The Determinants of the CDS-Bond Basis During the Financial Crisis of 2007-2009 *

Jennie Bai† Pierre Collin-Dufresne‡

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Abstract

We investigate the cross-sectional variation in the CDS-bond basis, which measures the difference between the CDS and cash-bond implied risk-neutral expected loss, for a large sample of individual firms during the crisis. We test several possible explanations that have been offered for the violation of the arbitrage relation between cash bond and cds contract that would in normal conditions drive the basis to zero. Our findings do not uncover a clear main driver for the anomaly. Rather they point towards several drivers related to funding risk, counterparty risk and collateral quality that force the individual bond basis into negative territory at different phases of the crisis.

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†Economist, Capital Markets Function, Federal Reserve Bank of New York, 33 Liberty Street New York, NY 10045, `e-mail:` *jennie.bai@ny.frb.org.*

‡Department of Finance, Graduate School of Business, Columbia University, 3022 Broadway Street New York, NY 10027, `e-mail:` *pc2415@columbia.edu.*

1 Introduction

Financial markets experienced tremendous disruptions during the 2007-2009 financial crisis. Credit spreads across all asset classes and rating categories widened to unprecedented levels.[1] Perhaps even more surprising, many relations that were considered to be text-book arbitrage before the crisis were severely violated. For example, in currency markets, violations of covered interest rate parity occurred for currency pairs involving the US dollar (Coffey, Hrung, Sarkar (2009)). In interest rate markets the swap spread, which measures the difference between Treasury bond yields and libor swap rates, turned negative. In Interbank markets, basis swaps that exchange different tenor LIBOR rates (e.g., 3-month for 6-month) deviated from zero. In inflation markets, break-even inflation rates turned negative. In credit markets, the CDS-bond basis which measures the difference between CDS and cash-bond implied credit spreads turned negative.

These anomalies suggest that such relations are not, in fact, arbitrage opportunities in the traditional textbook sense. It seems important to understand why these disruptions occurred. One possible explanation is that arbitrage relations broke down during the crisis because of institutional or contractual features. For example, many of these relations (but not all), involve a fully funded (e.g., cash) instrument and one or more unfunded derivative positions. This raises the possibility that counterparty risk on the derivative made the arbitrage risky. It also raises the possibility that funding costs on the cash instrument are responsible for the deviations. In the former case, the payoff of the arbitrage trade is not risk-free for any investor, whereas in the latter case, the payoff to the arbitrage trade would be risk-free for an investor with infinitely deep pockets.

More generally, these violations could be evidence of classical 'limits to arbitrage,' such as the inability of arbitrageurs to raise capital quickly and/or their unwillingness to take large positions in these 'arbitrage' trades because of marking to market risk, or, more generally, market segmentation. Consequently, the dynamics of the arbitrage violations should be affected by the structure of funding markets, the ability of investors to process information, and the ability to move capital across markets (Duffie (2010)) among others. Certainly, the financial crisis provides a nice laboratory to test some of those theories (Gromb and Vayanos (2009)).

[1] For example, investment-grade corporate credit spreads as measured by the CDX.IG index rose from 50bps in early 2007 to more than 250bps at the end of 2008. Even at the safest end of the spectrum the widening was dramatic. AAA-rated synthetic debt products, that would have been deemed virtually risk-free before the crisis, saw their spreads widen dramatically: CDX.IG super senior tranche widened from 5bps to 100bps, CMBX AAA "super duper" widened from 2bps to 700bps, ABS-HEL AAA tranche price rose from 0 to 20% upfront plus 500bps running. These numbers illustrate that it became much more expensive to insure AAA-rated debt across various markets (corporate, residential and commercial real estate).

In this paper, we focus on the CDS-bond basis, which measures the difference between credit default swap (CDS) spread of a specific company and the credit spread paid on a bond of the same company. Figure 1 plot the time series of the average CDS-bond basis for investment-grade and high yield bonds, where the funding cost is measured by the libor swap curve. The figures show that the basis, which hovers usually around +5 bps, fell to -250 bps for investment-grade firms and -650 bps for high yield firms. At first sight, a large negative basis smacks of arbitrage, since it suggests that an investor can purchase the bond, fund it at libor swap, and insure the default risk on the bond by buying protection via the CDS contract. The resulting trade is 'virtually' risk-free and yet, as the figures show it generates between 250 and 650 bps in guaranteed return per annum.

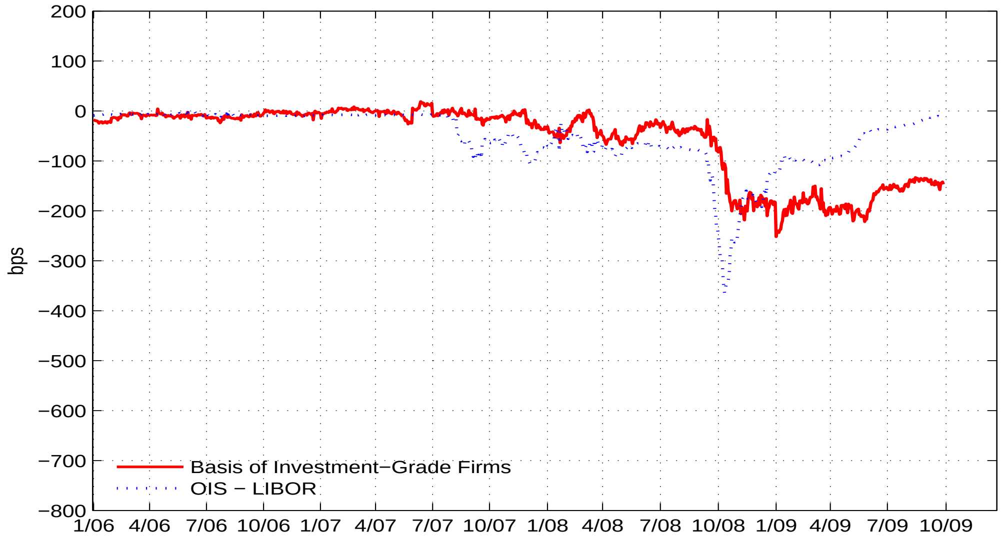
Studying the CDS-bond basis during the crisis is interesting for several reasons. First, early studies of this basis (pre-crisis) found that the arbitrage relation between CDS and cash-bond spreads holds fairly well (Blanco, Brennan, Marsh (2005), Hull, Predescu and White (2009), Nashikkar, Subrahmanyam and Mahanti (2009)). Further, these studies typically conclude that the basis is, if anything, slightly positive.

There are several reasons why the basis should not be expected to be exactly zero. The arbitrage is, in general, not perfect (Duffie (1999)). There are a few technical reasons (specifically (i) difficulty in shorting bonds, (ii) cheapest-to-deliver option) that tend to push the basis into the positive domain (Blanco, Brennan, Marsh (2005)). However, during the crisis the basis was tremendously negative, which suggests the need for an alternative explanation.

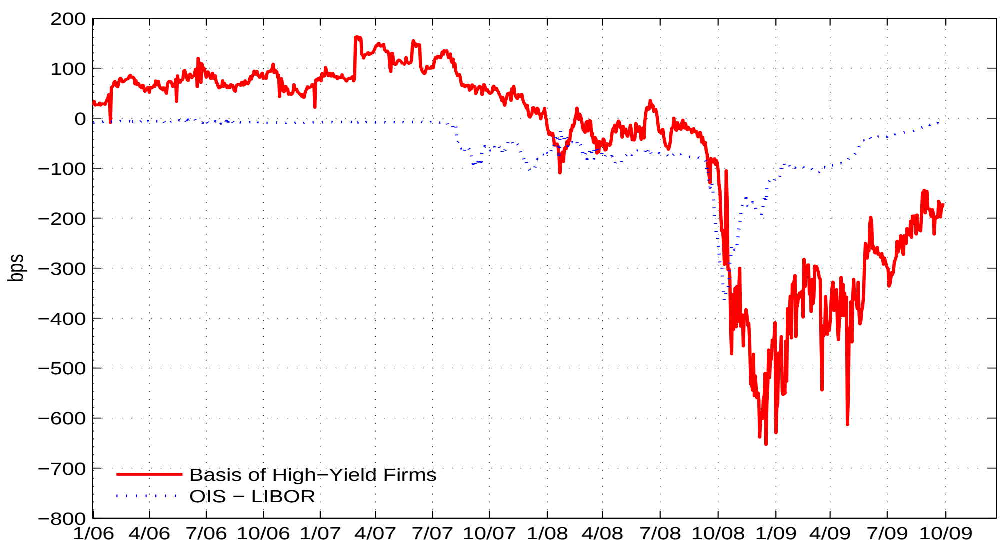
Another important issue for the measurement of the basis is the funding or 'risk-free' rate benchmark (Hull, Pedrescu and White (2004)). Several authors have argued that the Treasury curve is not the appropriate risk-free benchmark and, indeed, that it is lower than the typical funding cost an investor can achieve via collateralized borrowing.[2] In fact, Hull, Predescu and White (2004) use the basis package (a portfolio long several corporate bonds and long CDS protection) to define a risk-free asset available to any investor. They argue that since the average CDS-bond basis is zero when measuring funding cost using swap rate minus 10 bps and the CDS-bond basis exhibits little cross-sectional variation, this is evidence that the 'true' shadow risk-free rate for a typical investor is around swap minus 10 bps (or approximately Treasury plus 50 bps). We note that the very large cross-sectional variation in the basis (across rating categories) documented in Figure 1 allows us to immediately dismiss the fact that mis-measurement of the risk-free rate benchmark is the explanation for the puzzling behavior of the CDS-bond basis during the crisis. If we were simply mis-measuring the risk-free benchmark we

[2] Studies that document the special status of the US Treasury curve, –presumably due to its greater liquidity– include Longstaff (2004), Feldhutter and Lando (2008) among others.

Figure 1: A. The CDS-bond Basis of Investment-Grade Firms vs OIS-LIBOR spreads



B. The CDS-Bond Basis of High-Yield Firms vs OIS-LIBOR spreads



would observe an approximately constant CDS-Bond basis across firms reflecting the spread between our benchmark risk-free curve and the true (unobserved) risk-free curve. Further, the methodology we adopt to measure the CDS-bond basis, due to J.P. Morgan which we explain in the next section, is relatively insensitive to the risk-free benchmark. Nevertheless, in our robustness section we investigate the sensitivity of the results to the risk-free benchmark, by using (i) the Treasury curve and (ii) the risk-free curve that minimizes the observed CDS-bond basis.

