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

Monika Trapp*

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ABSTRACT

We analyze trading opportunities that arise from differences between the bond and the CDS market. By simultaneously entering a position in a CDS contract and the underlying bond, traders can build a default-risk free position that allows them to repeatedly earn the difference between the bond asset swap spread and the CDS, known as the basis. We show that the basis size is closely related to measures of company-specific credit risk and liquidity, and to market conditions. In analyzing the aggregate profits of these basis trading strategies, we document that dissolving a position leads to significant profit variations, but that attractive risk-return characteristics still apply. The aggregate profits depend on the credit risk, liquidity, and market measures even more strongly than the basis itself, and we show which conditions make long and short basis trades more profitable. Finally, we document the impact of the financial crisis on the profits of long and short basis trades, and show that the formerly more profitable long basis trades experienced stronger profit decreases than short basis trades.

JEL classification: C31, C32, G12, G13, G14, G32
Keywords: bond asset swap spreads, CDS premia, basis trading profits, credit risk, liquidity, fixed-effects, vector error correction model

*Department of Finance, University of Cologne, and Centre for Financial Research, Albertus-Magnus-Platz, D-50923 Cologne, e: trapp@wiso.uni-koeln.de, t:++49 221 470 6966. Financial support from the Fritz Thyssen foundation is gratefully acknowledged.

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I. Introduction

The purpose of this paper is to 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 yield spreads for floating rate par bonds, 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, Gruber, Agrawal, and Mann (2001) find that only 25% of the yield spread can be attributed to default risk. Collin-Dufresne, Goldstein, and Martin (2001) analyze corporate yield spread changes and show that these are closely associated with measures of aggregate bond market liquidity, but that a large, systematic component of yield spread changes can be neither explained by credit risk nor by liquidity. For the CDS market, Aunon-Nerin, Cossin, Hricko, and Huang (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 high positive liquidity premium in CDS transaction premia.

In this study, we focus on the difference between CDS premia and asset swap spreads, known as the basis. We use the asset swap spread instead of the conventional yield spread since it derives from a synthetical floating rate par bond, and is thus more comparable to the CDS premium. Nevertheless, we document in a vector error correction analysis that a stable comovement of asset swap spreads and CDS premia is by no means given for all firms. This result supports the findings by Blanco, Brennan, and Marsh (2005) who find a stable cointegration relation between the bond and the CDS market for only 26 out of 33 analyzed firms, Norden and Weber (2004) who document cointegration of 36 out of 58 firms, and de Wit (2006) who finds cointegration for 88 out of 144 firms.

The first contribution of our study lies in analyzing three potential reasons why the basis may deviate from 0, and why there may be no comovement in the short run. As a first reason, we determine whether 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.

As a second reason, 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, Mithal, and Neis (2005) who only analyze the impact of bond-specific variables on the non-default component of bond yield spreads. Our analysis shows that both the bond- and the CDS-specific liquidity proxies 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).

As a third reason, 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 the interest rate level and slope, aggregate bond market index yield spreads, and a broad financial market liquidity indicator. We document a significant impact of the aggregate market conditions in addition to the firm-specific variables.

As a second contribution, we analyze the profits which a trader can make by simultaneously taking on positions in the bond and the CDS market. By buying the bond and buying protection in the CDS market at the ask quote (long basis trade), or short-selling the bond and selling protection in the CDS market at the bid quote (short basis trade), a trader can build up a default-risk free position. Abstracting from technical mismatches and interest rate and liquidity risks, the trader can thus make an arbitrage profit if he holds the position to maturity.

In the first step of our analysis of the profits obtained from the basis buy-and-hold trades, we show that these profit are large, even if transaction costs are taken into account, and arise on around 10% of our observation dates. In this respect, we extend the descriptive analyses of Berd, Mashal, and Wang (2004) and Schueler and Galletto (2003).

Second, we take into account that basis traders may need to dissolve their positions because of liquidity issues, funding constraints, or as a stop-loss measure. We analyze the resulting profits obtained if a long or short basis trade is canceled out by taking on the opposite position in the CDS and the bond market, and show that particularly long basis trades retain an attractive risk-return profile. Short basis positions, on the other hand, frequently need to be dissolved at such adverse conditions that significant losses are incurred. This finding agrees with the lower average basis profits for short basis trades documented by Bühler and Xuanlai (2009). In contrast to their analysis, which focuses on basis trades dissolved due to a fixed holding period limit, or a beneficial convergence of CDS and asset swaps, we view dissolution as a negative event which traders do no voluntarily undertake.

In comparing the results which we obtain for the time period between 2001 and 2007 to the results for the period from mid-2007 to early 2009, we document that the profitability of basis strategies has decreased during the current turbulent market phase. However, certain basis strategies still exhibit attractive risk-return characteristics.

In the last step, we explore the extent to which firm-specific and market-wide credit risk and liquidity factors affect basis trade profits. Interestingly, constellations which result in a large basis - implying ex ante more profitable trades - do not necessarily result in more profitable trades. Overall, we identify credit risk, liquidity, and interest rates as systematic risk factors in the profitability of basis trades.

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 asset swap spreads between BBB and BB rated bonds.

We believe that a distinction between financial and non-financial firms is also 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, Mithal, and Neis (2005) also document that the non-default component in bond yield spreads for financial firms is significantly larger than for non-financial firms.

II. Data

A. Asset Swap Spreads and CDS Premia

All CDS and bond data are obtained via the Bloomberg system. CDS bid and ask premia were made available to us by a large international bank. Mid bond asset swap spreads were taken directly from Bloomberg. We focus on Euro-denominated CDS contracts and bonds 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.[1] 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, Lüdecke, and Uhrig-Homburg (2007).

For each firm, we collect the 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 asset swap spreads from June 1, 2001 to June 30, 2007. We linearly interpolate these to obtain a maturity identical to that of the CDS.

If the matched time series of asset swap 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 116 firms for which mid asset swap spreads are

[1] We initially exclude the current turbulent market phase.

observed. The average number of trading days equals 806 with a total of 110,498 CDS ask and bid quotes each and 759,027 asset swap spreads. 109 firms have an average investment grade rating; only 7 lie in the subinvestment grade range. Nevertheless, we observe 6,464 CDS ask quotes and 29,813 asset swap spreads for these 7 firms. The largest industry sector, both regarding the number of firms and the number of observations, is the financial sector with 38 firms and 158,524, respectively 26,770, asset swap spread and CDS ask (and bid) quote observations. These numbers amount to 21% of the bond observations and 24% of the CDS premia observations. Moreover, financial firms are among the top-rated ones, constituting 49% of the investment grade firms.

B. Firm-Specific Factors

We employ the firm's rating and variables derived from traded stocks and stock options as firm-specific measures of credit risk. First, we use Standard&Poor's (S&P) and Moody's ratings. In their empirical analysis, Aunon-Nerin, Cossin, Hricko, and Huang (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 Moody's and S&P 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 the 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 lowest resulting numerical rating equals 2 (AAA S&P rating) while the highest 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, Predescu, and White (2004) shows that CDS premia anticipate rating changes while only reviews for rating downgrades contain information that significantly affects the CDS market. More recently, Lehman Brothers was still rated A a month prior to its bankruptcy, while CDS premia skyrocketed.

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, Driessen, Maenhout, and Weinbaum (2004) and Benkert (2004) who show that historical and implied volatilities have additional explanatory power in excess of the rating. We obtain a time series of ex-dividend stock prices and option-implied volatilities for each firm from Bloomberg. We use the implied volatilities of European vanilla at-the-money options with a maturity of 12 months since these were most widely available.

We also explore the impact of bond and CDS liquidity. For the CDS, the bid-ask spread represents a direct liquidity proxy. Choosing an appropriate proxy for the bond 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, Mentink, and Vorst (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, Bayless, and Price (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 asset swap spreads. The daily mid yield for all bonds for which we also observed an asset swap spread is taken from Bloomberg.

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, respectively asset swap 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, Cossin, Hricko, and Huang (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. 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 asset swap 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 asset swap spreads, respectively CDS premia, and interest rates.

We use the term structure of interest rates which is provided by the Deutsche Bundesbank on a daily basis as the default-free reference curve. 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.

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, Goldstein, and Martin (2001) who document a positive association between changes in the implied volatility of the S&P 500 index and yield spread changes. Ericsson, Jacobs, and Oviedo-Helfenberger (2008) extend the analysis for CDS bid and ask quotes. The results of Schueler and Galletto (2003) suggest that not only CDS premia and asset swap 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' 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 asset swap 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 market tightness. The fourth, fifth and sixth measures proxy for market depth. 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 I.

Insert Table I about here.

Panel A of Table I shows that asset swap spreads are about 15% smaller than CDS ask premia, and 4% smaller than CDS bid premia. This implies that asset swap spreads are lower and/or CDS premia are higher than if credit risk were the only priced factor in the two instruments. On comparing the investment to the subinvestment grade segment, we observe that the difference between asset swap spreads and CDS premia is on average larger in the subinvestment grade segment. This could point at a different effect of credit risk on asset swap spreads and CDS premia, or at the impact of additional factors, such as liquidity or the CDS delivery option, which are also related to credit risk. The difference between financial and non-financial firms is even more distinct. For financial firms, asset swap spreads on average exceed both CDS bid and ask premia. For non-financial firms, we obtain the reverse relation with asset swap spreads below both ask and bid premia. This suggests that corporate bonds for financial firms contain additional risk premia, such as a premium for systemic risk, or reflect the same risk factors more strongly, compared to 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 22.95% with a lower value for the investment grade and a higher one for the subinvestment grade segment. Across the financial and the non-financial corporate sectors, the average volatility is surprisingly similar, given that financial companies tend to have a better rating. The bond liquidity measure ranges between 0.00% and 16.71%. The lower mean value for the investment grade segment is consistent with the on average higher liquidity of highly rated bonds which Longstaff, Mithal, and Neis (2005) and Edwards, Harris, and Piwowar (2007) document. In addition, the mean value of 1.17% for financial companies compared to 0.95% for non-financial companies agrees with the evidence by Campbell and Taksler (2003) and Bedendo and Cathcart (2007), that bonds for financial companies tend to be less liquid 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. Tang and Yan (2007) document a similar result in their study; the higher the credit risk of the underlying firm, the higher the CDS liquidity. For financial and non-financial firms, on the other hand, the relation is similar to that in the bond market. This is consistent with Acharya and Johnson (2007)'s evidence of informed trading in the CDS market. If a CDS trader expects his counterparty to have private information regarding the underlying, he will increase the bid-ask spread in order to account for this informational asymmetry.

