additional explanatory power in excess of the rating. For 3 fully state-owned and 6 private firms, no equity data was available. For the remaining 146 firms, we obtain a time series of ex-dividend stock prices and option-implied volatilities from Bloomberg. We use the implied volatilities of European vanilla at-the-money options with a maturity of 12 months since the data for these was most widely available.

The impact of the credit risk measures on the *basis* is not clear ex ante since there is no theoretically compelling argument why either yield spreads or CDS premia should be more sensitive to either credit risk measure than the other.

We also explore the impact of bond and CDS liquidity. For the CDS, the bid-ask spread represents a direct liquidity proxy. We expect that the higher the bid-ask spread, the higher the illiquidity and the CDS mid premium. Choosing an appropriate proxy for the yield spread is more difficult as we do not have access to historical transaction data or quotes and thus no direct liquidity measures. Instead, we follow Houweling et al. (2004) who identify the impact of a number of liquidity measures on the yields of corporate bond portfolios. The authors find that among potential liquidity proxies including issued amount, age, and number of quote contributors, the bond yield volatility on a given date across a specific portfolio is one of the most powerful explanatory variables for the portfolio's liquidity. As the studies by Shulman et al. (1993) and Hong and Warga (2000), their study shows that higher yield volatility is associated with higher illiquidity and higher yields. We therefore expect a positive association between the volatility across a firm's bond yields on a given date and yield spreads.

Regarding the impact of the liquidity proxies on the *basis*, it seems plausible that the sign of the coefficient estimates is positive for the yield volatility and negative for the bid-ask spread. However, the liquidity of the markets is linked both directly and indirectly which may affect the sign and size of the coefficient estimate for the *basis*. This liquidity link between the markets is due to two effects. First, CDS premia are directly affected by bond liquidity since a lower liquidity of a reference asset will in general decrease its price. Therefore, in case of default, the expected value transfer to the protection buyer (face value minus expected bond price after default) will increase. This increase will be anticipated by the protection seller who asks for a higher CDS premium. Second, credit risk can be taken on or sold off either directly by buying or selling the bond or indirectly by selling or buying protection in the CDS market. Therefore, it is possible that funds are drawn to either one market or the other which would cause increasing yield spreads in the bond market, and thus an increasing basis, due to an increasing CDS liquidity. On the other hand, a higher CDS liquidity may also have a yield spread reducing effect as the demand for credit risk in the bond market may increase due to the hedging potential through more liquid CDS. The results by Ashcraft and Santos (2007), however, suggest that this hedging effect is not likely to be dominant.

C. Market-Wide Factors

It is a well-documented finding that the level of the interest rate curve has a significant impact on the level and the changes of CDS premia and yield spreads. From a theoretical perspective, Longstaff and Schwartz (1995) argue that a higher spot rate increases the risk-neutral drift of the firm value and thus decreases the default probability and yield spreads. Empirically, Duffee (1998) observes that yield spreads decrease if the level of the Treasury curve increases. CDS premia also depend negatively on the interest rate level as Aunon-Nerin et al. (2002) and Benkert (2004) show. Therefore, the effect for the *basis* is not obvious.

Economically, it is not even clear whether these aggregate findings for bond and CDS markets hold for all industry sectors and rating segments for the following reason. On the one hand, the effect described by Longstaff and Schwartz (1995) leads to negative associations of yield spreads and CDS premia with the interest rate. Also, default-free interest rates function as key rates in monetary policy. In recession phases, central banks lower interest rates to boost the economy and increase them in booms to prevent an overheating of the economy. Therefore, low interest rates coincide with recession phases marked by high yield spreads and CDS premia. On the other hand, higher interest rates make financing more costly, and in particular firms who depend on short-term financing such as commercial papers may be more sensitive towards their financing cost. This effect would cause a positive association between yield spreads, respectively CDS premia, and interest rates.

We use the European Interbank Offered Rate (EURIBOR) instead of the government or swap rate in order to avoid endogeneity in the empirical analysis. We obtain the official daily 1-month EURIBOR interest rates from the International Capital Markets Association (ICMA) website.

As a measure of market-wide credit risk, we use a corporate bond yield spread index. Empirical evidence for a relation between market-wide risk and yield spreads is given by Collin-Dufresne et al. (2001) who document a positive association between changes in the implied volatility of the S&P 500 index and yield spread changes. Ericsson et al. (2008) extend the analysis for CDS bid and ask quotes. The results of Schueler and Galletto (2003) suggest that not only CDS premia and yield spreads are affected by the return of bond and stock market indices, but that the *basis* may also be affected. In order to extend the authors' anecdotal evidence, we include the S&P Creditweek Global Bond Index for which weekly yield spreads are available from Bloomberg. These yield spreads are determined with regard to a specific rating class from AAA to B and have a constant maturity of 5 years. They are therefore comparable both to the CDS premia and the interpolated firm-specific yield spreads.