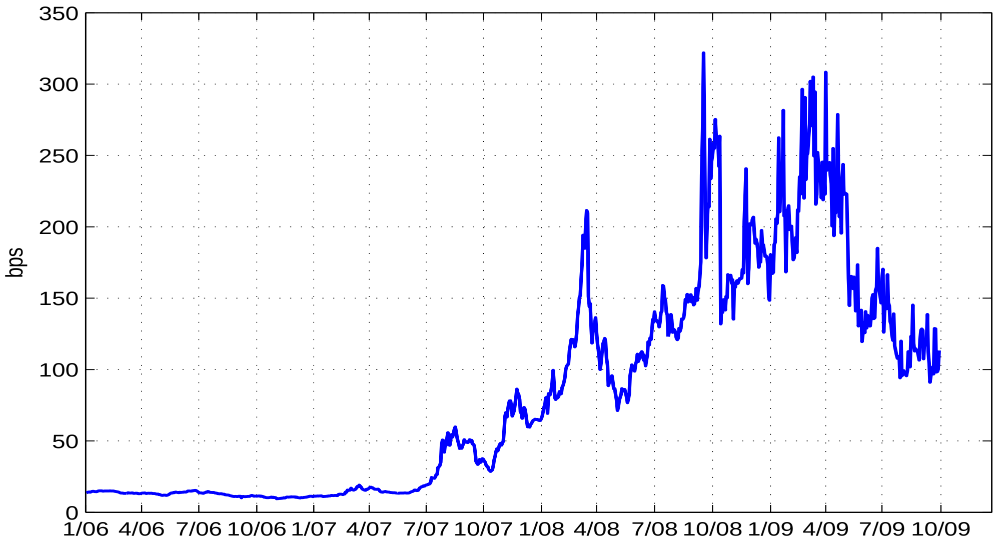
The important point however is that, since we do not observe the appropriate risk-free benchmark curve, the relevant information to understand the negative basis episode is the cross-sectional variation in the basis (focusing on the average level could be misleading given the significant 'flight-to-quality' effects in the benchmark Treasury and Swap yield curves). Below we exploit the cross-sectional variation to investigate the main drivers of the basis during the crisis.

There are several reasons why one might expect the basis to become negative during the financial crisis of 2007-2009. Anecdotes for the negative basis claim that most major financial institutions, pressed to free up their balance sheet and improve their cash balance, conducted deleveraging by reducing their bond holdings significantly and concurrently. This exerted downward pressure on bond prices, and upward pressure on credit spreads relative to CDS spreads that represent the 'fair' value of the default risk insurance. This however cannot be the whole story, since in a perfectly functioning market with unlimited capital, investors would simply borrow cash to buy the bonds, buy protection and finance the position until maturity (or default). For deleveraging to have a persistent impact on the basis, there must be some 'limits to arbitrage' (Shleifer and Vishny (1996)). In particular, if capital is limited then the basis trade becomes risky and investors will tend to buy the bonds that are (ex-ante) most attractive from a risk-return trade-off.

In this paper we analyze the risk-return trade-off in a basis trade for an investor with limited capital. We find that the investor is exposed to (a) the basis becoming more negative, (b) increased funding costs, (c) increased repo rates, (d) increased hair-cuts. Further, the profitability of the trade per unit of capital is decreasing in the collateral that must be posted to enter the basis trade (essentially the hair-cut). All else equal, this suggests that basis should be less negative for bonds with smaller hair-cuts (i.e., better collateral quality), and for bonds with basis that have a lower covariance with funding costs (i.e., lower funding cost risk). In this explanation for the negative basis, the corporate yield spread is temporarily too high relative to the fairly valued CDS, due to the lack of available 'arbitrage risk capital.'

A different explanation for the negative basis focuses on the CDS side of the trade. In

Figure 2: The Average Five-Year CDS Spread for the Primary Broker-Dealers



a basis trade, the protection is typically bought from a broker dealer such as J.P. Morgan, Goldman Sachs, Lehman Brothers. Clearly, the counterparty risk of these protection sellers widened considerably during the crisis. Figure 2 plots the credit spreads on the primary broker-dealers in the U.S. market. We see a striking widening in the default risk of the average broker-dealers. A direct implication is that the insurance sold by these broker-dealers should be less valuable. So increasing counterparty risk of the broker-dealers should directly lead to lower CDS spreads, and therefore could explain the observed negative CDS-Bond basis.

Our empirical investigation seeks to identify whether either of the above three mechanisms – funding liquidity risk, collateral quality and counterparty risk – can explain the cross-sectional variation in the observed CDS-bond basis.

The negative basis has been subject of considerable attention in the practitioner literature (DE Shaw 'The basis monster that ate wall street' (2009), JP Morgan 'The bond-cds basis handbook' (2009), Mitchell and Pulvino (2010)). These papers emphasize the role of financing risk in generating the negative basis, as well as the deleveraging of key leveraged investors in generating downward price pressure on cash-bonds. In the academic literature Garleanu and Pedersen (2010) provide a theoretical model, where leverage constraints can generate a pricing difference between two otherwise identical financial securities that differ in terms of their margin requirements or hair-cuts. They find their model to agree with the average basis difference between high grade and high yield bonds. Our study differs from these previous papers in that we focus on the cross-sectional variation in individual firms' basis (rather than on the average basis level) during the crisis and try to relate the variations to firm, bond and CDS characteristics that might help explain the basis.

Focusing on the cross section of CDS-bond basis is also interesting as it provides more general insights into the 'limits to arbitrage' literature. Our analysis is a preliminary step in testing the implications of the literature that models the behavior of arbitrageurs with limited capital facing multiple 'arbitrage' opportunities (Gromb and Vayanos (2009)).[3]

In section 2 we discuss some practical issues regarding an actual basis trade and isolate the various sources of risk in such trade. In section 3, we discuss our proxies for counterparty risk, funding cost risk and collateral quality. Section 4 and 5 presents the data and cross-sectional regression results. We do robustness check in section 6 and section 7 concludes.

2 The CDS-Bond Basis

A credit default swap is essentially an insurance contract against a credit event of a specific reference entity. It is an over-the-counter transaction between two parties in which the protection buyer makes periodic coupon payments to the protection seller until maturity or until some credit event happens. When a credit event occurs,[4] typically the protection buyer delivers a bond from a pool of eligible bonds to the protection seller in exchange for its par value.[5]

The contract is designed so that if you own a particular bond and buy CDS protection on it you are essentially fully hedged against default risk. As a result we would expect CDS spreads to be similar to credit spreads observed on corporate bonds that are deliverable into the CDS contract. In fact, under some conditions an arbitrage relation states that the CDS spread should equal the credit spread on the deliverable corporate bond.[6] This leads to the theoretical definition of the CDS-bond basis as the CDS spread minus the corporate bond credit spread.

While the CDS spread is observable in the market, it is not obvious how to compute the

[3]While we are not formally testing the first order condition of such an investor in the current paper, the CDS-bond basis dataset clearly presents an interesting laboratory to test such a theoretical framework.

[4]In the 2003 definition, the International Swap and Derivative Association (ISDA) lists six items as credit events: (1) bankruptcy, (2) failure to pay, (3) repuidation/moratorium, (4) obligation acceleration, (5) obligation default, and (6) restructuring. For more detail, see "2003 ISDA Credit Derivatives Definitions," released on 11 February 2003.

[5]See Duffie and Singleton (2006)**?** for a detailed description.

[6]Duffie (1999) discusses specific conditions and shows why this relation might not exactly hold in practice.

appropriate corporate bond spread. As discussed by Duffie (1999) the ideal corporate bond spread would be the spread over libor of a floating rate note with the same maturity as the CDS referenced on the same firm. In practice, this spread is often not observable as firms rarely issue floating rate notes. Instead, we have to rely on other available fixed rate corporate bond prices. Several methodologies have been proposed in the literature. Following Elisade, Doctor, and Saltuk (2009) we adopt the Par Equivalent CDS (PECDS) methodology developed by J.P. Morgan.**?** This method, which we present for completeness in the appendix, essentially amounts to extracting the default intensity consistent with the prices of the corporate bonds observed in the market and using the libor swap curve as the risk-free benchmark curve. Then one can calculate the fair CDS spread consistent with the bond implied default intensity and the risk-free benchmark curve (given a standard recovery assumption). It is this theoretical bond-implied CDS spread, called the PECDS spread, that we compare to the quoted CDS spread on the same reference entity to define the CDS-bond basis:

$$Basis_i(\tau) = CDS_i(\tau) - PECDS_i(\tau), \tag{1}$$

where τ is the maturity and i indicates the reference entity. This methodology has several advantages, reviewed in Elisade, Doctor and Saltuk (2009). It has also been used by previous academic studies such as Subramanyam et al. (2009). In our robustness section we confirm that our main results are robust by using an alternative approach.

The basis becomes positive when the credit default swap spread is greater than the bond spread. An investor could short the bond and sell the CDS protection to capture the pricing discrepancy. The basis becomes negative when the credit default swap spread is lower (tighter) than the bond spread. This means the bond is cheaper than the CDS and if an investor buys the bond and buys CDS protection, the investor has "locked-in" a risk-free annuity. In both cases, the principle is that the bond and CDS position offset each other in the case of default, allowing the investor to take a view on the relative pricing of bonds and CDS without taking exposure to credit risk.

As discussed in the introduction, during normal times the CDS-bond basis tends to be very small and, if anything, slightly positive when measured relative to the libor-swap benchmark. This has been studied extensively by Blanco, Brennan, and Marsh (2005) and Subramanyam et al. (2009). However, Figure 1, which shows the time-series pattern of the CDS-bond basis for the overall U.S. investment-grade and high-yield bonds over the past four years, reveals that the CDS-bond basis has been significantly and persistently negative during the recent financial crisis. Furthermore, there has been substantial cross-sectional variation in the negative basis as we can see from the conspicuous difference in basis between the investment-grade bond in Figure 1A and the high-yield bond in Figure 1B.