The market-wide explanatory variables are presented in Panel C. Over time, we observe a U-shaped interest rate time series; the maximum is attained in August 2002, the minimum in January 2006. The slope displays a hump-shaped time series with the maximum in late 2004. As for the interest rate level, a U-shaped time series also applies for the credit risk and liquidity indices. The credit risk indices are maximal for all rating classes during the beginning of the observation interval, and exhibit a subsequent decrease until mid-2003. The liquidity index first decreases from 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 behavior points at an overall increasing liquidity starting from early 2003 until mid-2007.

III. Time-Series Properties

We now explore the connection between the time series of asset swap spreads and CDS premia for each firm. If credit risk is the main priced factor, we should find a close comovement of asset swap spreads and CDS premia. The theoretical relationship has first been explored by Duffie (1999). Numerous empirical studies such as Hull, Predescu, and White (2004), Blanco, Brennan, and Marsh (2005), and de Wit (2006) have documented a positive covariance, respectively a negative cointegration, of yield spreads and CDS premia. This relation should still hold (and for asset swap spreads even more so than for yield spreads) if the factors which lead to differences between CDS premia and asset swap 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 asset swap spreads, it is natural to ask which factors can obscure the credit-risk induced relationship.

In order to explore the relation between asset swap 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 asset swap 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 15 firms. Second, we perform the Johansen test to determine whether the asset swap spreads 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:

$$\begin{pmatrix} \Delta as_t^k \\ \Delta cds_t^{k,l} \end{pmatrix} = \begin{pmatrix} \alpha_{as}^{k,l} \\ \alpha_{cds}^{k,l} \end{pmatrix} \begin{pmatrix} 1 & \beta^{k,l} \end{pmatrix} \begin{pmatrix} as_{t-1}^k \\ cds_{t-1}^{k,l} \end{pmatrix} + \sum_{j=1}^{5} \Gamma_j^{k,l} \begin{pmatrix} \Delta as_{t-j}^k \\ \Delta cds_{t-j}^{k,l} \end{pmatrix} + \begin{pmatrix} \varepsilon_{as,t}^{k,l} \\ \varepsilon_{cds,t}^{k,l} \end{pmatrix}, \quad (1)$$

where as_t^k is the asset swap spread and $cds_t^{k,l}$ the CDS ask ($l = a$), respectively bid ($l = a$), premium of company k at date t. $\alpha_{as}^{k,l}$ and $\alpha_{cds}^{k,l}$ are the error correction coefficients for the asset swap spread and the CDS premium changes. $\beta^{k,l}$ is the cointegration coefficient, and $\Gamma_j^{k,l}$ is the 2x2 coefficient matrix for the first differences with lag j. Lags up to order 5 are considered in order to capture autocorrelation up to a weekly level.

Even though most research focuses on the reaction of the bond market to changes in the CDS market, we believe that it is important to account for bilateral effects between the two markets. On the one hand, the lower liquidity of bond markets is likely to give rise to an information spillover regarding an issuer's credit risk from the CDS market, as Norden and Weber (2004) argue. On the other hand, a CDS is a derivative and should thus also reflect price changes of the underlying asset (the bond) not due to credit risk changes. Therefore, we believe that Equation (1) is well-specified.

The estimation results are displayed in Table II.

Insert Table II about here.

Only 82 out of the 116 firms exhibit a significant cointegration relation between asset swap spreads and CDS ask premia. For the bid side, we only find 81 cointegrated asset swap spreads and CDS premia. The negative average cointegration coefficient estimate of -1.26 for CDS ask premia and -1.35 for bid premia points at a comovement of asset swap spreads and CDS premia, but the high standard deviation across the significant coefficient estimates suggests that this relation differs strongly across firms. The on average larger error correction coefficient estimates $\alpha_{as}^{k,l}$ (on an absolute level) for asset swap spread changes imply that asset swap 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 for asset swap spread changes (74 versus 48 for ask premia / 73 vs. 45 for bid premia).

Across the different rating classes, the cointegration coefficient estimates are higher for the investment grade segment (on an absolute level), but the high standard deviation across the significant coefficient estimates suggests that the relation differs strongly across firms. Interestingly, both CDS ask and bid premia in the subinvestment grade segment react more frequently to deviations from the long-run relationship than in the investment grade segment, suggesting that price discovery takes place about as often in the bond market as in the CDS market.

For the different industry sectors, the average coefficients and their standard deviations also differ for financial and non-financial firms. For financial firms, the cointegration coefficient estimates are significant less frequently, smaller (on an absolute level), and CDS premia react less frequently to deviations from the long-run relationship. Therefore, the link between the bond and the CDS market are weaker, and the relation more asymmetric, for financial than for non-financial firms.

Overall, the results of this section imply that CDS premia and asset swap spreads can differ strongly in the short run. We observe a significant time-series comovement for only 70% of our firm sample, suggesting that differences between the bond and the CDS market are persistent, and affected by time-varying factors. These differences are particularly prevalent for financial firms. In the next section, we explore whether the differences can be attributed to a different sensitivity of asset swap spreads and CDS premia to firm-specific and market-wide risk factors.

IV. Explaining the Basis

In the previous section, we demonstrated that asset swap spreads and CDS premia frequently evolve independently from one another. Even if we identify a significant cointegration relation, the often insignificant error correction coefficients imply that there is no stable long-run relation between the two quantities. In this section, we explore whether the deviation between asset swap spreads and CDS quotes is related to time-varying firm-specific and market-wide risk factors. Since we are mainly interested in the profitability of basis trades, we only analyze cases where the long or the short basis are positive, since entering a basis trade with a negative basis would result in certain cash outflows.[2] The results of this analysis also allow us to infer under which conditions bond and CDS markets converge.

[2] This limitation rests on the assumption that the trader can only buy protection at the (higher) ask premium and sell protection at the (lower) bid premium. If buying and selling is possible both at the ask and at the bid premium, a negative basis can also be traded profitably. However, a trader could then simply go short at the ask, i.e. be paid the ask premium, and go long at the bid, i.e. pay the bid premium, which appears to be a violation of the no-arbitrage principle.

As the basis time series are often 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.[3] 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.

The system of equations which we estimate is given by

$$\begin{aligned} bs_t^{k,i} &= f_0^k + f_1 r_t^k + f_2 vol_t^k + f_3 ba_t^k + f_4 yv_t^k \\ &\quad + f_5 \mathrm{LEUR}_t + f_6 \mathrm{SEUR}_t + f_7 \mathrm{SPWC}_t^k + f_8 \mathrm{FML}_t + \nu_t^{k,i}. \end{aligned} \tag{2}$$

$bs_t^{k,i}$ defines the long ($i = l, bs^{k,l} = as^k - cds^k_{\text{ask}}$) or short ($i = s, bs^{k,s} = cds^k_{\text{bid}} - as^k$) basis for firm k at time t if this quantity is positive. f_0^k is the time-invariant firm-specific fixed effect. r_t^k and vol_t^k refer to the rating and option-implied volatility (replaced, if unavailable, by the historical stock return volatility). ba_t^k and yv_t^k 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. LEUR_t denotes the 5-year German Government rate level, SEUR_t the German Government rate slope defined as the difference between the 10-year and the 1-year rate, SPWC_t^k 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.

We proceed in three steps. First, we identify the firms which had at least 20 positive basis observations on days when all explanatory variables were observed. This leads to the exclusion of 16 firms from the analysis. We then estimate Equation (2) by OLS and determine the significance of the coefficient estimates using the Newey-West covariance estimate to adjust for autocorrelation and heteroscedasticity.[4] We subsequently test

[3] See e.g. Wooldridge (2002), p. 252.

[4] See Campbell, Lo, and MacKinlay (1997), pp. 534-535.

whether the time series of the residuals is stationary for each firm using the Phillips-Perron test.[5] The results of the estimation are given in Table III.

Insert Table III about here.

We first discuss the results for the long basis in Panel A of Table III, and subsequently the results for the short basis in Panel B.

As the last column of Panel A shows, for the entire sample all variables significantly affect the long basis at the 1% significance level. Firm-specific credit risk decreases the long basis, whether measured by the rating or the option-implied volatility. Lower CDS liquidity decreases the basis, and lower bond liquidity increases its. This is consistent with the definition of the basis: lower bond liquidity results in higher asset swap spreads, and thus in a higher basis, while lower liquidity in the CDS market increases the ask premium, and thus decreases the basis. Jointly, the results agree with an on average higher liquidity of the CDS market (at least when a positive long basis is observed): a decrease of CDS liquidity and an increase of bond liquidity both result in convergence of the two markets.

The market-wide explanatory variables have a significant impact on the basis in excess of the firm-specific variables. A higher interest rate level increases the long basis, and thus the difference between the bond and the CDS market, while a higher slope decreases it. Therefore, more adverse economic conditions which coincide with lower interest rates lead to a tighter long basis. Higher overall credit risk, reflected by a higher value of SPWC, and lower overall market liquidity, proxied by lower values of FML, increase the long basis and thus the differences between the bond and the CDS market. The adjusted R^2 lies at 29.33% which, taking into account that the basis measures the difference between two quantities often viewed as identical, is rather large.

Comparing the estimation results for the investment and the subinvestment grade segment in Panel A of Table III, we observe that the coefficient signs remain unchanged from those for the entire sample with two exceptions. Both the bond liquidity proxy and the interest rate level negatively affect the basis for the subinvestment grade segment. These findings, however, are spurious: if we perform the same analysis for the asset swap

[5] See Enders (1995), pp. 239-240.

spread or the CDS ask premium only, the coefficient estimates do not differ significantly from zero at the 10% significance level. The adjusted R^2, interestingly, is higher for the subinvestment grade segment, implying that firm-specific and market-wide risk explain a larger proportion of the differences between the bond and the CDS market.

Regarding the differences between financial and non-financial firms in Panel A of Table III, we find that the rating becomes insignificant in explaining the basis variation for financial firms. This appears sensible since for a financial institution, press coverage is higher, and financial market information is in general more easily available. Therefore, differences between the impact of the rating on the asset swap spread and the CDS premium become negligible. In addition, the impact of the market-wide risk factor is not significant. In spite of the lower number of significant explanatory variables, the adjusted R^2 is higher for financial firms, suggesting that differences between the bond and the CDS market are more closely associated with credit risk, liquidity, and interest rates for financial firms.