As a measure of market-wide liquidity, we use the European Central Bank (ECB) Financial Market Liquidity Indicator which aims at simultaneously measuring the liquidity dimensions price, magnitude, and regeneration by combining 8 individual liquidity measures for the Euro area. The time series and the description of the liquidity indicator were made available to us by the ECB. The first three measures which enter the indicator are proxies for the market tightness. The fourth, fifth and sixth measures proxy for market depth are. The final components quantify the liquidity premium. The ECB describes that higher values of the liquidity indicator imply a higher market-wide liquidity.

To conclude the data description, we provide a basic overview over the mean, standard deviation, minimum, and maximum in Table II.

Insert Table II about here.

Panel A of Table II shows that yield spreads are about 65% larger than the CDS mid premia. For the entire sample, yield spreads fluctuate between -199.60 bp and 2,288.17 bp with a mean of 91.92 bp while CDS premia are consistently positive with a mean of 55.44 bp, a minimum of 3.00 bp, and a maximum of 1,874.88 bp. Consequently, the mean *basis* is positive at 48.75 bp. This is a hint that yield spreads are higher and/or CDS premia are lower than if credit risk were the only priced factor in the two instruments. However, the relatively high standard deviation of 121.22 bp and the minimum of -726.41 bp also point at a significant proportion of negative values which implies that CDS premia also exceed yield spreads to a considerable amount. On comparing the investment to the subinvestment grade segment, we observe that the *basis* is on average smaller in the subinvestment grade segment with a mean of 18.32 bp compared to 50.29 bp. Clearly, the impact of credit risk on yield spreads and CDS premia is strong enough to dominate other effects for the subinvestment grade segment. Consequently, bonds and CDS become more similar, the higher the credit risk is. The *basis* for financial and non-financial industry sectors, on the other hand, differs less strongly with a mean *basis* of 40.74 bp for financial and 52.03 bp non-financial firms.

Concerning the explanatory variables displayed in Panel B, the firm-specific credit risk measure (the option-implied and, when unavailable, the historical stock return volatility) on average equals 22.66% with a lower value of 22.18% for the investment grade segment and a higher value of 35.52% for the subinvestment grade segment. Across the financial and the non-financial corporate sector, the average volatility is surprisingly similar, given that the financial companies tend to have a better rating. The bond liquidity measure has a mean value of 1.18% and ranges between 0.00% and 15.89%. With a volatility of only 0.93%, the variability is rather small. The lower mean value of 1.15% for the investment grade segment compared to 1.95% for the subinvestment grade segment is consistent with the on average higher liquidity of highly rated bonds which Longstaff et al. (2005) and Bühler and Trapp (2008) document. In addition, the mean value of 1.62% for financial companies compared to 1.00% for non-financial companies agrees with the evidence by Campbell and Taksler (2003) and Bedendo et al. (2007) that bonds for financial companies tend to be less illiquid than comparable bonds for non-financial companies. For CDS, the relation between the liquidity measure in the investment and the subinvestment grade segment is reverse to the one in the bond market. The mean value of 19.65% in the investment grade segment considerably exceeds the mean value of 8.22% in the subinvestment grade segment. Tang and Yan (2007) document a similar result in their study; the higher the credit risk of the underlying firm is, the higher is the CDS liquidity. For financial and non-financial companies, on the other hand, the relation is similar to that in the bond market with a higher mean value of 27.83% for the financial and of 15.54% for the non-financial sector.

The market-wide explanatory variables are presented in Panel C. The average 1-month EURIBOR lies at 2.81% p.a. with a standard deviation of 0.73%. Over time, we observe a U-shaped interest rate time series, the maximum of 4.56% is attained on June 1, 2001, the minimum of 2.02% on March 29, 2004, and on the last observation date, the interest rate lies at 4.12%. A less pronounced U-shaped time series applies for the credit risk and the liquidity indices. The credit risk indices are maximal for all rating classes during the beginning of the observation interval with a maximum of 7.39% in the B rating class in the week of October 10, 2001 and a subsequent decrease with the minimum of -0.30% for the AAA rating class in the week of June 6, 2003. The liquidity index first decreases from around -0.20 at the beginning of the observation interval to a minimum of -0.55 on January 3, 2003 and then increases almost consistently. Since higher values of the index are associated with a higher market-wide liquidity, this behaviour points at an overall increasing liquidity starting from early 2003.