While a positive basis can often be traced back to some inability to implement the 'arbitrage' trade because either bonds are difficult to short, or there exists cheapest to deliver option (see Blanco, Brennan, and Marsh (2005)), a negative basis is harder to explain. Indeed, in the negative basis case, the 'arbitrage' trade requires buying the bond, financing its purchase, and buying protection to hedge against the default event. Figure 1 suggests that the return to the 'negative basis' trade would have been between 200bps and 700bps for investment-grade and high-yield bonds respectively. These seem like very high arbitrage profits. So it is important to review the details of such a basis trade implementation to better understand where the 'limits to arbitrage' may arise.

2.1 Negative Basis Trade

In practice, there are several reasons why a negative basis trade is not a pure arbitrage. These risks are discussed in detail in Elisade, Doctor, Saltuk (2009) (see, in particular, their Table 2 on page 23). The main issues when implementing a negative basis trade have to do with funding risk, sizing the long CDS position, and counterparty risk.

Suppose we find a bond with negative basis that trades at a price B below its notional of N. A negative basis trade requires buying the bond. The purchase is funded via the repo market where investors face a haircut h. This effectively implies that arbitrageurs will have to provide hB dollars of 'risk-capital' funded at $Libor + f$ where f is the funding spread over libor faced by the arbitrageur. The repo contract is typically over-night (up to a few months at most) with an agreed upon repo rate and needs to be rolled over repeatedly until the maturity of the basis trade which is the lesser of default and maturity (e.g., 5 years).

At the same time, to offset the risk of default, the investor buys protection in the CDS market. A question arises as to how to size the CDS position. A conservative approach from a point of view of minimizing exposure to 'jump to default' is to buy protection on the full notional N of the bond.

Market participants typically prefer to buy less protection to improve the carry profile of the trade (pay less in insurance premium). The justification is that the maximum capital at risk in the transaction is the initial purchase price of B.[7] In fact, a customary approach is to make an assumption about recovery (for example, assume that in case of bankruptcy a fraction R of the notional of the bond is recovered) and buy protection on a CDS notional of N_{CDS}

[7]For bonds that trade at a premium one may in fact buy more protection!

so as to cover the loss in capital, i.e., such that $B - N\,R = N_{CDS}(1 - R)$. This will increase the carry of the trade (since the CDS premia are now reduced), but expose the investor to a jump to default in case the recovery is smaller than expected. An alternative approach is to choose the notional of the CDS position to match the spread duration on the risky bond (this approach tries to minimize marking to market differences between the bond and CDS position over the life of the bond as opposed to thinking about jump to default risk). As explained in Duffie (1999) there is no perfect arbitrage when the underlying bond is not a floating rate note with the same maturity as the CDS contract.

For illustration, suppose the investor buys protection on a notional N_{CDS}. This requires a margin payment of M and periodic marking to market margin calls. The margin has to be funded at $Libor + f$.

After one day the profit or loss (P&L) on the trade can be written as:

$$\begin{aligned} P\&L(t+1) &= B_{t+1} - B_t + N_{CDS} D_{CDS} * (CDS_{t+1} - CDS_t) \\ &\quad - B_t * [h(libor + f) + (1-h) * (repo)] - M_t(libor + f) \end{aligned}$$

where D_{CDS} is the duration of the CDS (such that the P&L on the CDS is the product of the duration with the change in CDS rate; note that if CDS increases the long position makes money). For illustration, suppose we size our position in the CDS to match the libor-spread duration on the corporate bond, then we can rewrite the P&L as:

$$\begin{aligned} P\&L(t+1) &= D_B * (Basis_{t+1} - Basis_t) \\ &\quad - B_t * [h(libor + f) + (1-h) * (repo)] - M_t(libor + f) \end{aligned}$$

Specifically, this relation shows that the typical basis trade, when rolled over repeatedly, is exposed to:

- The basis becoming more negative,
- An increase in market liquidity as measured by the benchmark Libor rate.
- An increase in the arbitrageurs own credit worthiness, which would lead to a larger markup (f). We note that if the arbitrageur has a large position in basis trades then this could be tied to the basis becoming more negative (i.e., the trade running away from him).
- A worsening of collateral quality of the bond (funding liquidity), which would lead to an increase in the haircut (h) and the Repo rate.

- An increase in the margin requirements on the CDS position (M_t).

Last but not least, the trade is also affected by counterparty risk in the sense that if a default on bond occurs at time τ_B, then the P&L will be:

$$P\&L(\tau_B) = R\,N + N_{CDS}(1 - R)\mathbf{1}_{\tau_C > \tau_B}$$

where τ_C denotes the default time of the counterparty selling protection. Specifically, if the counterparty defaults (or has defaulted) when the underlying firm defaults then the CDS protection expires worthless. This highlights the fact that from an ex ante perspective counterparty risk depends on the correlation between the default risk of the underlying name and the counterparty selling the protection, which is typically a large bank such as J.P. Morgan, Lehman Brothers, Bear Stearns, and Goldman Sachs. Now, it is important to stress that, in general, counterparty risk is viewed as likely to be small, since if the counterparty defaults prior to the default event (i.e., $\tau_C < \tau_B$) then, if marking to market were perfect, the investor could reopen a new position at no cost with another counterparty. Thus, in theory, counterparty risk only affects the investor if the counterparty defaults on the exact same day as the underlying bond ($\tau_C = \tau_B$). In practice however, it is likely that the failure of the counterparty, especially during an extraordinary period like the financial crisis, would be associated with substantial costs and risks for the investor. These losses would typically be related to the likely marking to marking loss in the position on the day of the counterparty default as well as more technical considerations, which have to do with the specific bankruptcy provisions in the ISDAs covering the CDS trade.

In the next section we explain how we try to use the cross-sectional variation in individual bond basis to disentangle the effects of various risks outlined above that affect the risk-return trade-off of a basis trade. Our working hypothesis is that an arbitrageur having limited access to capital will try to exploit the basis trade opportunities that offer the best expected return per unit of risk-capital. So he will choose basis trades that have the most negative basis (highest expected return) but controlling for ex ante measures of exposure to market and funding liquidity. All else equal he will prefer basis trades on bonds with low hair cuts, low exposure to funding cost (in the sense that for two bonds with equally negative basis, the one which correlates more with funding costs is more attractive, since the basis trade converges when funding costs rise), low counterparty risk (in the sense that the probability of the underlying firm defaulting at the same time as the counterparty in the CDS is lower). If this hypothesis is correct than we expect that the risk characteristics of the basis trade (counterparty risk, funding liquidity risk, collateral quality) should be related to the level of the basis in the cross-section.[8]

3 Measure The Underlying Risk Factors

3.1 Counterparty Risk

When an arbitrageur buys CDS protection from a bank, then he has the risk that when he wants the bank to buy bonds at par in default, the bank may not have the ability to do so. A good example is the Lehman Brothers case. Imagine if a hypothetical mutual fund had bought some Washington Mutual corporate bonds in 2005 and decided to hedge their exposure by buying CDS protection from Lehman Brothers. After Lehman's default, this protection was no longer active, and Washington Mutual's sudden default only days later would have led to a massive loss on the bonds, a loss that should have been insured by the CDS. So the counterparty risk of the bank will lead to lower CDS spreads, and therefore could explain the observed negative CDS-bond basis.

The heterogenous CDS-bond basis across firms depend on the intensity a firm ties to its CDS protection sellers. All else equal a firm with tighter correlation with its CDS issuers is expected to have higher counterparty risk, and hence lower CDS spread and more negative CDS-bond basis. The challenge is how to measure the correlation between the default risk of the underlying name and the counterparty selling the protection.

The CDS market is over-the-counter and opaque, thus we cannot identify the exact counterparies for each CDS contract. Even if we had known the counterparty information, the process of 'netting' in the credit market makes it extremely hard to find out the true counterparty exposure for each reference entity.[9] Given these two features of the credit default swap market (unknown and netting counterparty), we conservatively set up a central counterparty for all reference entities from a pool of primary broker dealers. Prominent broker dealers (in addition to insurance companies such as AIG and Monoline) dominate the credit market in issuing CDS contracts. Pooling them together by constructing a representative CDS issuer can capture the interlinked chain of CDS transactions between financial institutions and hence help solve the problem of 'netting'.

[8]A more sophisticated analysis would be to solve the optimal capital allocation decision of the arbitrageur to the available basis-trades and test his first order condition.

[9]In September 2008 the bankruptcy of Lehman Brothers caused a total close to $400 billion to become payable to the buyers of CDS protection referenced against the insolvent bank. However the net amount that changed hands was around $7.2 billion This difference is due to the process of "netting". Market participants co-operated so that CDS sellers were allowed to deduct from their payouts the inbound funds due to them from their hedging positions. Dealers generally attempt to remain risk-neutral so that their losses and gains after big events will on the whole offset each other.

To construct such a representative CDS issuer, we use the list of primary dealers designated by the Federal Reserve Bank of New York.[10] These primary dealers are banks and security broker-dealers that trade in the U.S. government securities with the Federal Reserve System. To become qualified as a primary dealer, a firm must be in compliance with capital standards under the Basel Capital Accord, with at least $100 million of Tier I capital for a bank or above $50 million of regulatory capital for a broker-dealer. As trading partners of the central bank, these primary dealers often are the biggest and most competitive financial institutions who happen to be dominant issuers of credit default swap contracts. As of September 2008, there were 19 primary dealers such as Citigroup, Goldman, J.P. Morgan Chase and Morgan Stanley. The list changes over time since some primary dealers may fail to meet required capital standards. Accordingly, we update the components of the primary dealer index. For example, the index includes Lehman Brothers' Holdings before its bankruptcy on September 15, 2008, but exclude it afterwards and adds Nomura Securities International, Inc. starting from July 27, 2009.

For the primary dealer index, we calculate its stock return (R^{index}) weighted by each constituent's market capitalization. Appendix B lists the current component in our primary dealer index. We then measure an underlying entity's counterparty risk as the comovement of its stock return with the excess return of primary dealer index in minus of the U.S. stock market return:

$$\beta^i_{cp} = \frac{cov(R^i, (R^{index} - R^{mkt}))}{var(R^{index} - R^{mkt})} \tag{2}$$

where R^i is company i's stock return, R^{mkt} is the CRSP value-weighted stock market return, and R^{index} is the stock return of primary dealer index. The reason we use excess return is to exclude the market impact.