As Panel B of Table III shows, the results for the short basis are partly reverse to those for the long basis. Higher firm-specific credit risk increases the positive short basis, suggesting that the impact of firm-specific credit risk on the CDS quote (both bid and ask) is higher than on the asset swap spread. The CDS liquidity proxy also has the reverse sign to that in Panel A, but the coefficient for the bond liquidity proxy surprisingly again implies that the basis increases when bond liquidity decreases. The adjusted R^2 lies at 37.70% and thus exceeds that for the long basis, suggesting that the short basis is due to firm-specific credit risk and liquidity as well as market-wide factors to a larger extent.

On comparing the investment grade to the subinvestment grade, we observe that as for the long basis, the impact of the CDS liquidity differs. While the investment grade short basis increases when the CDS becomes more illiquid, the subinvestment grade basis decreases. The same is true for the level of the interest rate curve and the market risk factor, suggesting that the basis for the investment grade is larger when CDS liquidity, interest rates, and market risk are high, while the subinvestment grade basis is lower under these conditions. Financial and non-financial firms also differ regarding the basis sensitivity. For financial firms, the rating, option-implied volatility, CDS liquidity, and the slope of the interest rate curve have no significant impact on the basis. The negative coefficient for the CDS liquidity for non-financial firms is due to the impact of the subinvestment grade firms.

To summarize, we find that the impact of the explanatory variables on the long and the short basis differs strongly, depending on which subsample we analyze. Only a higher slope of the interest rate curve and a higher market-wide liquidity lead to a consistently tightening basis. For the entire sample, credit risk, either measured as the rating or the option-implied volatility, tightens the long basis, and increases the short basis. This finding is in line with the intuition that CDS quotes are a purer measure of credit risk. In addition, we document a significant impact of the bond and CDS liquidity proxies on the basis and thus show that the commonly held view of a perfectly liquid CDS market is not supported by the data. A higher CDS liquidity increases the long basis and decreases the short basis, while a higher bond market liquidity tightens both the long and the short basis. Deteriorating overall market conditions (lower interest rates due to central bank intervention, higher market-wide credit risk) are associated with a widening long and a tightening short basis and thus with converging asset swap spreads and CDS bid quotes. The adjusted R^2 is large, and maximal for the short basis and the subinvestment grade segment, suggesting that differences between the bond and the CDS market for these are explained to a large extent by firm-specific and market-wide factors.

V. Bond-CDS Basis Trading

A. Risks Associated with Basis Trading

Market participants can actively exploit differences between the bond and the CDS market through two basic strategies. Consider a bond with maturity equal to that of a CDS contract. First, if that bond's asset swap spread exceeds the CDS ask premium, a basis trader can take out a loan with maturity identical to that of the bond, use the money to buy the bond, and buy protection through a CDS. The resulting position is default-risk free: If no default occurs, the bond's coupon payments $as + i$ can be used to pay the loan interest rate payments i and the CDS ask premium cds^{ask}, and the face value of the bond can be used to repay the loan. Since the bond's asset swap spread exceeds the CDS ask premium, the position yields a profit of $as - cds^{\text{ask}}$ at each payment date. If a default occurs, the CDS pays the difference between post-default market price of the bond and its face value. Thus, a profit of $as - cds^{\text{ask}}$ is incurred at each payment date before the default, and there are no further payments either through the bond, the loan, or the CDS. This buy-and-hold strategy is known as a long basis trade.

Second, if the asset swap spread lies below the CDS bid premium, a basis trader can short the bond and sell protection through a CDS. As in a long strategy, he obtains a profit of $cds^{\text{bid}} - as$, less the shorting costs, until the maturity of the contracts or until a default event occurs. This strategy is known as a short basis trade.

By trading on the pricing differences between bonds and CDS, basis traders have an important role in providing liquidity to both the bond and the CDS markets since they repeatedly act as buyers and sellers in the two markets. This is of particular importance since both bonds and CDS are mostly traded on over-the-counter markets instead of organized exchanges in which market makers provide liquidity. Simultaneously, the trading strategies lead to an increasing convergence of the bond and the CDS market: In a long basis trade, the asset swap spread is too high, and thus the price too low, compared to the CDS ask premium. By buying the bond and buying protection at the ask quote, basis traders contribute to increasing bond prices, or decreasing asset swap spreads, and increasing CDS ask quotes. Reversely, short basis traders cause asset swap spreads to increase, and CDS bid quotes to decrease. Through mitigating the impact of non-systematic price distortions, basis trades can thus increase market efficiency, and the informativeness of bond prices and CDS premia.

However, the basis trading strategies as described above depend on simplifying assumptions. First, the maturity and payment dates of the bond, the loan, and the CDS must coincide. A maturity mismatch between the bond and the CDS leads to a default risk exposure between the different maturity dates. Second, we assume that borrowing and lending is possible at the swap rate. Therefore, funding constraints and margin and collateral requirements are not taken into account. Obtaining a loan in order to buy the bond might bind up resources which could be used for more profitable investments. Also, haircuts which are necessary for the repurchase agreements for a short basis trade might conflict with funding constraints. For the CDS, the recent financial crisis has led to wide demand for a marking to market and associated margin and collateral requirements, in particular for protection sellers. Third, counterparty risk in the CDS market is neglected, even though a default of the CDS protection seller would leave a long basis trader with an uncovered long credit risk position, and a default of the CDS protection buyer would leave a short basis trader with an uncovered short credit risk position in the bond.

Last, and most important, the described strategies rely on the trader's ability to keep up the buy-and-hold position. If the trader is forced to dissolve the position before default or maturity, this may lead to a significant loss. As an example, assume that the asset swap spread equals 100 bp, the CDS ask premium 90 bp, and the bid premium 80 bp. Then a long basis trade results in an annual cash inflow of $as - cds^{\text{ask}} = 10$ bp. If, however, the position is dissolved immediately after the inception, this results in an annual outflow of $cds^{\text{bid}} - as = -20$ bp, and a net outflow of -10 bp.

As the above numerical example shows, a basis trade that is dissolved is more profitable when the asset swap spread converges to the opposite CDS quote of the original trade. In a long position, where the asset swap spread is initially above the ask spread, the trader can lock in a profit when the asset swap spread decreases and does not exceed the bid quote more than it did the original ask quote. In a short position, the asset swap spread should increase at least until it lies no further below the ask quote than it did below the original bid quote.

Given that a buy-and-hold strategy appears optimal, it is valid to question whether dissolving basis trades at all is a realistic scenario. We believe that taking dissolving into account is central for two reasons. First, dissolving a basis trade at current market conditions corresponds to determining its current market value. It seems sensible that even though a buy-and-hold strategy might be optimal, a position's current market value is relevant because it serves as input for most risk management tools, and is reflected in the balance sheet under IFRS and US GAAP. Second, basis traders might not be able to sustain financing for the long basis trades via loans, or to roll over the short bond position for the short basis trades, for as long as necessary.

This dissolving risk is amplified because of the maturity structure in the CDS market. Similar to equity options, CDS are written for certain fixed maturity dates (March, June, September, and December 20), such that a 5-year CDS contract which is entered into on March 21 matures on June 20 5 years later. Offsetting one CDS position by opening a new standard contract is therefore only possible until the next change of reference date. After this date, the position must either be dissolved by agreement with the original counterparty, or a new counterparty must be found that agrees to a non-standard CDS maturity. Such a trade is likely to take place at adverse conditions, i.e. at unattractive quotes, for the basis trader.

B. Buy-and-Hold Basis Trades

We first demonstrate the profitability of basis strategies in a simplified trading study. We assume that the basis trader can borrow and lend at the swap rate, and that a default-risky par bond with the same maturity as the CDS is outstanding.

The base case strategies consist of a long / short buy-and-hold basis trade, where a position is entered into if the synthetical 5-year asset swap spread and the CDS ask, respectively bid, premium differ by more than a specific trigger amount e_0, plus the transaction costs which we assume to be a proportion n of the asset swap spread. We let n take on values of 5%, 15%, and 30% which agrees with the average range of the price discounts documented by Edwards, Harris, and Piwowar (2007). For the long trade, the total cash inflow then equals the difference between the asset swap spread and the CDS ask premium, $ys - cds^{\text{ask}}$, times the maturity, less the transaction costs which we assume are paid at the inception of the position. For the short trade, we assume that the annualized borrowing costs s for the default-risky bond equal 40 bp. This agrees with the average specialness of corporate bonds in Nashikkar and Pedersen (2008). A short basis trade is incepted when the CDS bid premium exceeds the asset swap spread by the trigger amount e_0 plus the borrowing costs s plus the transaction costs which we again assume to be a proportion n of the asset swap spread. Following Bühler and Xuanlai (2009), we determine the present value of the future payments from the basis trade at the swap rate plus the mid CDS premium. Hence, our discount rate reflects the risk that default occurs prior to the maturity of the contracts, and the basis position is automatically dissolved.

We present the results of the base case for different levels of e_0 and different levels of transaction costs in Table IV.

Insert Table IV about here.

As Table IV shows, all long and short basis trades are profitable with mean profits between 225 bp and 1,402 bp. The profitability increases in the entry trigger and the level of transaction costs, as only trades that are more profitable are entered into. This does not imply that it is better to enter *only* into these, since there is no downside risk associated with any of the positions, and the number of potential trades decreases in the entry trigger and transaction cost level. If, however, a trader faces a total position limit, he will naturally focus on the highest available basis positions.

Comparing the long and the short basis trades in Panel A and B of Table IV, we observe that long basis trades are, with the exception of the entry trigger $e_0 = 10$ bp, less frequent, but more profitable, than short basis trades. For $e_0 = 10$ bp, we observe long basis trades on 12%, and short basis trades on 5% of all available trading dates. This lower proportion of short basis trades is due to the cost of shorting the bond. A short basis trade is only entered into when the asset swap spread and the CDS bid quote differ by the entry trigger plus the borrowing costs plus the transaction costs, compared to the entry trigger plus the transaction costs for the long basis trades. However, if we set the borrowing costs to zero, there are more short than long basis trades for all entry triggers.

C. Dissolving Basis Trades

We compare the buy-and-hold basis trade to a long / short basis trade that is dissolved before the maturity of the contracts. Dissolving an existing position incurs taking on the reverse position in both markets, i.e. for a long basis trade, selling protection at the current bid premium, and selling the bond at the current asset swap spread.

We use three different exit triggers. First, a position is dissolved when the reference date for the CDS contract changes. This ensures that the trader can cancel out the CDS position by entering into an offsetting trade at current market prices. Therefore, no basis trade can last longer than 90 days.