III. Time-Series Properties

We now explore the connection between the time series of yield spreads and CDS premia for each firm. If credit risk is the main priced factor, we should find a close comovement of yield spreads and CDS premia. The theoretical relationship has first been explored by Duffie (1999), and numerous empirical studies such as Hull et al. (2004) and Blanco et al. (2005) have documented a positive covariance, respectively a negative cointegration, of the yield spread and CDS premia time series. This relation should still hold if the factors which lead to differences between CDS premia and yield spreads do not exhibit a high amount of variation over time, e.g. if they indicate the market on which the instrument is traded. If, on the other hand, we do not find a significant cointegration relation between CDS premia and yield spreads, it is natural to ask which factors can obscure the credit-risk induced relationship.

In order to explore the relation between the yield spreads and CDS premia, we estimate a vector error correction model (VECM). To ensure that the VECM is applied correctly, we proceed in three steps. First, we apply the augmented Dickey-Fuller test on daily data for each company k. If the yield spreads and CDS premia exhibit a different order of integration at the 10% level, we exclude the firm from the time-series analysis because a relation between stationary and non-stationary variables is difficult to interpret economically. This procedure leads to the exclusion of 52 firms. Second, we perform the Johansen test to determine whether the yield spread and CDS premia are cointegrated. If cointegration is not rejected at the 10% level, we estimate in the third step for each remaining firm k the following VECM specification:

$$\begin{pmatrix} \Delta ys_t^k \\ \Delta cds_t^k \end{pmatrix} = \begin{pmatrix} a_{ys}^k \\ a_{cds}^k \end{pmatrix} \begin{pmatrix} 1 & b^k \end{pmatrix} \begin{pmatrix} ys_{t-1}^k \\ cds_{t-1}^k \end{pmatrix} + \sum_{j=1}^{5} G_j^k \begin{pmatrix} \Delta ys_{t-j}^k \\ \Delta cds_{t-j}^k \end{pmatrix} + \begin{pmatrix} \varepsilon_{ys,t}^k \\ \varepsilon_{cds,t}^k \end{pmatrix}, \qquad (1)$$

where ys^k_t is the yield spread and cds^k_t the CDS mid premium of company k at date t, a^k_{ys} and a^k_{cds} are the error correction coefficients for the yield spread and the CDS premium changes, b^k is the cointegration coefficient, and G^k_j is the 2x2 coefficient matrix for the first differences with lag j. Lags up to order 5 are considered in order to capture higher-order autocorrelation up to a weekly level. The estimation results are displayed in Table III.

Insert Table III about here.

As Table III shows, only 92 out of the 155 firms exhibit a significant cointegration relation between yield spreads and CDS premia. The negative average cointegration coefficient estimate of -5.34 points at a comovement of yield spreads and CDS premia, but the high standard deviation across the significant coefficient estimates of 32.99 suggests that this relation differs strongly across firms. For 28 firms, we obtain individual coefficient estimates that are larger than 0. This suggests that CDS premia and yield spreads move in the opposite direction, an effect that cannot be due to credit risk. The average error correction coefficient estimates of -0.13 for the yield spread changes and of 0.02 for CDS premia changes suggest that yield spreads are affected more strongly by deviations from the long-run relation. Thus, credit risk changes are first reflected in CDS premia. This result is also supported by the higher number of significant coefficient estimates a^k_{ys} for yield spread changes (45 versus 19).

Across the different rating classes, the proportion of significant cointegration coefficient estimates is higher for the investment grade segment with 89 out of 146 compared to 3 out of 9. Simultaneously, the average coefficient estimate is higher (on an absolute level) for the investment grade segment. This agrees with the on average higher *basis* for the investment grade segment. For the different industry sectors, the average coefficients and their standard deviations differ strongly for financial and non-financial firms even though the proportion of cointegrated yield spreads and CDS premia is similar. For financial firms, the cointegration coefficient estimate equals -10.54 while the estimate for non-financial firms lies at -2.44. The asymmetry between significantly affected yield spread and CDS premia changes is also larger for financial firms, suggesting that information discovery takes place mostly in the CDS market. This finding points at a higher impact of non-credit risk factors on yield spreads than on CDS premia and supports the hypothesis that liquidity plays a more important role for bonds than for CDS.

IV. Explaining the Basis

To explore the determinants of the difference between yield spreads and CDS premia, we perform a regression analysis. As the *basis* time series are frequently non-stationary, we cannot use OLS to determine the impact of the explanatory variables. A standard way to cope with this problem is the use of first differences instead of levels. This procedure, however, has the drawback that the results become more difficult to interpret economically.