3.2 Funding Cost Risk

If financing becomes more expensive and more scarce, – higher funding cost risk – then the basis trade becomes riskier and aggregate demand for corporate bonds decreases, which drives the basis in a negative direction. From an ex-ante perspective, a firm's basis will be more negative if its credit default spread change moves in line with the market funding cost.

A natural candidate for market funding cost is the Libor-OIS spread, the difference between the interbank loan rate and the overnight indexed swap rate. The spread indicates the easiness of financing in the banking system, and then a good benchmark of funding liquidity

[10] A current list of primary dealers can be found at the Bank's website: http://www.newyorkfed.org/markets/primarydealers.html.

in the financial market. When the change of a reference entity's CDS moves along with the Libor-OIS spread, we expect the reference entity's CDS-bond basis to widen. We thus measure an underlying entity's funding liquidity risk as the comovement of its credit default spread change with the change of the Libor-OIS spread:

$$\beta_{fl}^{i} = \frac{cov(\Delta CDS^{i}, \Delta(Libor - OIS))}{var(\Delta(Libor - OIS))} \tag{3}$$

A caveat on the Libor-OIS spread however says that this spread contains not only liquidity risk but also credit risk during the financial crisis of 2007-2009. To sharpen the measure of funding liquidity risk, we also try another funding cost indicator: the repo spread, which is calculated as the 3-month Repo Treasury rate (with general collateral) minus the 3-month Treasury Bill. The difference between the collateralized and uncollateralized interest rate, both on Treasury note, get insulated from credit risk and thus a more accurate measure for funding liquidity (See Adrian and Shin (2008))**?**. Correspondingly, a company's alternative funding liquidity beta becomes

$$\beta_{fl}^{i} = \frac{cov(\Delta CDS^{i}, \Delta RepoSpread)}{var(\Delta RepoSpread)} \tag{4}$$

We study the relationship of these two measures and use both in our empirical tests.

3.3 Collateral Quality

A third risk factor that affects the CDS-bond basis is the quality of bonds issued by the reference entity in a CDS contract. To do the negative basis trade, an arbitrageur needs to buy bonds which is funded via the repo market using bonds as collateral. Meanwhile the arbitrageur faces an hair cut, which implies additional capital requirement. The hair cut depends on the collateral quality. Therefore we expect a firm with higher collateral quality bond should have lower hair cut and hence narrower CDS-bond basis.

In the empirical literature multiple firm characteristics potentially have an influence on the collateral quality.[11] When a firm has more total assets, more tangible assets, higher rating, lower leverage, lower credit default swap spread, lower CDS volatility, the firm tends to have higher collateral quality. For each firm we construct a collateral index in the similar way as Altman's Z-score (Altman (1968))**?**. At each sampling phase (Before Crisis, Crisis I and Crisis II), we collect and calculate firms' size(+), leverage(-), tangible ratio(+), rating(+), average

[11] See Ashcraft and Santos (2009).**?**

CDS spread(-) and CDS volatility(-), standardize them cross-sectionally and add up the values according to the sign in the parentheses. The resulting value is called collateral index which reflects the collateral quality of bonds under each reference entity.

4 Data

The data used to study the CDS-bond basis come from several sources. We start with the universe of firms whose single-name CDS is traded in the derivative market and transactions are recorded in Markit database. Then we collect these firms' corporate bond information from Mergent Fixed Income database. Finally we match each firm's credit default swap and bond spread to corresponding equity returns in the Center for Research in Security Prices (CRSP). All data are in daily frequency from January 1, 2006 through September 30, 2009. The whole sample is further partitioned into three phases: Phase 1 is the period before the subprime credit crisis, named 'Before Crisis' (1/2/2006 - 6/30/2007);[12] Phase 2 is the period between the subprime credit crisis and the bankruptcy of Lehman Brothers, called 'Crisis I'(7/1/2007 - 8/31/2008); and Phase 3 is the period after Lehman Brothers' failure, 'Crisis II'(9/1/2008 - 9/30/2009).

4.1 Credit Default Swap

We download single-name credit default swap data from Markit Inc. for U.S. firms. The prices are quoted in basis points per annum for a notional value of $10 million and are based on the standard ISDA contract for physical settlement. The original dataset provides daily market CDS prices in various currencies and different types of restructuring documentation clause. Following a conventional rule, we choose the CDS price in US dollar and the documentation clause type as 'Modified Restructuring'(MR).[13]

The original dataset also provides a CDS spread term structure incorporating maturities of 3m, 6m, 1y, 2y, 3y, 4y, 5y, 7y, and 10y. We use all maturities in conjunction with matching interest rate swaps to calculate a term structure of default probability, which is an integral component in deriving the bond-implied CDS spread (PECDS) and hence the CDS-bond basis

[12]

[13]Under the 2003 Credit Definitions by the International Swap and Derivative Association (ISDA), there are four types of restructuring clauses: Cumulative Restructuring (CR), Modified Restructuring (MR), Modified-Modified Restructuring (MM), and No Restructuring (XR). 'Modified Restructuring' is used by most broker-dealers in the U.S. market. This convention rule holds till April 8, 2009. Afterwards the U.S. market adopts the 'No Restructuring' convention. For consistency, we choose the MR documentation clause throughout our sample.

(see Appendix A). In the end we focus on the CDS-bond basis with maturity of five years because 5-year CDS is by far the most liquid in the credit derivative market and for the convenience of comparison, 5-year CDS is also widely used in the literature.

4.2 Corporate Bond

We get corporate bond data from Mergent Fixed Income Databases. This database contains information on virtually all publicly-traded bonds issued in the United States since 1980. For each firm in the Markit dataset, we search Mergent datascope for all of its bonds which have 3 to 7 years left to maturity measured at the start of 2006. We find quite a few conspicuous firms such as Warren Buffet's Berkshire Hathaway Inc. don't issue mid-term bonds less than 7 years, then we further expand the bond sample to include firms which issue bonds with 7 to 10 years left to maturity also measured at the start of 2006. In line with Blanco, Brennan and Marsh (2005), we exclude floating-rate securities and all bonds that have embedded options, step-up coupons, sinking funds, or any special feature that would result in differential pricing.

For each bond, we collect bond price, coupon rate, annual payment frequency, issuing date and maturity date. We then apply the methodology described in Appendix A to calculate the bond price implied CDS spread and further to calculate the CDS-bond basis. Since we target on the 5-year CDS contract, we prefer bonds with maturities as close to five year as possible for better maturity matching. Therefore, if an underlying firm issues bonds with $3 \sim 7$ years left to maturity, we only use these mid-term bonds to calculate the basis. If an underlying firm like Berkshire doesn't have bonds with $3 \sim 7$ years left to maturity in the sampling period, we then calculate the basis from the firm's bonds with $7 \sim 10$ years left to maturity.

The methodology we use to calculate the CDS-bond basis is quite different from Blanco, Brennan and Marsh (2005). They choose bonds with $3 \sim 5$ year to maturity at the beginning of their sample period, and use linear interpolation method to estimate a 5-year bond yield to match the 5-year CDS spread. In terms of CDS data, Blanco et al. (2005) only need the five-year CDS spread. Yet we need to use the complete CDS term structure to get more accurate measures of default intensity and hence a better fitting of bond-implied CDS spread.

Finally we match the combined Markit-Mergent data to CRSP to gather information on stock prices and outstanding shares. All together we get a little more than 300 firms in our sample.

4.3 Reference Rate

We use the U.S. dollar interest rates swaps as the measure of reference rate. The reference rate is used to proxy the risk-free interest rate when credit spreads are calculated. The natural choice are government bond yields. As Blanco, Brennan and Marsh (2005) pointed out, "government bonds are no longer an ideal proxy for the unobservable risk-free rate" due to taxation treatment, repo specials, legal constraint among others. Also in practice the Wall Street investors more often do CDS-bond basis arbitrage using interest rate swaps as reference rates.

4.4 Firm Characteristics

To construct the risk factors introduced in Section 3, we download firm characteristics from Capital IQ and Mergent. For each firm in the merged CDS-Bond-Equity dataset, we collect and calculate the following variables in the quarterly frequency from 2006:Q1 to 2009:Q3: *SIZE*, the logarithm of the total assets; *LEVERAGE*, the ratio of total debt over market capitalization; *TANGIBLE RATIO*, the percentage of tangible asset in the total asset; *RATING*, the firm's rating by Standard & Poor's; and *INDUSTRY SECTOR*.

Finally we download the libor rate, interest rate swaps, repo rates from Federal Reserve Board, and download the overnight indexed swap (OIS) from Bloomberg.

4.5 Summary Statistics

Table 1 presents summary statistics of the CDS-bond basis. The basis across all firms was slightly negative before the crisis, -3bps on average between 1/2/2006 to 6/30/2007, but descended to -21bps in the first phase of the financial crisis (7/1/2007 - 8/31/2008) and further fell to -171bps after the bankruptcy of Lehman Brothers (9/1/2008 - 9/30/2009). Meanwhile the volatility of the basis kept increasing for all types of firms, on average from 9bps before the crisis to 22bps and further to 46bps in the turmoil of the financial crisis, which is five times more volatile.

Panel A also shows that firms with investment-grade rating share the same pattern as the overall firms, whose basis become more and more negative and volatile with the deepening of the financial crisis. However, firms with high-yield rating has strikingly different basis dynamics. Before the crisis these high-yield firms have positive basis as high as 83bps. These firms' basis began to narrow since the start of the subprime mortgage crisis in the summer of 2007, yet they were still positive on average and higher than the basis of investment-grade firms in the first phase of the crisis. Only until the collapse of giant investment bank Lehman, high-yield firms' basis plunged, deep and quickly to an average -322 bps. Indeed, high-yield firms are always much more volatile than investment-grade firms, evidenced by the significantly bigger volatility in all periods and especially in the second phase.

Panel B provides additional evidence to the different basis pattern between investment-grade and high-yield firms. We refine the rating to subcategories from AAA, AA to CCC and NR(no rating). Here each rating category includes both its + and - notch, for example, "AA" group contains firms with ratings of AA, AA+ and AA-. We find consistent patten as in Panel A that firms with lower credit rating tend to have more negative and more volatile basis, suggesting a monotonic relationship between a firm's rating and the discrepancy between the CDS and cash-bond price of the same firm. However such a relationship only holds in the second phase of the crisis, i.e. after the Lehman Brothers failure. The basis displays a right-skewed 'smile' from AAA to CCC in pre-Lehman chapter. AA-rated firms tend to have slimly positive basis, and the basis narrows and switches sign from the category of A, then reaches the trough for BBB-rated firms. Ever since the first level of speculative-grade, BB, the value of the basis becomes higher and higher till the CCC category. The change from the pre-Lehman V-shape to a post-Lehman's monotonic relationship is an interesting puzzle.