The second exit trigger is a change in the risk-free interest rate. If the interest rate increases, rolling over the loan which finances the long bond position becomes increasingly expensive. If the interest rate decreases, the difference between the interest rate specified in the repo agreement and the market interest rate becomes larger, and shorting the bond becomes relatively more expensive. Hence, we use an overnight increase of the 1-year government interest rate by 10 bp as an exit trigger for long basis trades, and a decrease by 10 bp as an exit trigger for short basis trades.

As a third exit trigger, we use divergence of the asset swap spread and the CDS quote for the dissolving position, i.e. for a long basis trade, a short basis of at least e_τ, which the trader needs to pay out at each future payment date. This trigger choice resembles a stop-loss strategy¿ even though the trader realizes a loss through dissolving the basis trade at current conditions, this loss is limited. To avoid unnecessary positions which are associated with a certain loss, the trader does not enter into a basis trade when the exit trigger is exceeded at the time when he could open a new position.

The profits the dissolving-risky basis trades are given in Table V.

Insert Table V about here.

Table V shows the basis strategies become much less profitable when they are dissolved, irrespective of the dissolving criterion.

On comparing Panel A of Table V to the first block in Panel A of Table IV, we find that the average long basis trade profit lies between -8 bp (for $e_0 = 10$ bp) and 38 bp (for $e_0 = 50$ bp). Clearly, the losses incurred through dissolving the long basis position when the reference date changes (hence, every position that was set up in Panel A of Table IV is also closed out) partly compensate the initial profits. Also, we obtain large losses which cannot be prevented by increasing the entry trigger. However, as the results for the short basis trades in Panel A of Table V show, these are even less profitable than the long basis trades with average profits between -21 bp (for $e_0 = 10$ bp) and 33 bp (for $e_0 = 100$ bp).

This lower profitability is due to the following effect. Overall, it is rare that the asset swap spread lies above the CDS ask quote. Hence, the *normal* condition under which a basis trade is entered into is that of a short basis trade: the asset swap spread lies below the CDS bid quote. Since it is already exceptional that the asset swap spread lies above the CDS ask quote, it is even less likely that the asset swap spread increases to a level that makes dissolving a short basis trade profitable. This constellation leads to an on average lower profit of the short basis strategies. The lower profit, however, is also reflected in a somewhat lower variability: The Sharpe ratio of the long basis strategy with an entry trigger of 50 bp and of the short basis strategy with an entry trigger of 100 bp both lie at 7%.

As Panel B of Table V shows, closing out a basis trade because of an upwards or downwards interest rate shift also swallows up a large fraction of the basis trade profits. Average profits remain positive, but the values decrease for higher entry triggers for the long basis trades. Overall, we only observe 13 interest rate upwards shifts, but these lead to closing out almost all long basis positions (10,010 for $e_0 = 10$ bp, 1,775 for $e_0 = 50$ bp, and 1,152 for $e_0 = 100$ bp). Hence, if fewer positions are taken on due to a higher entry trigger, a larger fraction is closed out at an eventual loss (73% for $e_0 = 10$ bp, 81% for $e_0 =$ 50 bp, and 95% for $e_0 = 100$ bp) The 16 downwards shifts lead to the closing out of 3,434 (2,268 / 1,303) short positions, which corresponds to 60% (68% / 64%) of all opened short positions. The lower fraction of short basis positions which must be dissolved results in increasing average profits as the entry trigger increases, and a Sharpe ratio of up to 37% (for the 100 bp entry trigger). The large negative minimum profits for all basis trades, however, show that the strategies still entail a high risk of a negative profit.

Third, we analyze the effects of a stop-loss strategy in Panel C of Table V. First, we remark that in comparison to Panel A of Table IV, only slightly more than half the long basis trades (7,463) are entered into for the entry trigger of 10 bp and the stop-loss trigger of 75 bp. If asset swap lies above the CDS ask quote by the entry trigger, it also lies above the bid quote, such that it is likely that the stop-loss trigger is also exceeded. In this case, we assume that the trader does not open a basis trade. Slightly more than half of the opened long basis positions (3,992) are dissolved because the stop-loss trigger is hit at a future date. These proportions reverse for the higher exit triggers: For $e_\tau = 100$ bp, 10,762 out of the 13,708 long basis trades in Panel A of Table IV are entered into, and only 3,296 of these trades are dissolved. For $e_\tau = 125$ bp, 11,832 long basis trades are entered into, and 2,426 are dissolved. Hence, the average profit increases in the level of the stop loss trigger. Interestingly, the trades which are dissolved appear to be the most profitable ones: The maximum long basis trade profit equals 537 bp, compared to values in excess of 3,000 bp in Panels A and B. Short basis trades are entered into much less frequently than long basis trades: For $e_\tau = 75$ bp, we obtain only 716 opened basis positions, which amounts to less than 13% of the 5,557 short basis trades in Panel B of Table IV. The majority of these opened position (517) are dissolved ($e_\tau = 100$ bp: 1,619 opened / 1,170 dissolved, $e_\tau = 125$ bp: 2,563 opened / 1,631 dissolved). The negative average profit and minimum as well as the small positive maximum profit illustrate that short basis trades are, as for the maturity date change, much less profitable than long basis trades if they have to be dissolved.

In summary, basis trades that are dissolved become much less profitable, and frequently result in large losses. Given that they are dissolved, e.g. because of a stop loss criterion, short basis trades are particularly prone to losses. Conditional on the entry and exit trigger, long basis strategies can still attain Sharpe ratios of up to 34% (stop loss trigger of 125 bp), and short basis trades of 37% (interest rate shock, entry trigger of 100 bp). Interestingly, stop loss triggers effectively limit the upside potential of basis trades which need to be dissolved. Interest rate shifts affect long basis trades more strongly, which implies that a positive long basis may imply a future upwards shift in interest rates.

D. The Impact of Firm-Specific and Market-Wide Risk on Basis Trade Profits

As the analysis of the long and short basis in Section IV shows, the size of the basis is highly sensitive to changes in firm-specific and market-wide variables. Clearly, the profit of the buy-and-hold strategies will exhibit a similar sensitivity to the explanatory variables, but it is not clear ex ante which association prevails between the profits for basis trades which are dissolved, and the firm-specific and market-wide risk measures.

We therefore relate the trading profits that can be attained in basis trading strategies which are dissolved to the explanatory variables used in Section IV in a fixed-effects analysis. As the dependent variable, we use for each day and each firm the profit from a long, respectively short, basis trade with the same entry and exit triggers as in Table V. Naturally, this profit is only known ex post to the basis trader, and can be negative in contrast to the analysis in Table III.

The system of equations which we estimate is given by

$$\begin{aligned} p_t^{k,i} &= g_0^k + g_1 r_t^k + g_2 vol_t^k + g_3 ba_t^k + g_4 yv_t^k \\ &\quad + g_5 \mathrm{LEUR}_t + g_6 \mathrm{SEUR}_t + g_7 \mathrm{SPWC}_t^k + g_8 \mathrm{FML}_t + \eta_t^{k,i}. \end{aligned} \tag{3}$$

$p_t^{k,i}$ defines the long ($i = l$) or short ($i = s$) basis profit as summarized in Table V for firm k at time t. The explanatory variables are defined as in Equation 3. We estimate the system separately for the three different dissolving strategies, but jointly for the three different entry, respectively exit, triggers. The estimation results are given in Table VI.

Insert Table VI about here.

We first discuss the results for the basis trades dissolved due to a change of the reference date (Panel A.1 and A.2 of Table VI), then for the trades dissolved due to an interest rate shock (Panel B.1 and B.2), and last for the trades dissolved due to the stop loss trigger (Panel C.1 and C.2).

Panel A.1 of Table VI shows that all explanatory variables are significant and that the coefficient estimates increase strongly for the pooled sample. Clearly, the profitability of the basis strategies is more dependent on the firm-specific and market-wide conditions than the mere basis size. With regard to the coefficient signs for the entire sample, we observe that the rating, the CDS liquidity, the interest rate level, and the market-wide credit risk proxy change their signs from that of the long basis in Panel A of Table III to that of the short basis trades in Panel B of Table III. A higher numerical rating (and, conditional on the rating, a lower option-implied volatility), lower CDS and bond liquidity, lower and less steep interest rate, lower market-wide credit risk, and lower market-wide liquidity are associated with higher long basis trade profits. Hence, long basis trades which are dissolved are effectively long positions in liquidity risk at the time that the trades were entered into. Also, long basis trades profit from the *relative* higher riskiness of a firm compared to market conditions, since the current rating coefficient is positive, and the market-wide credit risk coefficient is negative.

Financial and non-financial firms in Panel A.1 of Table VI exhibit a similar behavior, but we observe that the coefficients for financial firms have much larger absolute values than for non-financial firms. Clearly, long basis trade profits for financial firms are more sensitive against changes of the - publicly observable - explanatory variables. This finding agrees with the less prevalent cointegration of asset swap spreads and CDS premia for financial firms in Table II. Comparing the investment and subinvestment grade segment, we also observe clear differences: CDS liquidity has a significant negative impact on the basis trade profits for subinvestment grade firms, and higher interest rates have a significant positive impact. For the CDS liquidity, this is consistent with the negative coefficient for short basis trades in Panel B of Table III, supporting that the basis trade profits are more dependent on the dissolving than the inception conditions.

The short basis trade profits, as shown in Panel A.2 of Table VI, exhibit the reverse sensitivities as the long basis trade profits with the exception of the interest rate and the market liquidity proxy. A low rating, high CDS and bond liquidity, low and flat (or even reverse) interest rate curves, and a low financial market liquidity lead to higher profits for short basis strategies. Interestingly, the reverse sensitivity does not hold for the investment grade sample, for which basis trade profits again depend positively on each liquidity proxy (recall that a lower value of FML indicates lower market liquidity). However, this finding does not imply that *deteriorating* liquidity conditions lead to higher basis trade profits. The profits depend positively on the liquidity conditions at the trade inception. For short basis trades, buying the illiquid bond at a cheaper price at a future date to dissolve the short bond position may be beneficial. Buying protection at a higher CDS ask quote due to illiquidity, however, is harmful. For the long basis trades, the bond and CDS liquidity effects are similar: Short-selling a less liquid bond at a future date is likely to be costly, and selling protection at a lower bid quote due to liquidity concerns is less profitable.