We therefore analyze the impact of the explanatory variables in a fixed-effects framework. This type of model is used to explore the impact of a time-invariant, unobserved effect that is potentially correlated with the explanatory variables on the dependent variable.[1] Since the fixed-effects formulation allows us to pool the *basis* observations in levels across all firms, the size coefficient estimates are economically more intuitive.

A. Firm-Specific Measures

We first determine how firm- and instrument-specific measures of credit risk and liquidity affect the *basis*. The system of equations which we estimate is given by

$$bs_t^k = f_0^k + f_1 r_t^k + f_2 vol_t^k + f_3 ba_t^k + f_4 yv_t^k + n_t^k . \quad (2)$$

$bs^k_t = ys^k_t - cds^k_t$ t defines the *basis* for firm k at time t. f^k_0 is the time-invariant firm-specific fixed effect. r^k_t and vol^k_t refer to the rating and option-implied volatility (replaced, if unavailable, by the historical stock return volatility). ba^k_t and yv^k_t are the proxies for the CDS and the bond liquidity as described in Section II.B. In order to avoid endogeneity, we use the liquidity proxies two business days prior to t.

We determine the significance of the coefficient estimates using the Newey-West covariance estimate to adjust for autocorrelation and heteroscedasticity.[2] We subsequently test whether the time series of the residuals is stationary for each firm using the Phillips-Perron test.[3] The results of the estimation are given in Table IV.

Insert Table IV about here.

As Table IV shows, for the entire sample all credit risk and liquidity measures significantly affect the *basis* at the 1% significance level. Interestingly, the coefficient signs of the rating and the volatility measure differ: While the rating has a positive impact, the volatility

[1] See e.g. Wooldridge (2002), p. 252.
[2] See Campbell, Lo, and MacKinlay (1997), pp. 534-535.
[3] See Enders (1995), pp. 239-240.

decreases the *basis*. Since both, a higher numerical rating and a higher option-implied volatility, are associated with higher credit risk, this finding shows that yield spreads are more rating-sensitive, while CDS premia are more sensitive to the option-implied volatility. With regard to the liquidity proxies, we observe that lower bond liquidity increases the *basis* while lower CDS liquidity decreases it. In the full sample, an increase of the numerical rating by one increases the basis by 3 bp while a volatility increase by one percentage point decreases the basis by 0.5 bp. In comparison, an increase of the CDS bid-ask spread by one basis point decreases the basis by 0.8 bp, and an increase of the yield volatility by one percentage point increases the basis by 12 bp.

The adjusted R^2 lies at 15.60%, which, taking into account that the *basis* measures the difference between two quantities often viewed as identical, is rather large. If we repeat the analysis univariately (the results are suppressed for brevity), we obtain coefficient estimates with the same sign as in the multivariate model. The univariate adjusted R^2 ranges between 13.18% for the rating and 10.85% for the CDS liquidity measure, suggesting that all quantities have a significant impact and explanatory power. However, the differences between yield spreads and CDS premia are clearly not entirely due to credit risk and liquidity.

Comparing the estimation results for the investment and the subinvestment grade segment in Table IV, we observe that the coefficient signs remain unchanged from those for the entire sample. Except for the CDS liquidity coefficient, the absolute value of the coefficient estimates and the adjusted R^2 are larger for the subinvestment grade segment which points at more strongly credit risk and liquidity-related differences between yield spreads and CDS premia. In the next section, we will explore whether the differences for the investment grade segment can be attributed to different sensitivities to market-wide measures.

With regard to the different industry sectors in Table IV, we observe that the credit risk and liquidity measures have a higher explanatory power for the non-financial sector as measured by the higher adjusted R^2 of 19.75%. An interesting difference between the two sectors concerns the impact of the rating which becomes insignificant for the financial sector as CDS premia and yield spreads exhibit a similar rating sensitivity. The effect of the CDS liquidity, on the other hand, is stronger for the financial sector as measured by the higher coefficient estimate. Recall that in Table II, both the mean and the standard deviation of the CDS liquidity measure for the financial sector exceed those for the non-financial sector. Therefore, a higher proportion of the basis variation is due to CDS liquidity for the financial sector than for the non-financial sector.

To summarize, we find that firm-specific credit risk measures can have two effects on the *basis* which points at different sensitivities. While the bond market reacts more sensitively to the rating, the CDS market reflects the market-implied credit risk measure more strongly. This is in line with the intuition that CDS traders are sophisticated financial institutions while bond investors may have to rely on more easily available measures such as the rating. In addition, we document a significant impact of the bond and CDS liquidity measures on the *basis* and thus show that the commonly held view of a perfectly liquid CDS market is not supported by the data. The adjusted R^2 is largest for the subinvestment grade segment and for non-financial firms. Even though the basis is lower for the subinvestment grade segment, this segment is more sensitive to credit risk and liquidity, and the two risk factors explain a larger part of the basis. Therefore, the higher the credit risk - as measured by a lower rating – the stronger is the difference between the impact of the firm-specific risk factors. Both investment grade and financial firms, on the other hand, may be more sensitive to market-wide than to firm-specific conditions. We explore this hypothesis in the next section.