Figure 1A and 1B provide an illustration of the basis dynamics for investment-grade and high-yield firms respectively. The solid red line is the average cds-bond basis for firms in each rating category, weighted by firms' market capitalization. In addition to echoing numbers in Table 1, these plots suggest that credit conditions for firms in both rating category, though has improved, still far below the before-crisis level. By the end of September 2009, the investment-grade firms still had an average -150bps basis and the high-yield firms had -170bps basis. On the contrast, the negative of LIBOR-OIS spread illustrated by the dotted blue line, already came back to the pre-crisis level (12bps on September 30, 2009 compared with 9bps on January 3, 2006), indicating that the international bank financing system has recovered and the credit market becomes liquid again.

In Panel A we also notice that financial firms have more negative and volatile basis than non-financial firms in the crisis. Such pattern is well illustrated in Figure 3, where the solid red line is the average cds-bond basis for firms in financial and non-financial category, weighted by firms' market capitalization. Panel C reports detailed results for 14 subcategories. Unlike the rating-classified results in Panel B, we cannot find clear patterns among industry sectors except that (i) manufacturing firms tend to have positive cds-bond basis before the crisis, (ii) credit/financing sector was most hit in the crisis with largest discrepancy between CDS and cash-bond spread, (iii) leasing and manufacturing sector have relatively smaller discrepancy in the crisis. Though a lack of clear story, Panel C provides strong evidence for the existence of heterogeneity across firms. We will study the cross-sectional variation in the CDS-bond basis in next section.

5 Results

We study the cross-sectional determination of the CDS-bond basis with the following regression:

$$Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}\beta^i_{fl} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}\ ^i + \gamma\, Z^i + \epsilon_i \tag{5}$$

In Table 3 we present univariate as well as multivariate regressions of cross-sectional individual firm basis on our different proxies for counterparty risk, funding cost risk and collateral quality. The univariate full sample regressions presented in Panel A illustrate that the signs of the correlations are as expected in a world where arbitrageurs have a relative preference for the basis trades that exhibit less 'risks.' In particular, in the cross section the average basis is more negative for firms with higher counterparty risk, for firms with higher market liquidity beta (both when market liquidity is measured with respect to repo spread or libor-ois spread), and for firms with worse collateral quality.

When we focus on the multivariate regression, then in the full sample counterparty risk, collateral quality and funding cost risk (as measured by libor-ois spread) remain significant (and keep the same signe and slightly smaller magnitude). The findings are consistent with the results in the crisis period post Lehman bankruptcy (Panel D). In terms of magnitude counterparty risk and market liquidity are the main determinants during that period. Overall, the R^2 is 29% in the post-Lehman period, and 35% for the full sample indicating that the model explains the data fairly well. To provide some perspective on the ad-hoc definitions of the subperiod regressions, we present in figures 4 through 9 the time series of the coefficients and variance decomposition for the Fama-MacBeth cross-sectional regressions. These figures show the time variation in the 'premia' associated with each source of risk.

Figures 4 and 6 show the time series of the dynamic coefficients in the Fama-Macbeth regressions for two different choices of regressors measuring market liquidity beta. In Figure 4 we use beta with respect to the repo-spread change as a measure of liquidity, whereas in figure 6 we use beta with respect to the libor-ois spread. Comparing both figures, we see that the definition of liquidity beta has a significant impact on the estimated funding liquidity risk-premium, mainly because of a correlation with the counterparty risk beta. It is clear (and intuitive) that the beta with respect to libor-ois exhibits significant correlation with the counterparty risk beta. Therefore when we use it as our measure of market liquidity risk we tend to overstate the explanatory power of liquidity and understate counterparty risk relative to when we use repo-spread to measure funding liquidity. Figure 5 and 7 show a 'naive'[14] variance decomposition of the cross-sectional variance in the basis explained by each beta component. We see that the cross-sectional variance explained by the counterparty risk beta is five times smaller when we use libor-ois to proxy for market liquidity. This is a general issue with interpreting our results as it is difficult to correct for the endogenous correlation between the three factors, market liquidity, counterparty credit risk and collateral quality. In Figure 8 and 9 we show the model where we use both measures of liquidity jointly in addition to collateral quality, counterparty risk and controls. As we can see, the time series of coefficients of premia for collateral quality are quite stable across all specification. Also, the coefficients on the two measures of market liquidity are quite consistent with those measured in Figure 4 and 6 respectively.

Overall, the results indicate that the empirical model is reasonably successful at explaining cross-sectional variation in the basis. The main determinant of the cross-sectional basis seems to be funding liquidity as measured by the libor-ois rate, with the caveat noted above that it is difficult to actually disentangle counterparty risk from liquidity risk as measured by libor-ois.

We see that counterparty risk becomes significant (Figure 8, panel A) in the second half of 2008 and in the first quarter of 2009. Interestingly these two periods correspond precisely to the bankruptcy filing for Lehman Brothers Inc.(September 2008) and the stock market touching the bottom (March 2009) respectively. Outside these periods, the cross-sectional regressions do not find significant coefficient loading on the counterparty risk beta. Funding liquidity as measured by the libor-ois spread becomes statistically and economically most significant during the post-Lehman period, with achieving its largest negative loading in March 2009. Similarly collateral quality matters most during this post-Lehman period.

[14]We decompose the total explained variance into separate components explained by individual regressors, but ignoring the correlation between them.

6 Robustness and Discussion

6.1 Alternative basis calculation

6.2 Alternative funding cost benchmark

7 Conclusion

[Coming soon]

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A The Par-Equivalent CDS Methodology

We present the Par Equivalent CDS methodology developed by J.P. Morgan to calculate the CDS-bond basis in Section 2. This survival-based valuation approach provides an apple-to-apple measure across the cash-bond spread and the credit default swap spread.

The fair value of the coupon on a CDS is set so that the expected present value of the premium leg is equal to the expected present value of the contingent payment (see Duffie (1999), Hull and White (2001)). Assuming that we have a zero-coupon discount curve $Z(t)$ extracted from swap spreads and assuming a constant intensity survival probability $S(t)$, the expected present value of the premium leg is given by:

$$\mathrm{PV}_{premium}(C) = \sum_{i=1}^{n} Z(t_i)S(t_i)\, C * dt + \sum_{i=1}^{n} Z(\frac{t_i + t_{i-1}}{2})[S(t_{i-1}) - S(t_i)]\, C * dt/2, \quad (6)$$

where the second component is the present value of the accrued interest upon default (assumed to occur half-way between t_{i-1} and t_i). The expected present value of the contingent leg is:

$$\mathrm{PV}_{contingent} = (1 - R) \sum_{i=1}^{n} Z(\frac{t_i + t_{i-1}}{2})[S(t_{i-1}) - S(t_i)], \quad (7)$$

where R stands for the recovery rate. The fair credit default swap spread is the number C that sets

$$\mathrm{PV}_{premium}(C) = \mathrm{PV}_{contingent} \quad (8)$$

The par-equivalent CDS uses the market price of a bond to calculate a spread based on CDS-implied default probabilities. First, we need to get a CDS-implied default probability curve. We plug in the market CDS price with 3-month maturity ($C_{0.25}$) to get the 3-month survival probability, $S_{0.25}$. Then we plug in the CDS price with 6-month maturity ($C_{0.5}$) and the calculated 3-month survival probability ($S_{0.25}$) to get the 6-month survival probability, $S_{0.5}$. Sequentially plugging in CDS spread with longer maturity from 1-year to 10-year, we can get a curve of the survival probability $S_{cds}(t_i)$.

Second we need to get a bond-implied survival probability curve $S_{bond}(t_i)$ defined as follows

$$S_{bond}(t_i) = S_{cds}(t_i) + \varepsilon. \quad (9)$$

s.t.

$$\varepsilon = \arg\min \left(PV(S_{bond}) - \text{Market Price of Bond}\right)^2. \quad (10)$$

Then the bond-implied CDS spread term structure is defined by substituting the survival probability term structure fitted from bond prices, $S_{bond}(t)$, into the following equation for par equivalent CDS spreads, denoted as PECDS:

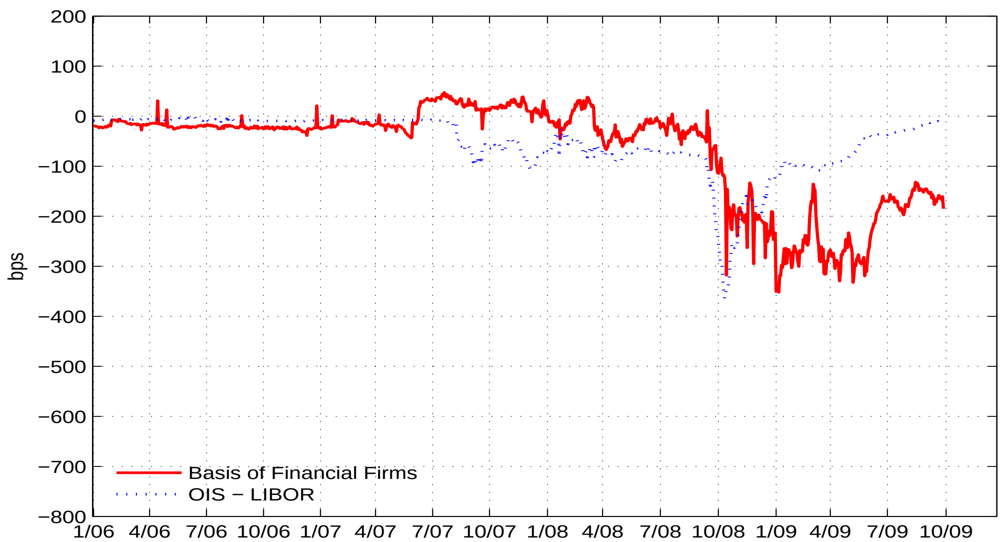
$$PECDS = \frac{(1-R)\sum_{i=1}^{n} Z(\frac{t_i+t_{i-1}}{2})[S_{bond}(t_{i-1}) - S_{bond}(t_i)]}{\sum_{i=1}^{n}\left[Z(t_i)S_{bond}(t_i) * dt + Z(\frac{t_i+t_{i-1}}{2})[S_{bond}(t_{i-1}) - S_{bond}(t_i)] * \frac{dt}{2}\right]} \tag{11}$$