Panel B.1 of Table VI shows that profits for long basis trades that are dissolved due to an interest rate shock behave like those for long trades dissolved due to a reference date change, only excepting the interest rate slope. The short basis trades in Panel B.2, however, exhibit different sensitivities than in Panel A.2 for the entire sample, only bond and market liquidity and the interest rate level retain the original coefficient sign. These changes imply that an interest rate shock creates a very different risk profile for the short basis trade profits than dissolving because of an (ex ante known) change of reference date. We can attribute the differences for the entire sample to the changes for non-financial companies (the signs for financial ones are the same as in Panel A.2), and mostly investment grade ones. This is particularly interesting, since we expect that financial companies react more strongly to interest rate shocks than non-financial ones. The higher absolute values of the coefficient estimates reflect that this higher sensitivity becomes more strongly reflected in the basis trade profits if the trades are dissolved due to an interest rate shock.

For the basis trade profits in Panel C.1 and C.2 of Table VI, we obtain the reverse relation as when moving from the base case of dissolving due to a change in reference date to dissolving due to an interest rate shock. The short basis trade profits in Panel C.2 have similar sensitivities an in Panel A.1, but the long basis in Panel C.1 differs. All liquidity proxies, however, are unchanged with regard to their coefficient sign.

In summary, our results show that conditions that lead to an ex ante high basis do not necessarily lead to a profitable basis trade when dissolving is taken into account. Our findings suggest that a main systematic component in all basis trade profits is a recompensation for bearing liquidity risk. Long basis trades hence are negatively correlated with liquidity (market-wide and industry-specific), while short basis trades are mostly positively correlated with liquidity. We believe this result to be sensible, since a long basis trade effectively yields the bond liquidity premium during the duration of the trade, while a short basis trade results in the trader's having to pay the bond liquidity premium.[6] Comparing the different triggers that lead to dissolving the basis, we find that long basis trades dissolved due to a change in the reference rate and due to an interest rate shock exhibit similar sensitivities. For the short basis, dissolving due to a change of the reference date leads to a similar risk profile as dissolving due to the stop loss barrier.

E. Basis Trading in the Financial Crisis

During the financial crisis, numerous financial institutions experienced large losses due to basis trades. A prominent example is Deutsche Bank, which was reported to have incurred a loss of 1 billion Euro in the fourth quarter of 2008, due to basis trades.[7] As we show in Section B, a buy-and-hold strategy generates non-negative profits - at least under the stated simplifications. The dissolving-risky strategies, on the other hand, also result in large negative profits, but the risk-return profile can remain attractive. It is natural to ask whether basis trades have become less profitable during the financial crisis, and whether the reported losses are due to an increased profit variability. In the latter case, it is still possible that the risk-return profile is sufficiently attractive for traders to remain engaged in basis trading. As we argued above, basis traders fulfill an important role in providing liquidity to bond and CDS markets, thus increasing market convergence, and may also increase market efficiency and price informativeness. Since the drastic liquidity decrease during to the financial crisis is a major impediment to well-functioning securities markets, it may be beneficial if basis traders continue trading on the pricing differences between the two markets.

We collect for all firms which we previously analyzed the CDS bid and ask quotes and the mid bond asset swap spreads from July 1, 2007 to January 31, 2009. Next, we interpolate the asset swap spreads to a maturity that matches that of the CDS contract as described in Section II. Last, we repeat the basis trade analysis for the buy-and-hold and the dissolving-risky strategies as in Table IV and Table V with entry triggers $e_0 = 10$ bp and 100 bp, and exit triggers $e_\tau = 75$ bp and 125 bp, and a proportional transaction

[6] The CDS bid-ask spread always has to be paid, and is never earned by the trader.
[7] See Financial Times Deutschland, Issue of February 23, 2009.

costs level $n = 5\%$. We again assume a shorting cost of 40 bp p.a. for the bond. The resulting mean, minimum, and maximum profit, the standard deviation across the profits, and the number of trades incepted are presented in Table VII.

Insert Table VII about here.

As Panel A of Table VII shows, the average buy-and-hold basis trade profits become more similar in the financial crisis. The average long basis trade profit for the entry trigger $e_0 = 10$ bp increases by 53%, the short basis trade profit for $e_0 = 100$ bp increases by 22%. Reversely, the long basis trade profit for $e_0 = 100$ bp decreases by 18%, and the short basis trade profit $e_0 = 10$ bp decreases by 28%. Interestingly, not only the average profits, but also the trading opportunities become more symmetrically distributed with long and short trades on 20% of all dates. By definition, the higher variability signifies a higher profitability of the basis strategies, which is also reflected in the extremely high maximum of 8,550.45 bp for the short basis trades.

Panels B to D of Table VII give the results for the dissolving-risky basis trades. The central finding is that all basis trades become on average unprofitable, with the exception of the long basis trades at the high entry trigger level dissolved because of the reference date change. The profits of the long basis strategies with the lower entry trigger $e_0 = 10$ bp on average decrease by 13 bp, 51 bp, and 202 bp (the latter for the low stop loss barrier). For the high entry trigger, we observe an increase of 6 bp in the average profit for the basis trades dissolved due to the reference date change, and the lower variability (620 bp compared to 699 bp in Panel A of Table V) implies that the Sharpe ratio of 7% is more attractive than before the financial crisis. Dissolving long basis trades due to the stop loss barrier becomes especially unprofitable with an average decrease of 200 bp. In contrast to the long basis trades in Panel B and C, for which the maximum and minimum profit effectively increase compared to Table V by up to 2,168 bp, the stop loss strategies therefore becomes even less attractive.

The short basis trade profits decrease by on average 23 bp (in Panel B and D) and 60 bp (in Panel C) for the low entry and exit trigger levels, while the higher entry and exit trigger level lead to an average profit decrease of 119 bp (Panel B), 271 bp (Panel C), and 59 bp (Panel D). The maximum profit, on the other hand, increases by 1,661 bp for the reference date change, and by 4,470 bp for the interest rate shock. These high values imply that in spite of the decreasing average profit, both long and short basis trades could still be highly profitable during the financial crisis.

To further demonstrate the profitability of the basis strategies during the financial crisis, we plot the empirical density function of the realized profits for the dissolving-risky trades in Figure 1. We use a discrete bin width of 100 bp to determine the relative frequency of the realized returns.

Insert Figure 1 about here.

As the Panel A of Figure 1 shows, long basis trade profits dissolved due to a change of the reference date are basically shifted to the left during the financial crisis. Short basis trade profits dissolved for the same reason are, as Panel B shows, mostly unaffected - only for the higher entry trigger, we obtain a somewhat heavier left tail. Apparently, short basis trades dominate long basis trades in a surprisingly large region during the financial crisis, while the reverse relation prevails in the pre-crisis interval.

Basis trades which are dissolved due to an interest rate shock are more symmetrically affected. However, as a comparison of Panel C and D reveals, short basis trades with a 100 bp entry trigger effectively have a heavier right tail, which agrees with the results in Panel C of Table VII. As for the trades dissolved due to a change in the reference date, we observe a large region of the distribution where short basis trades dominate long basis trades during the financial crisis.

Panel E and F of Figure 1 depict the results for the long and short basis trades dissolved due to the stop loss barrier. Panel E shows a rather unique effect on the long basis trade profits, which exhibit a strongly double-humped shape for the financial crisis. The long basis strategy with the exit trigger of 75 bp attains its maximum in the more negative range, and thus effectively reverses its earlier profile. The short basis strategies in Panel F are, as before, less strongly affected by the financial crisis, and the relative frequency plot resembles that of the long basis strategies.

Overall, Figure 1 shows that while long basis trades were initially more profitable, the crisis affected their profit profile more strongly. Hence, long and short basis trades mostly exhibit a similar relative return frequency during the financial crisis. For some regions, short basis trade profits actually dominate long basis trade profits. These results suggest that the large losses experienced by financial institutions who engaged in basis trades during the financial crisis may be due to the changing risk profile, and the underestimation of the associated losses, for long basis trades that need to be dissolved.

VI. Summary and Conclusion

The purpose of this paper was to explore which factors drive the differences between asset swap spreads and CDS premia, and whether these differences give rise to profitable trading strategies. In order to adjust for the different maturity schemes, we determine asset swap spreads which we interpolate to a 5-year maturity. We then compute the long basis as the difference between the interpolated asset swap spread and the CDS ask premium, and the short basis as the difference between the CDS bid premium and the interpolated asset swap spread.

Our results imply that for a broad sample of 116 firms with an average rating between AAA and CCC, CDS premia are higher, respectively asset swap spreads are lower, than if credit risk were the only priced factor. A VECM analysis reveals that the differences are caused by the impact of differentiating time-varying factors. For 34 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 asset swap spreads. Even for the 82 firms with a significant cointegration relation, the relation is not necessarily stable which we deduce from 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 of the long and the short basis. 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). Market-wide liquidity consistently tightens the long and the short basis. On average, higher firm-specific credit risk tightens the long and increases the short basis. Adverse market conditions, proxied by lower interest rates and a higher market-wide index yield spread, result in a widening long and a tightening short basis. Comparing different rating classes and industry sectors, however, we find that this convergence is not given for all firms.

In our analysis of the profitability of basis trades, we observe that buy-and-hold strategies result in large positive profits. Due to the on average lower asset swap spreads, short trade opportunities are more frequent, and on average more profitable for low entry triggers. Basis trades that need to be dissolved are less profitable, and more risky, than buy-and-hold strategies. Compared to the short basis trades, long basis trades on average retain a higher profitability when they need to be dissolved, but this result is not independent of the trigger for dissolving the basis position. We identify interest rate shocks as a potential cause for dissolving basis positions that can lead to higher profits for short basis trades. The related Sharpe ratios reach 34% for long basis trades, and 37% for short basis trades. Interestingly, higher entry triggers do not consistently lead to higher profits, and a higher stop loss barrier effectively decreases the average profit for short basis trades.

The fixed-effects analysis for the basis trade profits reveals a close relation between credit risk, liquidity, and basis profits. However, the sensitivities again change across the different subsamples. The main systematic component in basis trade profits is due to the basis trader being recompensated for bearing liquidity risk, such that long basis trades on average become more profitable when liquidity is low, and short basis becoming less profitable.

Interestingly, basis trades do not necessarily become less attractive during the financial crisis. Long basis strategies with sufficiently high entry barriers remain profitable on average during the financial crisis. However, we document the occurrence of extremely large negative profits which are incurred during the financial crisis, and negative average profits for almost all strategies. Comparing the profit distribution for the interval before and during the financial crisis, we observe that the long and short basis trades become more similar during the financial crisis. For some regions, short basis trade profits dominate the long basis trade profits. We propose the different sensitivity of the long and short basis trade profiles to the financial crisis as a potential explanation for the large losses which financial institutions experienced during the crisis.