B. Market-Wide Measures

In an extension of the firm-specific analysis, we now explore whether the *basis* exhibits a rating and industry-sector specific dependency on the market-wide risk measures described in Section II.C. As in Section A, we perform the following fixed-effects estimation:

$$bs_t^k = f_0^k + f_1 r_t^k + f_2 vol_t^k + f_3 ba_t^k + f_4 yv_t^k + f_5 EURIBOR_t + f_6 SPWC_t^k + f_7 FML_t + v_t^k, \quad (3)$$

bs^k_t, f^k_0, $r^k_{t,}$ vol^k_t, $ba^k_{t,}$ and yv^k_t are defined as in Equation (2). $EURIBOR_t$ denotes the 1-month EURIBOR level, $SPWC^k_t$ is the S&P Creditweek Global Bond Index yield spread for the rating class of firm k, and FML_t the liquidity index at date t. The results of the estimation are given in Table V.

Insert Table V about here.

As Table V shows, the market-wide explanatory variables have a significant impact on the *basis* in excess of the firm-specific variables, but the additional explanatory power is relatively small. For the entire sample, the sign and significance of the coefficient estimates for the firm-specific variables are unaffected by the inclusion of the market-wide variables. Overall, the interest rate level has a positive impact, i.e. increasing interest rate levels result in larger differences between the bond and the CDS market. A separate analysis of yield spreads and CDS premia reveals that the coefficient estimate for the interest rate level is negative for both. The estimate of 11.34 for the entire sample thus implies a higher CDS premia interest rate sensitivity. Therefore, for yield spreads the positive effect that is due to higher refinancing costs seems to be more important than for CDS premia.

Higher overall credit risk, reflected by a higher value of SPWC, decreases the *basis* and thus the differences between the bond and the CDS market. Higher financial market liquidity, proxied by higher values of FML, increases the *basis* while lower financial market liquidity decreases the *basis*. Therefore, CDS premia and yield spreads behave more similarly in adverse market conditions. With an adjusted R^2 of 16.49% compared to 15.60% in Table IV, the market-wide variables only have a very limited additional explanatory power.

For the different rating classes, we observe from Table V that including the market-wide explanatory variables affects the investment and the subinvestment grade segment differently. First, the coefficient estimate for the impact of yv becomes significantly negative at -2.11 compared to 5.04 in Table IV. The coefficient estimate for SPWC, on the other hand, is significantly positive at 2.40 compared to the estimate of -2.22 for the entire sample. A more detailed analysis of the investment-grade rating classes reveals that the negative coefficient estimate is driven by the AAA and AA rating class. For both rating classes, market-wide credit risk negatively affects CDS premia and yield spreads, and the coefficient estimate for CDS premia is more strongly negative. Therefore, the joint impact for the *basis* is positive due to a more pronounced effect in the CDS market.

For the subinvestment grade segment, the impact of the interest rate level is negative with a coefficient estimate of -19.26 which implies a tightening *basis* when interest rates rise. Analysing the CDS premia and yield spreads separately reveals that, as expected, the positive coefficient estimate is due to a higher, i.e. more strongly negative, interest rate sensitivity of yield spreads than of CDS premia, compared to the higher sensitivity of CDS in the investment grade segment.

Comparing the increase in the explanatory power for the investment and subinvestment grade reveals the surprising result that the increase is larger, both on an absolute and a relative scale, for the subinvestment grade segment. A separate analysis for CDS premia and yield spreads again allows us to attribute this result to the higher explanatory power of the market-wide explanatory variables for yield spreads in the subinvestment grade segment.

The final results of Table V concern the differences between the financial and the non-financial sector. While the coefficient estimates for the non-financial sector resemble those for the entire sample, for the financial sector including the market-wide variables leads to changes in the impact of the firm-specific variables. First, the coefficient estimates for the rating and the bond liquidity become significant and negative at -2.27 and -3.90 which is due to a high negative association with the yield spreads ys^k_t. This finding is especially noteworthy since market-wide credit risk only affects the *basis* significantly at the 10% level, and the impact of market liquidity is insignificant at the 10% level. Therefore, the different sensitivity to the firm-specific quantities and the higher adjusted R^2 can be attributed to the impact of the interest rate on yield spreads.