B The Primary Dealers List

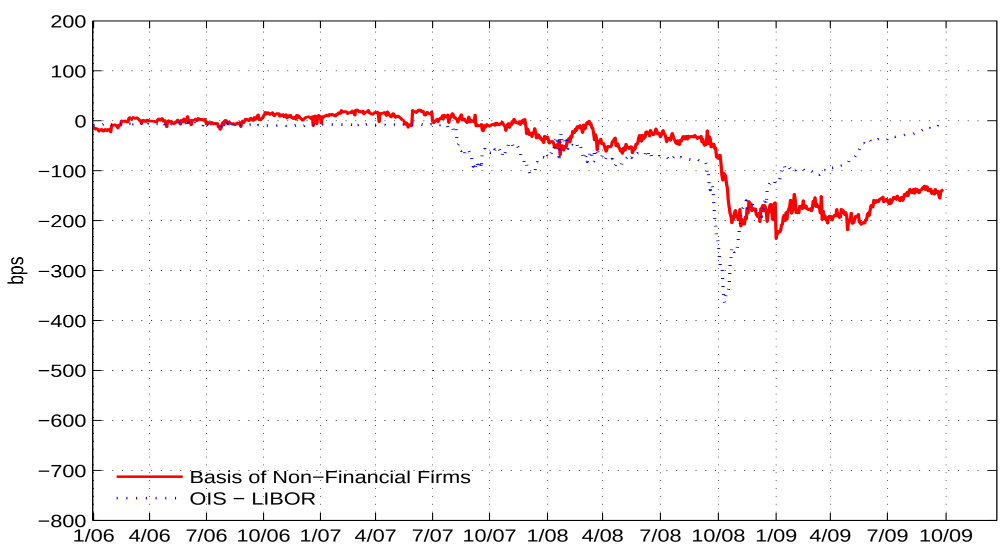
Effective since July 27, 2009. The list is downloaded from the website of the Federal Reserve Bank of New York: `http://www.newyorkfed.org/markets/pridealers_current.html`.

BNP Paribas Securities Corp.
Banc of America Securities LLC
Barclays Capital Inc.
Cantor Fitzgerald & Co.
Citigroup Global Markets Inc.
Credit Suisse Securities (USA) LLC
Daiwa Securities America Inc.
Deutsche Bank Securities Inc.
Goldman, Sachs & Co.
HSBC Securities (USA) Inc.
Jefferies & Company, Inc.
J. P. Morgan Securities Inc.
Mizuho Securities USA Inc.
Morgan Stanley & Co. Incorporated
Nomura Securities International, Inc.
RBC Capital Markets Corporation
RBS Securities Inc.
UBS Securities LLC.

Figure 3: A. The CDS-Bond Basis of Financial Firms vs OIS-LIBOR spreads



B. The CDS-Bond Basis of Non-Financial Firms vs OIS-LIBOR spreads



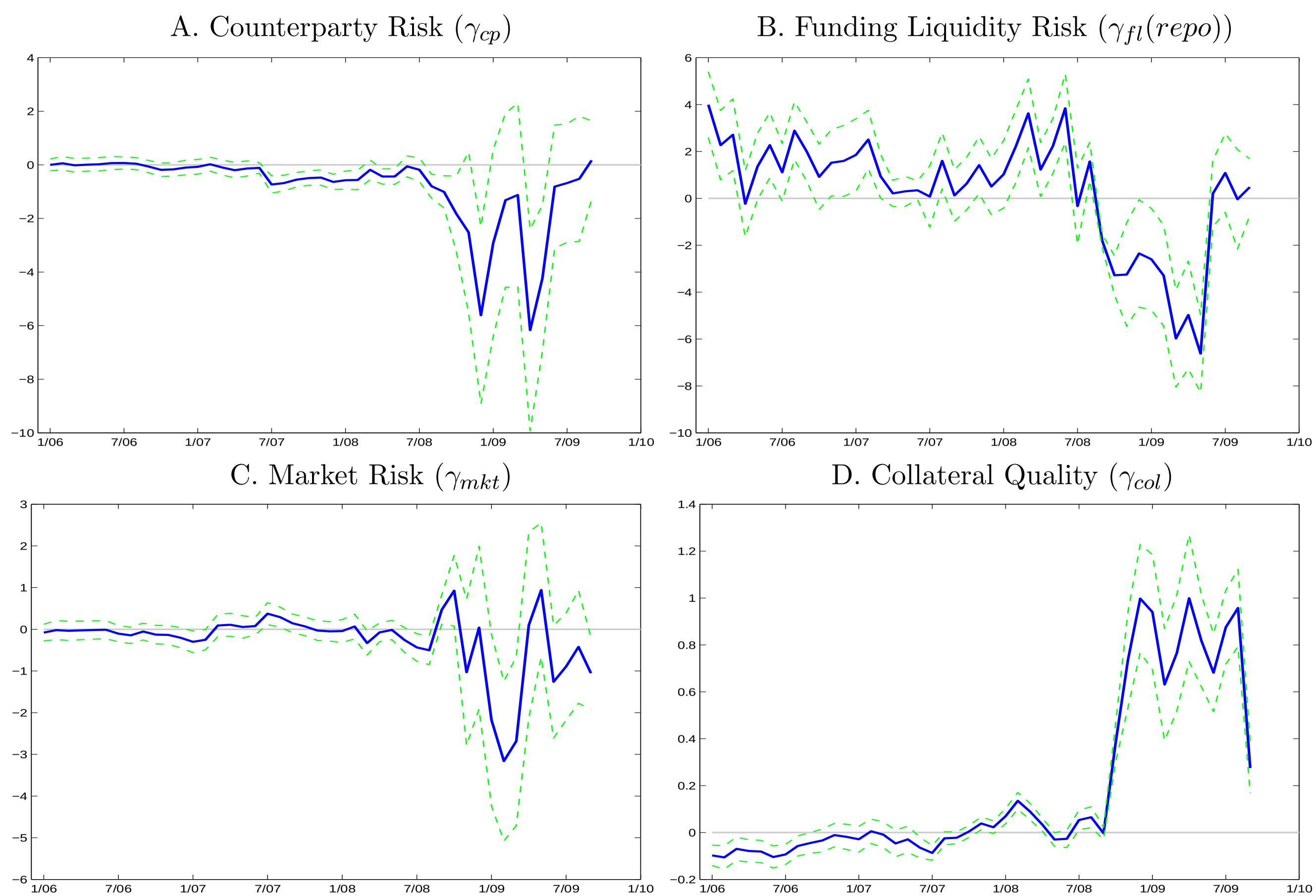


Figure 4: Dynamic Coefficients in the Cross-Sectional Regression: $Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}(repo)\beta^i_{fl_{repo}} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}^{\ i} + \gamma\,\text{Sign}^i + \epsilon^i$, where $\beta^i_{fl_{repo}}$ is measured by the change of the repo spread (3m repo rate minus 3m T-Bill rate).

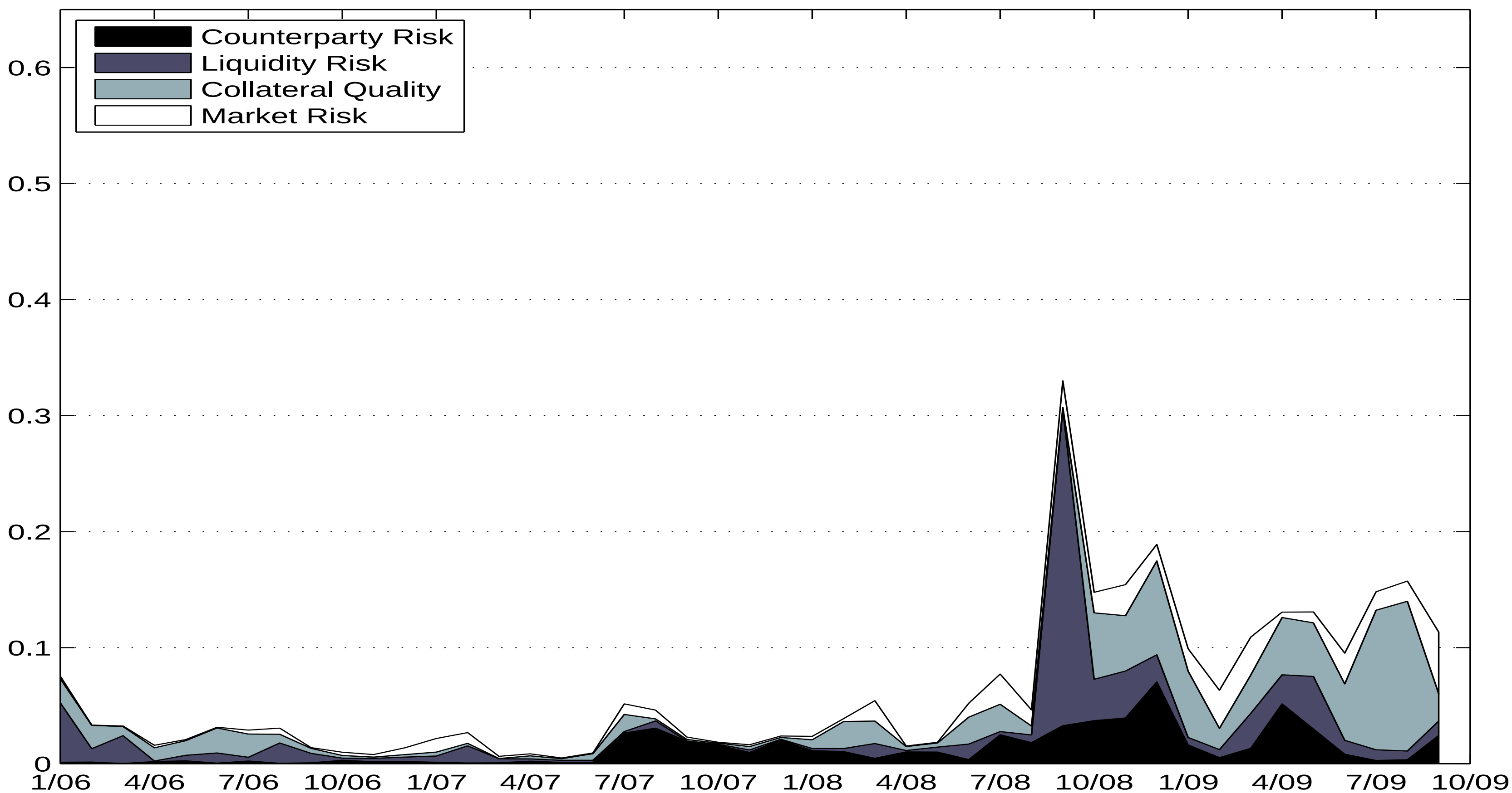


Figure 5: Dynamics of Variance Decomposition in the Cross-Sectional Regression: $Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}(repo)\beta^i_{fl_{repo}} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}\ ^i + \gamma\,\text{Sign}^i + \epsilon^i$, where $\beta^i_{fl_{repo}}$ is measured by the change of the repo spread (3m repo rate minus 3m T-Bill rate).