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 basis trading strategies, or in dynamic hedging strategies that depend on the convergence of CDS and bond markets, it is necessary to correctly quantify the associated risks of these strategies. We document that the convergence is by no means reliable, and that credit risk, liquidity, and market-wide conditions affect both the observed basis, and the profitability of long and short basis strategies.

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Table I
Descriptive Statistics

The table shows the mean, standard deviation, minimum, and maximum of each data category. The interpolated asset swap spread and the CDS bid and ask quote are measured in basis points per annum. Volatility is the option-implied volatility of at the money options with a 12-month maturity and, when this is unavailable, the historical stock return volatility, computed for stock returns in percentage points, over 12 months. Bond Liq. is the standard deviation of all observed bond yields for a given firm on a given date for yields in percentage points. CDS Liq. is the bid-ask spread relative to the mid CDS premium, LEUR is the 5-year German Government Rate, SEUR is the difference between the 10-year and the 1-year German Government Rate, and SPWC is the S&P Creditweek Global 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
# Firms		109	7	38	78	116
# Obs.		104,034	6,464	26,770	83,728	110,498
		Panel A: Dependent Variables				
Asset Swap Spread	Mean	43.21	199.15	28.44	59.98	52.34
	Std. Dev.	54.95	221.94	62.80	88.43	84.04
	Min.	-282.66	-277.51	-282.66	-282.50	-282.66
	Max.	899.53	1,629.04	899.53	1,629.04	1,629.04
Ask CDS	Mean	49.03	266.51	25.53	73.34	61.75
	Std. Dev.	61.32	270.32	25.79	113.95	102.07
	Min.	3.75	22.25	3.75	6.91	3.75
	Max.	1,146.00	2,126.00	277.00	2,126.00	2,126.00
Bid CDS	Mean	42.87	241.01	20.70	65.26	54.46
	Std. Dev.	57.09	231.79	22.92	101.99	91.50
	Min.	2.00	18.84	2.00	3.33	2.00
	Max.	944.00	1,731.33	243.00	1,731.33	1,731.33
		Panel B: Firm-Specific Explanatory Variables				
Volatility	Mean	22.72	29.92	21.34	23.41	22.95
	Std. Dev.	4.69	4.45	4.06	4.95	4.84
	Min.	3.66	20.25	3.66	8.12	3.66
	Max.	72.21	61.73	50.59	72.21	72.21
Bond Liq.	Mean	1.00	2.12	1.17	0.95	1.04
	Std. Dev.	0.89	2.22	1.01	0.97	1.00
	Min.	0.00	0.00	0.01	0.00	0.00
	Max.	7.91	16.71	5.81	16.71	16.71
CDS Liq.	Mean	18.61	9.59	26.40	15.43	18.09
	Std. Dev.	10.59	5.18	10.61	9.06	10.57
	Min.	0.00	0.00	0.00	0.00	0.00
	Max.	120.00	42.43	120.00	106.67	120.00
		Panel C: Market-Wide Explanatory Variables				
		Mean	Std. Dev.	Min.	Max.	
LEUR		3.66	0.58	2.53	5.02	
SEUR		1.34	0.65	-0.02	2.31	
SPWC		2.59	1.83	-0.30	7.39	
FML		0.17	0.34	-0.55	0.67	

Table II
The Dynamic Relation of CDS Premia and Bond Asset Swap Spreads

The table shows the estimated coefficients for the vector error correction model in Equation (1). ${as^k}_t$ is the asset swap interpolated to a 5-year maturity, $cds_t^{k,l}$ is the CDS ask ($l = a$) or bid ($l = b$) premium for a 5-year maturity. The dependent variables are the asset swap spread and CDS premium changes, the explanatory variables are the vector error correction terms (${as^k}_t - \beta^{k,l} cds_t^{k,l}$) and the lagged changes. $\beta^{k,l}$ denotes the cointegration coefficient, ${\alpha^{k,l}}_{as}$ and $\alpha_{cds}^{k,l}$ 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
			Panel A: Asset Swap / Ask CDS		
# sign	77	5	23	59	82
Mean $\beta^{k,a}$	-1.28	-0.98	-1.10	-1.32	-1.26
Std. Dev. $\beta^{k,a}$	1.70	0.68	0.90	1.87	1.65
# sign.	70	4	21	53	74
Mean $\alpha_{as}^{k,a}$	-0.07	-0.03	-0.09	-0.07	-0.07
Std. Dev. $\alpha_{as}^{k,a}$	0.10	0.05	0.08	0.10	0.10
# sign.	43	5	6	42	48
Mean $\alpha_{cds}^{k,a}$	0.03	0.03	0.03	0.03	0.03
Std. Dev.$\alpha_{cds}^{k,a}$	0.03	0.04	0.03	0.03	0.03
			Panel B: Asset Swap / Bid CDS		
# sign	76	5	22	59	81
Mean $\beta^{k,b}$	-1.35	-1.44	-1.24	-1.39	-1.35
Std. Dev. $\beta^{k,b}$	1.58	1.52	1.01	1.73	1.57
# sign.	69	4	20	53	73
Mean $\alpha_{as}^{k,b}$	-0.07	-0.03	-0.08	-0.06	-0.07
Std. Dev. $\alpha_{as}^{k,b}$	0.10	0.05	0.09	0.10	0.10
# sign.	41	4	6	39	45
Mean $\alpha_{cds}^{k,b}$	0.03	0.03	0.03	0.03	0.03
Std. Dev.$\alpha_{cds}^{k,b}$	0.03	0.03	0.03	0.03	0.03

Table III
Impact of Market-Wide Factors

The table shows the coefficient estimates, significance level, and adjusted R^2 for the fixed effects model in Equation (2). The dependent variables are the long ($i = l$) and the short ($i = s$) positive basis $bs^{k,i}$ for firm k 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. LEUR denotes the 5-year German Government Rate, SEUR is the difference between the 10-year and the 1-year German Government Rate, SPWC the rating-class specific S&P Global Bond Index yield spread, all 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. The last two rows give the number of firms for which the hypothesis of a unit root in the basis regression residuals was rejected at the 10% significance level, and the number of positive basis observations.

	AAA-BBB	BB-CCC	Financial	Non-Financial	All
Panel A: Dependent Variable Long Basis = Asset Swap Spread - CDS Ask Quote					
r	-0.54***	3.05***	-0.13	-0.20***	-0.11***
σ^{OI}	-0.01**	-0.56***	-0.23***	-0.03***	-0.04***
ba	-71.30***	-25.35**	-104.31***	-50.34***	-54.01***
yv	7.51***	-8.42***	19.01***	0.70***	6.86***
LEUR	8.16***	-12.50***	14.14***	4.99***	6.37***
SEUR	-5.87***	-8.95**	-12.55***	-3.73***	-5.59***
SPWC	3.06***	10.77***	1.11	1.96***	2.57***
FML	-23.45***	-28.11***	-51.37***	-20.51***	-24.74***
Adj. R^2	30.91	60.49	36.52	32.82	29.33
# Firms	94	6	28	72	100
# Obs.	41,004	1,334	10,448	31,890	42,338
Panel B: Dependent Variable Short Basis = CDS Bid Quote - Asset Swap Spread					
r	1.01***	8.32***	0.00	3.13***	2.79***
σ^{OI}	0.17***	-0.11*	0.74	0.31***	0.27***
ba	42.44***	-347.85***	-1.66	- 13.65***	22.59***
yv	2.69***	14.84***	1.71**	1.84***	2.88***
LEUR	5.34*	-16.36***	2.13***	-4.04***	-3.04***
SEUR	-2.85***	-9.77***	-0.23	-4.60***	-3.04***
SPWC	1.66***	-35.12***	3.08***	-1.36***	-1.02***
FML	-29.19***	-158.18***	-7.74***	-44.15***	-35.74***
Adj. R^2	31.66	75.84	19.21	41.78	37.70
# Firms	91	7	25	73	98
# Obs.	48,559	4,389	12,561	40,387	52,948

Table IV
Buy-and-Hold Basis Strategies

The table shows the mean, standard deviation, minimum, and maximum total trading profit for the long and short buy-and-hold basis trades. The entry trigger level e_0 varies between 10 bp and 100 bp, the transaction costs between 5% and 30% of the mid bond asset swap spread. For the short basis trade, the shorting costs equal 40 bp p.a. The last rows give the number of trades which were incepted under each strategy.

		Entry Trigger		
		$e_0 = 10$ bp	$e_0 = 50$ bp	$e_0 = 100$ bp
	Panel A: Long Basis Trade			
5% Transaction Costs	Mean	225.38	816.53	1,173.52
	Std. Dev.	357.96	611.69	614.74
	Min.	54.25	264.30	525.46
	Max.	4,205.17	4,205.17	4,205.17
	# Trades	13,708	2,183	1,218
15% Transaction Costs	Mean	310.81	924.51	1,257.37
	Std. Dev.	429.53	613.96	605.20
	Min.	61.61	296.22	578.66
	Max.	4,115.22	4,115.22	4,115.22
	# Trades	8,078	1,710	1,003
30% Transaction Costs	Mean	483.57	1,090.24	1,402.30
	Std. Dev.	528.30	604.08	582.66
	Min.	81.61	359.11	702.07
	Max.	3,980.29	3,980.29	3,980.29
	# Trades	3,920	1,189	723
	Panel B: Short Basis Trade			
5% Transaction Costs	Mean	528.66	775.44	1,030.19
	Std. Dev.	446.04	417.47	336.30
	Min.	50.88	251.78	502.21
	Max.	2,446.36	2,446.36	2,446.36
	# Trades	5,557	3,347	2,050
15% Transaction Costs	Mean	559.06	823.03	1,058.59
	Std. Dev.	444.45	407.00	322.37
	Min.	53.98	251.56	501.93
	Max.	2,438.62	2,438.62	2,438.62
	# Trades	4,974	2,891	1,821
30% Transaction Costs	Mean	591.21	877.88	1,085.34
	Std. Dev.	442.79	389.35	310.12
	Min.	53.71	255.18	508.28
	Max.	2,427.00	2,427.00	2,427.00
	# Trades	4,300	2,407	1,558

Table V
Dissolution-Risky Basis Strategies

The table shows the mean, standard deviation, minimum, and maximum trading profit for the long and short basis trades that are subject to dissolution risk. The entry trigger level e_0 varies between 10 bp and 100 bp. In Panel A, the position is dissolved when the maturity date for the CDS contract changes. In Panel B, the position is dissolved when the 1-month interest rate increases (for the long basis trade) or decreases (for the short basis trade) by 10 bp overnight. In Panel C, the position is dissolved if the reverse basis exceeds the exit trigger e_τ of 10 bp, 50 bp, or 100 bp, and the entry trigger equals 10 bp. The transaction costs equal 5% of the mid bond asset swap spread. The shorting costs equal 40 bp p.a.