The coefficient estimate for the interest rate of 29.84 is due to a *positive* coefficient estimate for yield spreads of 26.34. Since financial firms are more likely to refinance themselves at an interest rate close to EURIBOR, we believe that this positive relation indicates their sensitivity towards refinancing costs. In particular commercial banks, who traditionally invest in longer-term risky assets and refinance themselves via short-term liabilities, tend to hold fixed-interest rate assets and liabilities with diverging maturities. Therefore, increasing interest rates decrease the value of the fixed-income assets to a larger extent than the short-term liabilities, leading to higher credit risk and higher yield spreads. As Czaja et al. (2006) argue, this effect pertains to most financial institutions and makes them more sensitive to interest rate risk. However, it is puzzling why yield spreads reflect this firm-specific refinancing cost effect more strongly, while CDS premia reflect the business cycle effect more strongly. One potential explanation is that yield spreads contain a systematic component that is neither due to credit risk nor to liquidity – both of which we adjust for - which is positively associated with interest rates. A second potential explanation lies in different default events which are priced in CDS and bonds such as restructuring, which in particular for financial firms is more likely than failure to pay or bankruptcy.

To summarize, the analysis in this section shows that the entire sample is relatively robust against including market-wide explanatory variables. On average, deteriorating overall market conditions (lower interest rates due to central bank intervention, higher credit risk, lower liquidity) are associated with a decreasing *basis* and thus with converging yield spreads and CDS premia. For the subsamples, on the other hand, we observe significant differences. First, we find a negative credit risk sensitivity in the highest investment grade segment which affects the CDS market more strongly than the bond market. Second, yield spreads for financial firms have a positive dependence on interest rate levels which we attribute to the impact of refinancing costs. Third, the increase in explanatory power is largest for the subinvestment grade segment and the financial sector, suggesting that differences between the bond and the CDS market for these can partly be explained by a different sensitivity to market-wide factors, in particular the interest rate.

V. Summary and Conclusion

The purpose of our paper is to explore which factors drive the differences between yield spreads and CDS premia. In order to adjust for the different maturity schemes, we determine yield spreads which we interpolate to a 5-year maturity. We then compute the *basis* as the difference between the interpolated yield spread and the mid CDS premium.

Our results imply that for a broad sample of 155 firms with an average rating between AAA and CCC, CDS premia are lower, respectively yield spreads are higher, than if credit risk were the only priced factor. The *basis* is therefore mostly positive with an average of 48.75 bp.

A VECM analysis reveals that the differences are not mainly due to different levels of yield spreads and CDS premia but caused by the impact of differentiating time-varying factors. For 63 firms, to a large proportion financial ones, the impact of these factors is strong enough to allow us to reject the hypothesis of a cointegration relation between CDS premia and yield spreads. Even for the 92 firms with a significant cointegration relation, the relation is not necessarily stable which we deduce from the insignificant error correction coefficient estimates. For those firms for which at least one estimate is significant, we find that the bond market is more likely to react to the CDS market. This finding points at a unilateral information spillover from the CDS to the bond market, particularly for financial firms.

In order to explore the dependency of the *basis* on firm-specific and market-wide risk factors, we perform a fixed-effects regression analysis. We document a significant impact of bond- and CDS-related liquidity measures on the *basis*, thus extending the empirical evidence of Tang and Yan (2007), and show that a lower liquidity in the bond market causes CDS premia and yield spreads to drift apart. The impact of the credit risk measures on the *basis* differs, depending on which measure we use. The rating affects yield spreads more strongly than CDS premia and thus has a positive impact on the *basis*. The market-derived option-implied volatility, on the other hand, affects CDS premia more strongly than yield spreads and thus has a negative impact on the *basis*. Non-financial firms exhibit a higher adjusted R^2 than financial ones which implies that firm-specific conditions have a similar impact on CDS premia and yield spreads in the financial sector.

Including market-wide explanatory variables in the fixed-effects analysis allows us to explore the impact of aggregate market conditions. In general, the results imply that adverse market conditions, proxied by lower interest rates, a higher bond index yield spread, and a lower value of the market-wide liquidity indicator, lead to a decreasing *basis* and thus to converging yield spreads and CDS premia. Comparing different rating classes and industry sectors, however, we find that this convergence is not given for all firms. Highly rated firms exhibit a negative credit risk sensitivity which affects CDS premia more strongly than yield spreads, thus CDS premia and yield spreads drift apart for these firms when credit risk increases. For financial firms, the *basis* displays a high dependence on the interest rate level which we attribute to a positive dependence of the yield spread due to a higher refinancing risk.