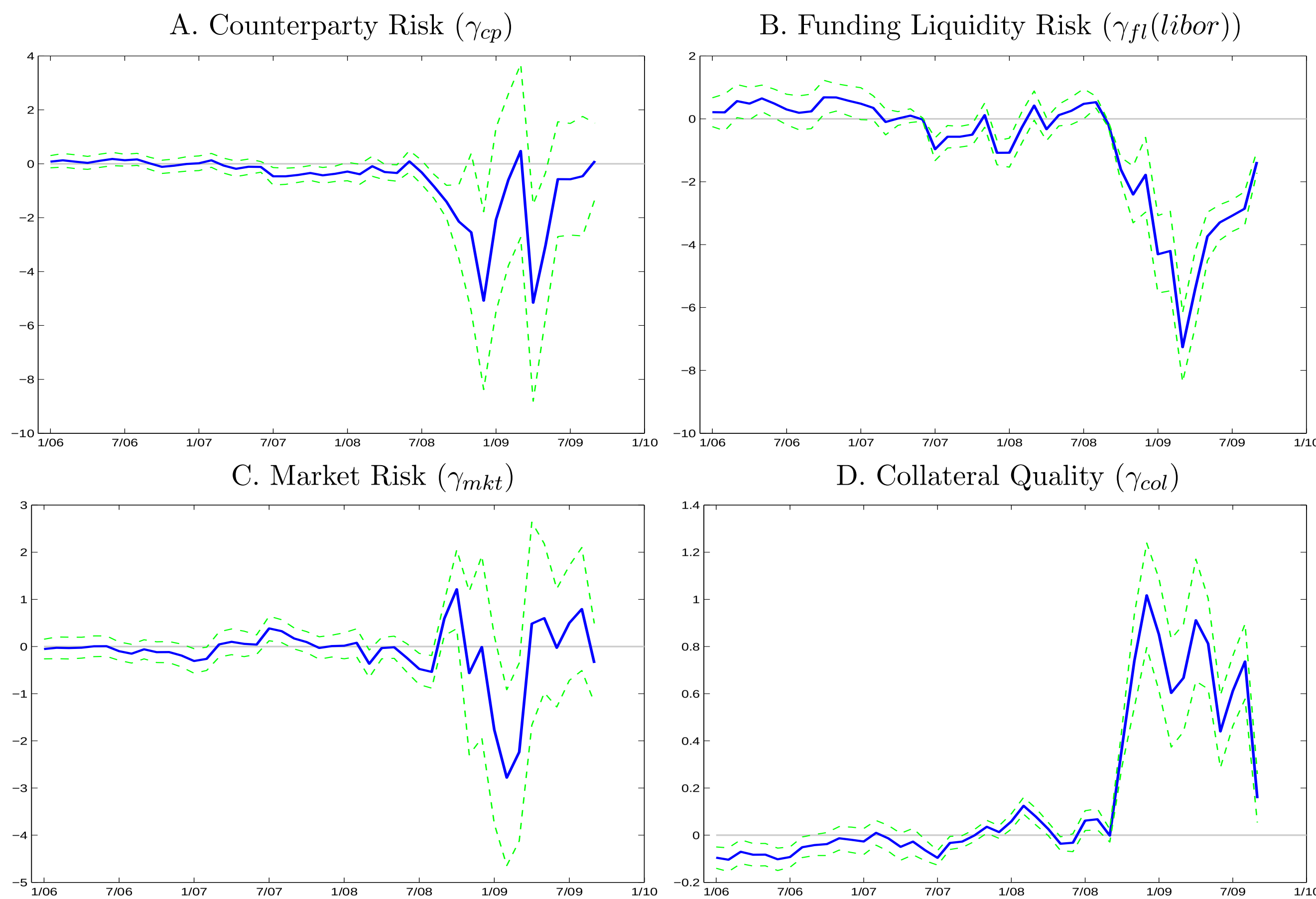


Figure 6: Dynamic Coefficients in the Cross-Sectional Regression: $Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}(libor)\beta^i_{fl_{libor}} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}^{\ i} + \gamma\,\text{Sign}^i + \epsilon^i$, where $\beta^i_{fl_{libor}}$ is measured by the change of the Libor-OIS spread.

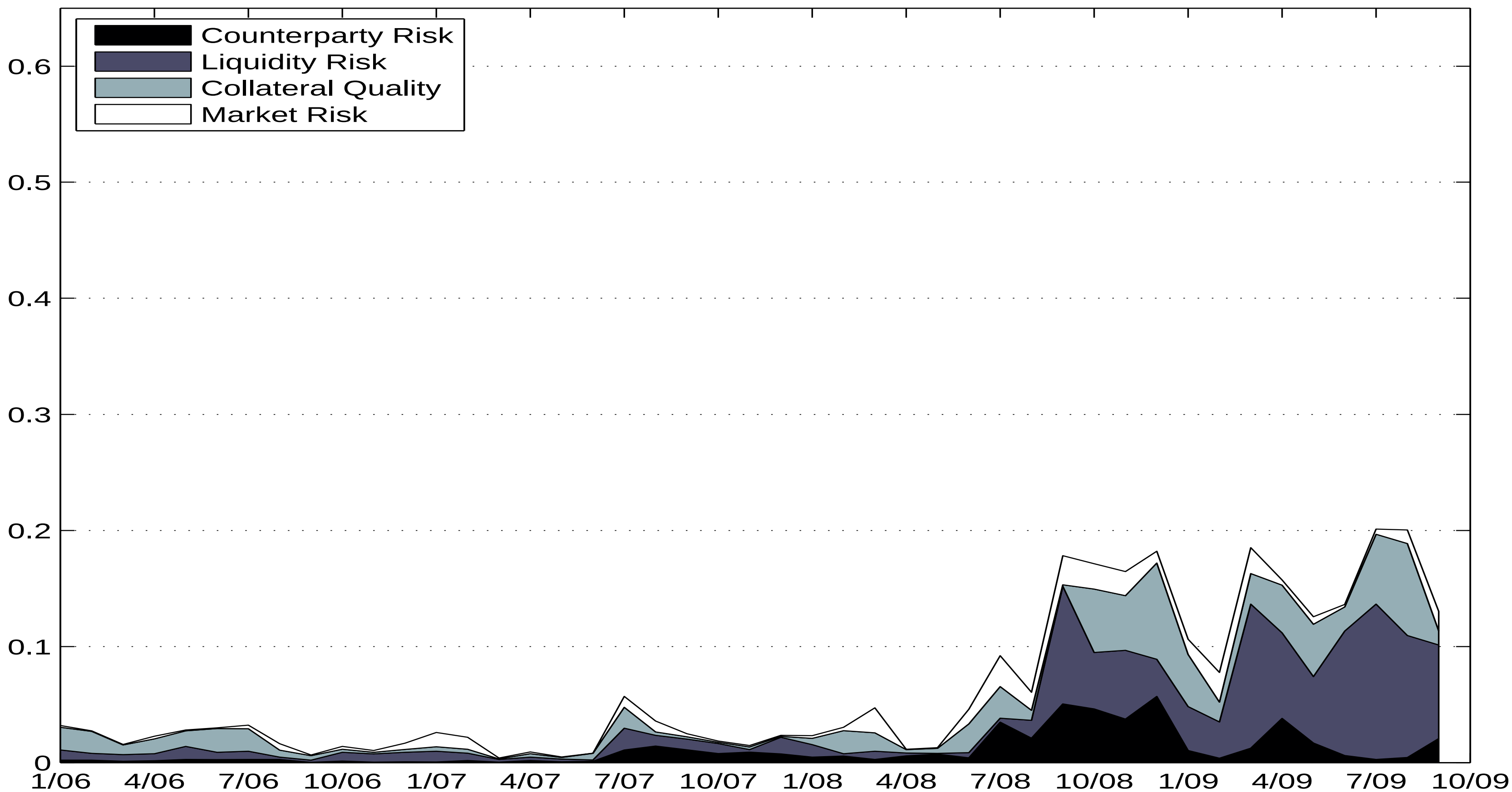


Figure 7: Dynamics of Variance Decomposition in the Cross-Sectional Regression: $Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}(libor)\beta^i_{fl_{libor}} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}\ ^i + \gamma\,\text{Sign}^i + \epsilon^i$, where $\beta^i_{fl_{libor}}$ is measured by the change of the Libor-OIS spread.