		Entry Trigger		
		$e_0 = 10$ bp	$e_0 = 50$ bp	$e_0 = 100$ bp
	Panel A: Maturity Date Change			
Long Basis Trade	Mean	-8.10	38.00	37.64
	Std. Dev.	264.99	544.73	699.19
	Min.	-3,526.90	-2,707.80	-2,707.80
	Max.	3,865.97	2,858.86	2,858.86
Short Basis Trade	Mean	-20.81	1.75	32.52
	Std. Dev.	397.08	455.97	490.83
	Min.	-2,567.69	-2,375.00	-2,097.12
	Max.	1,733.76	1,733.76	1,733.76
	Panel B: Interest Rate Shift			
Long Basis Trade	Mean	28.26	62.07	2.51
	Std. Dev.	271.87	639.64	821.46
	Min.	-3,526.71	-2,705.30	-2,705.30
	Max.	3,148.06	3,148.06	3,148.06
Short Basis Trade	Mean	9.91	49.18	168.92
	Std. Dev.	423.97	469.12	452.11
	Min.	-2,356.40	-1,796.10	-1,674.69
	Max.	2,681.83	2,681.83	2,681.83
	Panel C: Stop Loss Strategy			
		$e_\tau = 75$ bp	$e_\tau = 100$ bp	$e_\tau = 125$ bp
Long Basis Trade	Mean	2.28	23.01	41.51
	Std. Dev.	123.89	130.03	122.57
	Min.	-1,260.31	-1,260.31	-1,260.31
	Max.	342.02	422.13	536.58
Short Basis Trade	Mean	-81.68	-118.25	-167.93
	Std. Dev.	107.48	121.50	255.64
	Min.	-665.99	-665.99	-1,042.37
	Max.	183.84	187.08	259.17

Table VI
Impact of Market-Wide Factors on Basis Trade Profits

The table shows the coefficient estimates, significance level, and adjusted R^2 for the fixed effects model in Equation (3). The dependent variables are the long ($i = l$) and the short ($i = s$) basis trade profits $p^{k,i}$ for firm k in basis points, determined as in Table V. Panel A.1 and A.2 give the results for the basis trades dissolved when the reference date changes, Panel B.1 and B.2 the basis trades dissolved after an interest rate shock, and Panel C.1 and C.2 the basis trades dissolved when the stop loss barrier is reached. r, ba, yv, LEUR, SEUR, SPWC, and FML are defined as in Table III. ***, **, 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
	Panel A: Exit Trigger Reference Date Change				
	Panel A.1: Dependent Variable = Long Basis Trade Profit				
r	5.60***	25.93***	36.00***	3.20***	3.32***
σ^{OI}	-0.98***	-5.70***	-4.43***	-0.73***	-0.74***
ba	215.83***	-1,715.61***	1,609.20***	20.31**	168.55***
yv	77.44***	39.51**	437.62***	14.31***	74.04***
LEUR	-90.04***	440.28***	-439.47***	-36.25***	-77.60***
SEUR	-11.10*	-54.40	180.68***	-13.42**	-13.80**
SPWC	-73.75***	46.13	-311.13***	-0.47	-69.92***
FML	-220.54***	-386.22***	-413.66***	-127.90***	-217.32***
Adj. R^2	(11.18)	(27.58)	(56.35)	(3.57)	(10.81)
	Panel A.2: Dependent Variable = Short Basis Trade Profit				
r	-4.09***	-45.16***	-96.73***	-14.62***	-16.77***
σ^{OI}	1.88***	2.28***	-9.76***	2.46***	2.47***
ba	454.46***	-5,752.31***	-1,808.42***	-764.58***	-455.23***
yv	31.83***	-15.81**	-409.07***	-47.11***	-44.12***
LEUR	-222.05***	-738.14***	-435.18***	-260.80***	-262.34***
SEUR	22.66	111.78***	196.62***	-63.80***	-23.30*
SPWC	-0.92	-496.78***	162.77***	0.63	1.78
FML	-217.63***	-811.59***	752.60***	-302.70***	-140.73***
Adj. R^2	(8.61)	(40.72)	(44.94)	(15.46)	(14.97)

Table VI continued

	AAA-BBB	BB-CCC	Financial	Non-Financial	All
			Panel B: Exit Trigger Interest Rate Shock		
			Panel B.1: Dependent Variable = Long Basis Trade Profit		
r	4.77***	61.18***	28.05***	11.65***	10.21***
σ^{OI}	-1.29***	-8.49***	-7.58***	-1.80***	-2.06***
ba	86.17***	-2,533.77***	1,865.64***	146.80***	253.00***
yv	58.13***	117.85***	363.00***	26.80***	68.36***
LEUR	-69.35***	25.79	-252.00***	-80.71***	-83.78***
SEUR	14.86***	-85.77	257.84***	4.13***	15.76***
SPWC	-60.14***	-761.40***	-92.28***	-47.44	-65.00***
FML	-180.54***	-1,211.94***	-105.78***	-202.85***	-200.81***
Adj. R^2	(7.29)	(40.81)	(31.25)	(13.82)	(10.65)
			Panel B.2: Dependent Variable = Short Basis Trade Profit		
r	9.24***	-28.49***	-54.56***	15.01***	10.27***
σ^{OI}	-0.38	-2.14***	-2.29**	-1.89***	-1.58***
ba	1,623.94***	-1,462.19***	-1,788.46***	882.80***	1,408.89***
yv	-23.03***	-49.33***	-335.47***	-73.21***	-68.25***
LEUR	-167.78***	-33.59	-313.23***	0.76	-23.31*
SEUR	-49.19***	587.09***	182.12***	33.86**	90.18***
SPWC	0.01	-251.37***	140.44***	-4.08**	-1.87
FML	-380.09***	369.07***	736.37***	-269.07***	-64.06***
Adj. R^2	(12.00)	(40.58)	(46.79)	(15.49)	(11.44)

Table VI continued

	AAA-BBB	BB-CCC	Financial	Non-Financial	All
			Panel C: Exit Trigger Stop Loss Barrier		
s			Panel C.1: Dependent Variable = Long Basis Trade Profit		
r	1.64***	16.68***	-4.80***	2.64***	1.22***
σ^{OI}	0.66***	0.62*	0.01	0.88***	0.57***
ba	290.59***	241.11	229.60***	310.15***	285.27***
yv	23.14***	45.56***	8.95**	9.33***	23.22***
LEUR	12.81***	-65.68*	64.59***	12.32***	13.20***
SEUR	0.64	-127.23***	19.88***	-10.46***	-0.08
SPWC	9.15***	-18.16	42.96***	3.59*	9.92***
FML	-50.91***	230.50***	-24.45**	-73.58***	-49.20***
Adj. R^2	(15.67)	(80.69)	(35.64)	(17.36)	(9.22)
			Panel C.2: Dependent Variable = Short Basis Trade Profit		
r	6.46***	-19.58***	-22.05***	-6.72***	-3.36***
σ^{OI}	0.78***	2.05***	-4.89***	2.62***	1.85***
ba	-12.70	-822.06***	-520.47***	-139.79***	-339.95***
yv	14.92***	-13.50	-292.32***	-5.19	-20.39***
LEUR	-55.24***	-45.54	-155.76***	-83.54***	-77.28***
SEUR	-118.78***	-4.61	77.72	-88.53***	-83.28***
SPWC	-7.40***	40.08*	-17.07	1.82*	0.47
FML	-66.03***	691.26***	-12.98	-25.22*	-53.68***
Adj. R^2	(25.63)	(45.39)	(57.37)	(17.98)	(17.78)

Table VII
Basis Strategies in the Financial Crisis

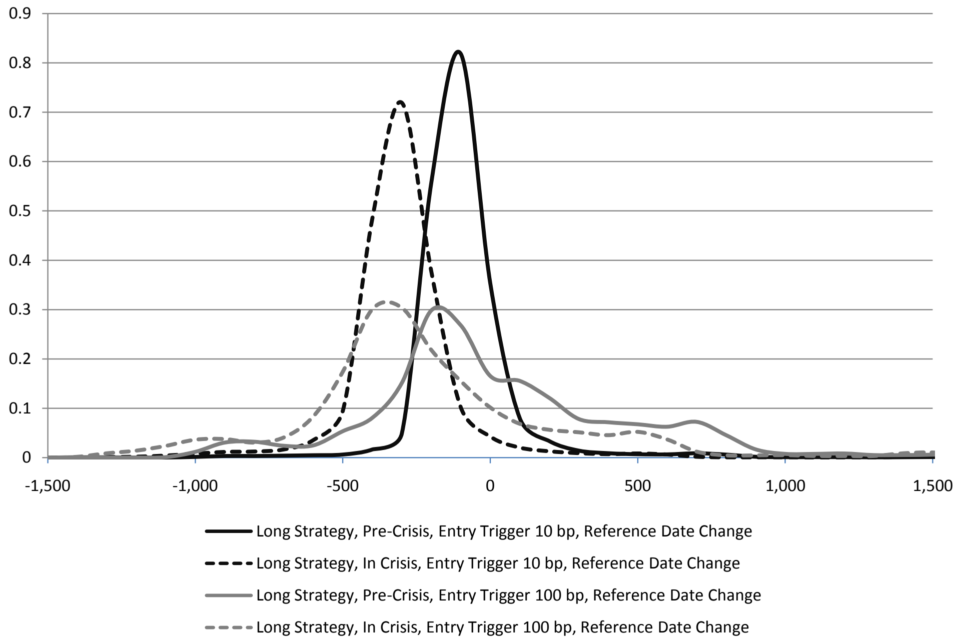
The table shows the mean, standard deviation, minimum, and maximum total trading profit in basis points for the long and short buy-and-hold basis trades (Panel A) and the dissolution-risky basis trades (Panel B). The transaction costs equal 5% of the mid bond asset swap spread. For the short basis trade, the shorting costs equal 40 bp p.a. The last rows give the number of trades which were incepted under each strategy.