Overall, our results shed light on the strongly discussed relation between the bond and the credit derivatives market. If CDS and bonds are used in a dynamic hedging strategy or, as hedge funds frequently do, in a *basis* trading strategy that depends on the convergence of CDS and bond markets, it is necessary to correctly quantify the associated risks of these strategies. We document in our time-series analysis that the convergence is by no means reliable. Instrument-specific liquidity in particular can cause yield spreads and CDS premia to drift apart, and while the *basis* on average decreases in adverse market conditions, we also find that more highly rated firms and firms from the financial sector can effectively exhibit more strongly diverging CDS premia and yield spreads when market-wide risk is high.

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Table I: **Firms by Rating Class and Industry Sector**

The table presents the number of firms in each rating class and industry sector. Ratings are averages for the firm over all dates on which both CDS ask and bid premia and at least two bond prices were observed. The last columns and rows show the number of mid bond prices and mid CDS premia for each rating class and industry sector between June 1, 2001 and June 30, 2007.

	AAA	AA	A	BBB	BB	B	All	# Obs. Bonds	# Obs. CDS
Basic Materials	-	2	4	7	2	1	16	33,393	13,079
Communication	-	1	7	8	3	-	19	73,211	20,481
Cycl. Cons. Goods	-	2	3	9	2	-	16	47,497	15,634
Noncycl. Cons. Goods	-	-	5	8	1	-	14	40,519	12,319
Diversified	-	-	2	2	-	-	4	6,536	3,096
Financial	-	22	28	4	-	-	54	175,870	38,046
Industrial	-	-	4	5	-	-	9	40,624	9,531
Utility	1	5	13	4	-	-	23	79,604	19,036
All	1	32	66	47	8	1	155	497,254	131,222
# Obs. Bonds	3,552	106,206	116,359	248,343	21,238	1,556	497,254		
# Obs. CDS	1,085	27,015	53,203	41,338	7,842	739	131,222		

Table II: **Descriptive Statistics**

The table shows the mean, standard deviation, minimum, and maximum of each data category. The CDS mid premia, the interpolated bond yield spreads, and the basis are measured in basis points. The volatility is the option-implied volatility of at the money options with a 12-months maturity and, when this is unavailable, the historical stock return volatility, computed for stock returns in percentage points, over 12 months. The bond liquidity is the standard deviation of all observed bond yields for a given firm on a given date for yields in percentage points. The CDS liquidity is the bid-ask spread relative to the mid CDS premium, EURIBOR is the 1-month European Interbank Offered Rate, SPWC is the S&P Bond Index yield spread, all in percentage points. FML is the Financial Market Liquidity Indicator as determined by the European Central Bank.

		AAA-BBB	BB-CCC	Financial	Non-Financial	All
			Panel A: Dependent Variables			
Yield Spread	Mean	93.05	327.69	59.81	122.58	91.92
	Std. Dev.	123.83	311.91	126.63	151.66	126.74
	Min.	-199.60	-20.56	-195.54	-199.60	-199.60
	Max.	1,603.09	2,288.17	1,380.78	2,288.17	2,288.17
CDS	Mean	42.69	309.46	19.03	70.30	55.44
	Std. Dev.	57.10	246.82	18.25	110.15	96.19
	Min.	3.00	38.50	3.00	5.33	3.00
	Max.	1,393.75	1,874.88	310.00	1,874.88	1,874.88
Basis	Mean	50.29	18.32	40.74	52.03	48.75
	Std. Dev.	115.99	195.84	127.71	118.30	121.22
	Min.	-516.48	-726.41	-217.97	-726.41	-726.41
	Max.	1,573.93	1,462.31	1,375.71	1,573.93	1,573.93
			Panel B: Firm-Specific Explanatory Variables			
Volatility	Mean	22.18	35.52	21.37	23.07	22.66
	Std. Dev.	3.90	9.89	3.69	5.20	4.94
	Min.	7.69	22.17	9.33	7.69	7.69
	Max.	46.51	64.35	32.74	64.35	64.35
Bond Liq.	Mean	1.15	1.95	1.62	1.00	1.18
	Std. Dev.	0.86	1.92	0.83	0.90	0.93
	Min.	0.00	0.00	0.01	0.00	0.00
	Max.	15.89	12.85	15.89	12.85	15.89
CDS Liq.	Mean	19.65	8.22	27.83	15.54	19.10
	Std. Dev.	11.33	5.01	11.16	9.35	11.37
	Min.	0.00	0.00	0.00	0.00	0.00
	Max.	160.00	42.43	160.00	158.62	160.00