	Long Basis Trade	Short Basis Trade	Long Basis Trade	Short Basis Trade
	Panel A: Buy-and-Hold Basis Trades			
	$e_0 = 10$ bp		$e_0 = 100$ bp	
Mean	343.72	380.42	964.27	1,258.66
Std. Dev.	364.82	574.54	455.74	975.81
Min.	56.87	50.42	539.45	503.67
Max.	4,003.18	8,550.45	4,003.18	8,550.45
# Trades	6,792	6,506	1,174	1,041
	Panel B: Basis Trade Dissolved due to Reference Date Change			
	$e_0 = 10$ bp		$e_0 = 100$ bp	
Mean	-21.42	-43.72	43.58	-86.18
Std. Dev.	355.18	511.62	619.73	1,008.02
Min.	-2,270.11	-4,874.88	-1,735.95	-4,476.00
Max.	5,315.73	3,395.37	5,315.73	3,395.37
	Panel C: Basis Trade Dissolved due to Interest Rate Shock			
	$e_0 = 10$ bp		$e_0 = 100$ bp	
Mean	-41.44	-50.07	-28.96	-102.42
Std. Dev.	193.21	422.33	378.49	899.36
Min.	-1,942.10	-4,773.29	-1,186.30	-3,459.18
Max.	4,065.53	7,151.38	4,065.53	7,151.38
# Trades	6,792	6486	1,174	1090
	Panel D: Basis Trade Dissolved due to Stop Loss Barrier			
	$e_\tau = 75$ bp		$e_\tau = 125$ bp	
Mean	-199.08	-104.95	-254.43	-226.51
Std. Dev.	134.11	75.91	225.82	167.06
Min.	-814.87	-1,511.25	-976.44	-1,511.25
Max.	30.50	28.31	109.55	60.30
# Trades	1,660	1949	4,377	4475

Figure 1. Basis Trade Profit Distribution

The figure depicts the relative frequency of the basis trade profits summarized in Table VII. The first and second panel give the plot for the long and short basis trade profits dissolved due to a reference date change before and during the financial crisis (pre and post June 2007). The third and fourth panel give the plot for the long and short basis trade profits dissolved due to an interest rate shock. The fifth and sixth panel give the plots for the long and short basis trade profits dissolved due to the stop loss barrier. The x-axis gives the profit, the y-axis the relative frequency with which the profit was observed.

Panel A: Long Basis Trades, Reference Date Change



Panel B: Short Basis Trades, Reference Date Change

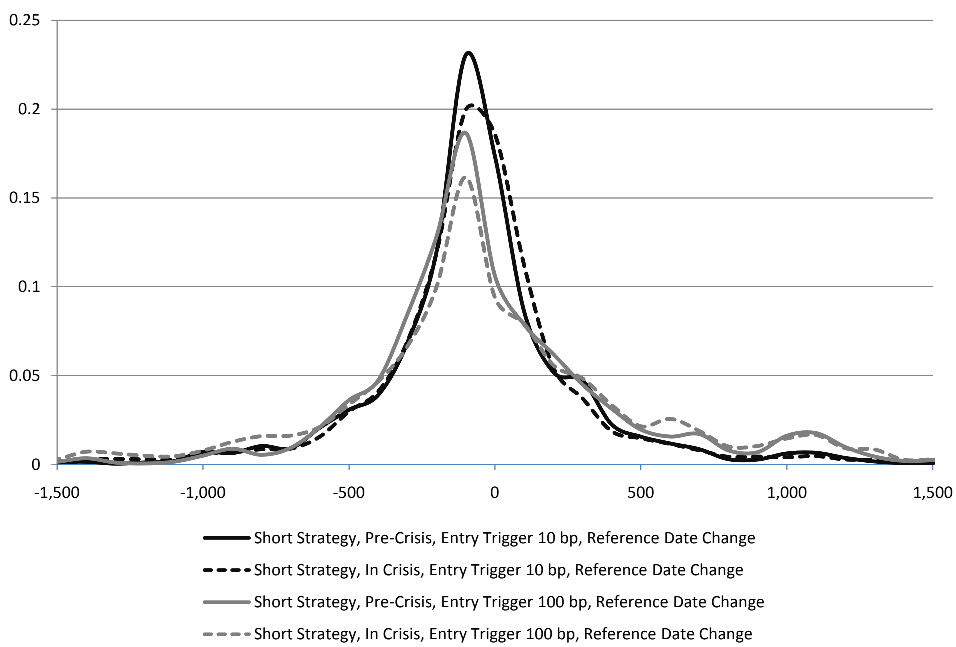
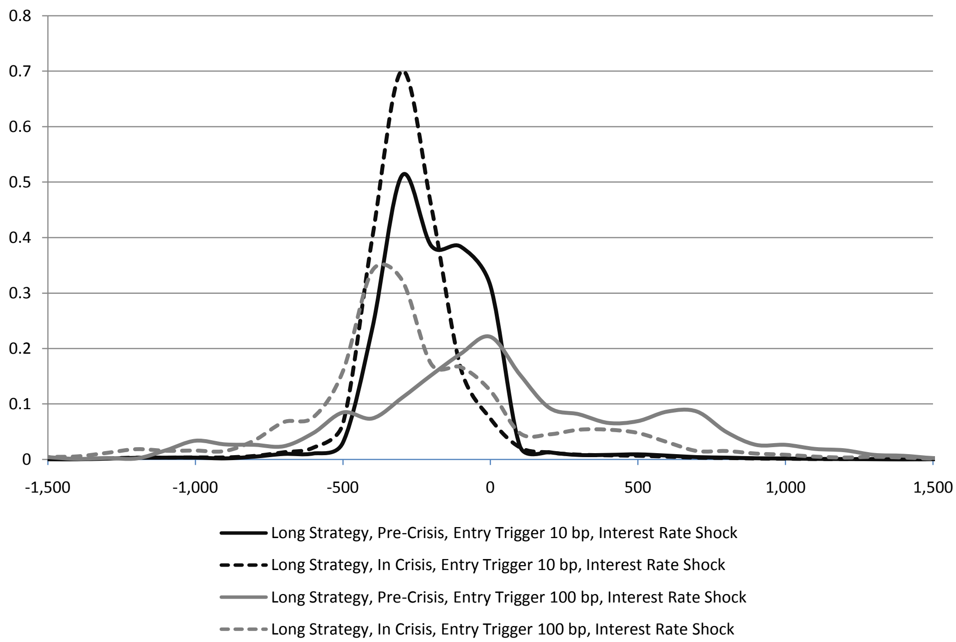


Figure 1 continued

Panel C: Long Basis Trades, Interest Rate Shock



Panel D: Short Basis Trades, Interest Rate Shock

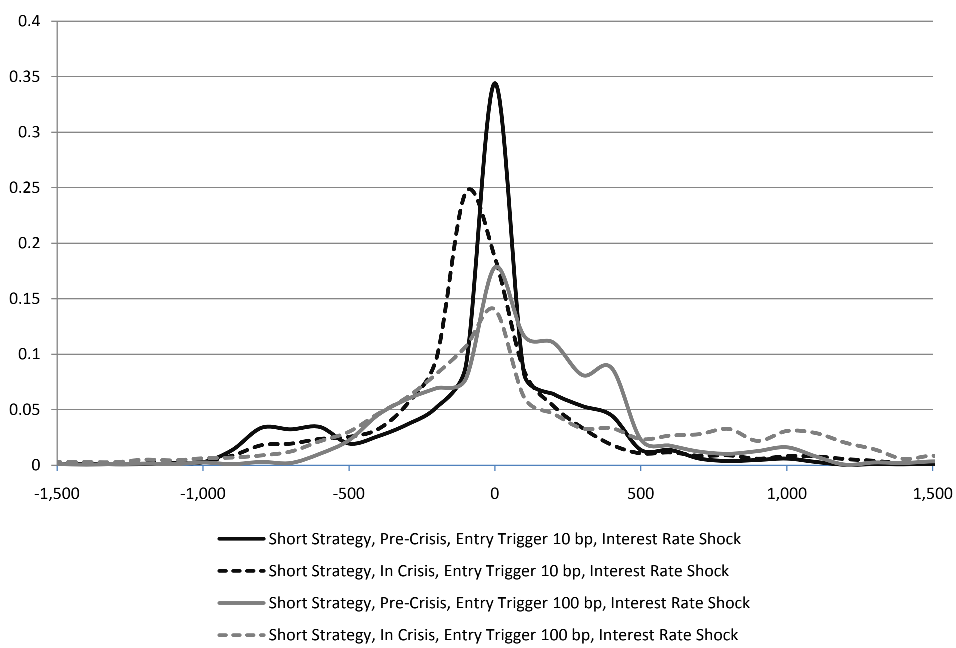
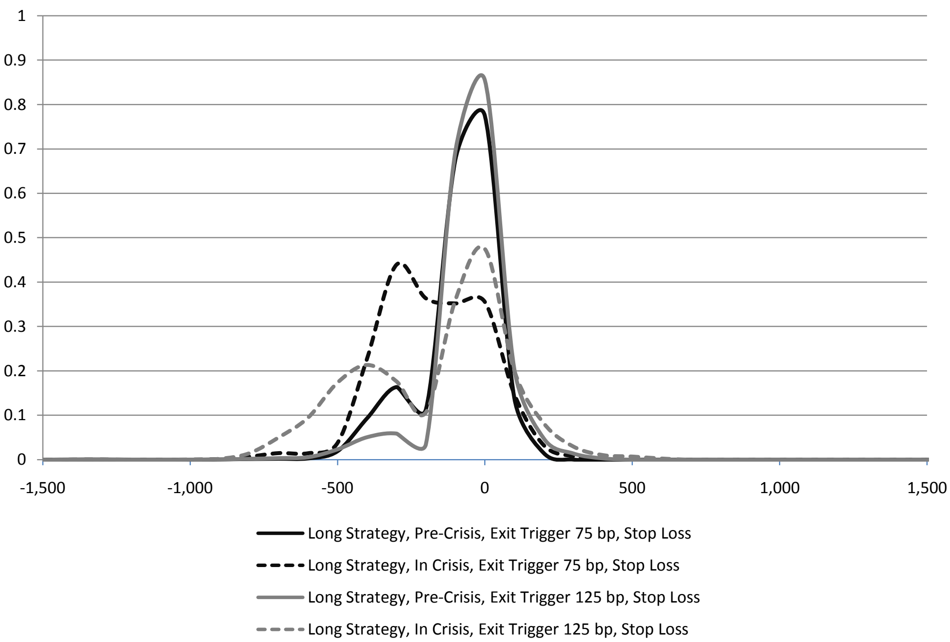


Figure 1 continued

Panel E: Long Basis Trades, Stop Loss Barrier



Panel F: Short Basis Trades, Stop Loss Barrier