Panel C: Market-Wide Explanatory Variables

	Mean	Std. Dev.	Min.	Max.
EURIBOR	2.81	0.73	2.02	4.56
SPWC	2.59	1.83	-0.3	7.39
FML	0.17	0.34	-0.55	0.67

Table III: **The Dynamic Relation of CDS Premia and Bond Yield Spreads**

The table presents the estimated coefficients for the vector error correction model in Equation (1). ys^k_t is the synthetic yield spread for a bond with a 5-year maturity, cds^k_t is the CDS mid premium for a 5-year maturity. The dependent variables are the yield spread and CDS premium changes, the explanatory variables are the vector error correction terms (ys^k_t - b^k cds^k_t) and the lagged changes. b^k denotes the cointegration coefficient, a^k_{ys} and a^k_{cds} the coefficient estimates of the error correction term. The top row displays the number of firms for which a) an identical order of integration could not be rejected at the 10% level, b) the Johansen test could not reject cointegration of the time series at the 10% level, c) the augmented Dickey-Fuller test could reject a unit root in the residuals of the VECM at the 10% level. Coefficients are given for premia in basis points.

	AAA-BBB	BB-CCC	Financial	Non-Financial	All
# Firms	89	3	33	59	92
Mean b^k	-5.48	-1.07	-10.54	-2.44	-5.34
Std. Dev. b^k	33.54	1.49	52.38	13.04	32.99
# sign.	89	3	33	59	92
Mean a^k_{ys}	-0.13	-0.05	-0.15	-0.11	-0.13
Std. Dev. a^k_{ys}	0.16	0.02	0.18	0.15	0.16
# sign.	42	3	12	33	45
Mean a^k_{cds}	0.02	0	0.05	0	0.02
Std. Dev. a^k_{cds}	0.15	0.01	0.25	0.03	0.15
# sign.	18	1	4	15	19

Table IV: **Impact of Firm-Specific Factors**

The table shows the coefficients, significance level, and adjusted R^2 for the fixed effects model in Equation (2). The first row gives the number of firms for which the hypothesis of a unit root in the basis regression residuals was rejected at the 10% significance level. The dependent variable is the basis $bs^k_t = ys^k_t - cds^k_t$ in basis points. r denotes the numerical rating, vol the option-implied volatility (replaced, if unavailable, by the historical stock return volatility) in percentage points, ba the CDS liquidity proxy in basis points, and yv the bond liquidity proxy in percentage points. ***, **, and * denote the 1%, 5%, and 10% significance level for a t-test using Newey-West errors. Adjusted R^2 are in percentage points.

	AAA-BBB		BB-CCC		Financial		Non-Financial		All	
# Firms	137		7		48		96		144	
r	3.08	***	6.47	***	-0.14		3.70	***	2.93	***
vol	-0.37	***	-0.68	***	-0.30	***	-0.54	***	-0.44	***
ba	-1.64	***	-1.27	***	-2.33	***	-0.80	***	-0.80	***
yv	5.04	***	33.10	***	8.43	***	10.01	***	12.36	***
Adj. R^2	15.73		29.99		11.08		19.75		15.60	

Table V: **Impact of Market-Wide Factors**

The table shows the coefficients, significance level, and adjusted R2 for the fixed effects model in Equation (3). The first row gives the number of firms for which the hypothesis of a unit root in the basis regression residuals was rejected at the 10% significance level. The dependent variable is the basis $bs^k_t = ys^k_t - cds^k_t$ in basis points. r, vol, ba, and yv are as in Table IV. EURIBOR denotes the 1-month EURIBOR level, SPWC the rating-class specific S&P Bond Index yield spread, both in percentage points, and FML the ECB Financial Market Liquidity Indicator. ***, **, and * denote the 1%, 5%, and 10% significance level for a t-test using Newey-West errors. Adjusted R^2 are in percentage points.

	AAA-BBB		BB-CCC		Financial		Non-Financial		All	
# Firms	144		9		52		101		153	
r	1.48	***	7.48	***	-2.27		3.40	***	2.06	***
vol	-0.56	***	-0.20	***	-0.39	***	-0.46	***	-0.41	***
ba	-1.69	***	-0.93	***	-2.83	***	-0.71	***	-0.57	***
yv	-2.11	***	32.93	***	-3.90	***	9.88	***	8.91	***
EURIBOR	14.06	***	-19.26	***	29.84	***	5.43	***	11.34	***
SPWC	2.40	***	-5.84	***	-1.53	*	-2.56	***	-2.22	***
FML	5.31	***	143.54	***	0.55		12.60	***	18.62	***
Adj. R^2	17.07		35.17		14.24		20.01		16.49	

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