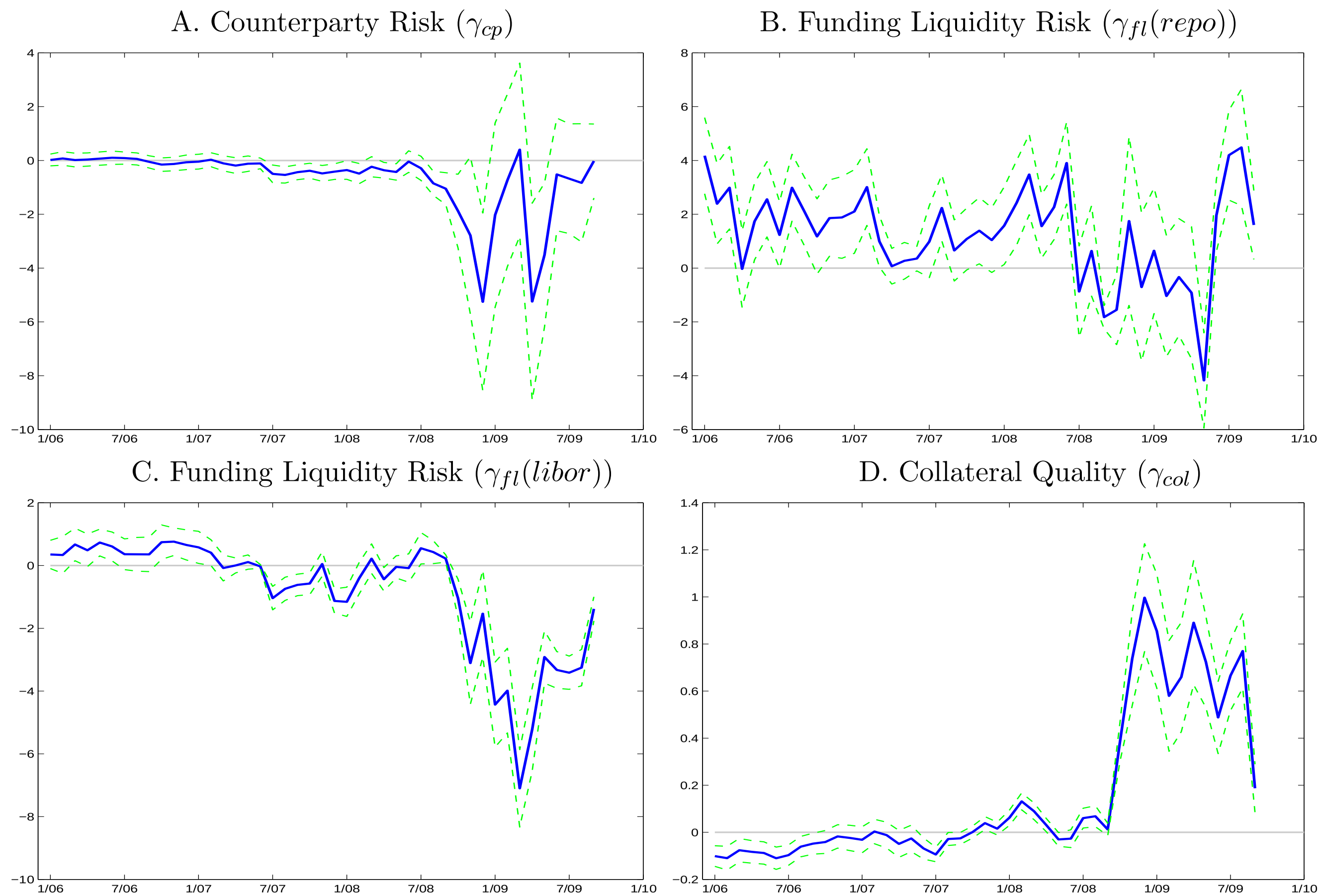


Figure 8: Dynamic Coefficients in the Cross-Sectional Regression: $Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}(repo)\beta^i_{fl_{repo}} + \gamma_{fl}(libor)\beta^i_{fl_{libor}} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}^{\ i} + \gamma\,\text{Sign}^i + \epsilon^i$, where $\beta^i_{fl_{repo}}$ is measured by the change of the repo spread (3m repo rate minus 3m T-Bill rate) and $\beta^i_{fl_{libor}}$ is measured by the change of the libor-ois spread.

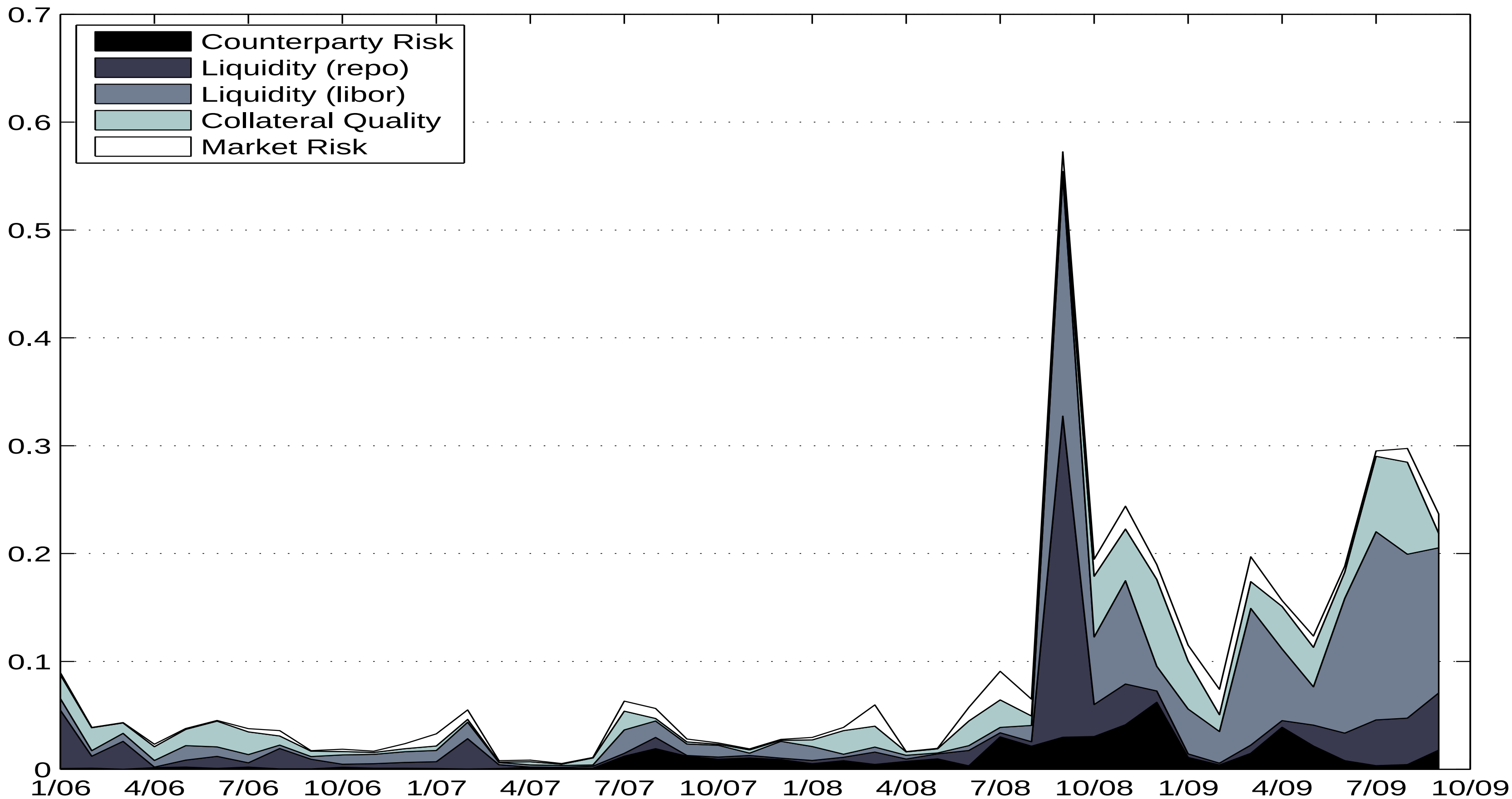


Figure 9: Dynamics of Variance Decomposition in the Cross-Sectional Regression: $Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}(repo)\beta^i_{fl_{repo}} + \gamma_{fl}(libor)\beta^i_{fl_{libor}} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}^{\ i} + \gamma\,\text{Sign}^i + \epsilon^i$, where $\beta^i_{fl_{repo}}$ is measured by the change of the repo spread (3m repo rate minus 3m T-Bill rate) and $\beta^i_{fl_{libor}}$ is measured by the change of the libor-ois spread.

Table 1
Summary Statistics of Discrepancies in CDS and Cash Bond Markets

This table provides descriptive statistics for the CDS-bond basis in three phases: Phase 1 is the period before the subprime credit crisis, named "Before Crisis" (1/2/2006 - 6/30/2007), Phase 2 is the period between the subprime credit crisis and the bankruptcy of Lehman Brothers, called "Crisis I" (7/1/2007 - 8/31/2008), and Phase 3 is the period after Lehman Brothers' failure, "Crisis II" (9/1/2008 - 9/30/2009). The basis is calculated as the difference between the CDS spread and the par-equivalent corporate bond spread, using the methodology in Appendix A. Panel A presents the average results across investment-grade and high-yield firms, financial and non-financial firms; Panel B provides further results according to firms credit rating; and Panel C list results by firm's industry sector. All numbers are in basis points.

Panel A

		All	Investment-Grade	High-Yield	Financial	Non-Financial
Before Crisis	Mean	-3	-7	83	-17	4
(T=375)	Std.Err	9	8	30	12	10
	Min	-22	-26	-9	-43	-23
	Max	29	19	163	36	22
Crisis I	Mean	-21	-27	11	-2	-24
(T=295)	Std.Err	22	19	53	28	20
	Min	-66	-69	-110	-67	-68
	Max	20	6	136	47	15
Crisis II	Mean	-171	-165	-322	-206	-161
(T=271)	Std.Err	46	44	136	73	43
	Min	-258	-252	-653	-352	-236
	Max	-17	-17	-28	11	-20

Panel B: By Credit Rating

		Investment Grade				High Yield			
		AAA	AA	A	BBB	BB	B	CCC	NR
Before Crisis	Mean	-20	18	-7	-31	17	170	440	-17
(1/2/2006 - 6/30/2007)	Std Err.	11	18	10	13	32	54	271	26
	Min	-54	-28	-49	-47	-27	-26	156	-58
	Max	3	68	15	31	100	285	1211	105
Crisis I	Mean	3	4	-35	-50	-22	36	436	32
(7/1/2007 - 8/31/2008)	Std Err.	20	21	17	34	41	91	314	55
	Min	-58	-50	-80	-124	-110	-109	-334	-77
	Max	44	43	-4	8	75	232	1232	135
Crisis II	Mean	14	-83	-176	-267	-262	-431	-1315	-96
(9/1/2008 - 9/30/2009)	Std Err.	47	29	53	76	116	238	1596	260
	Min	-87	-168	-263	-406	-754	-1244	-6099	-289
	Max	188	-11	-1	-87	-41	-3	746	871

Panel C: By Industry Sector

	Firm	Before Crisis				Crisis I				Crisis II			
	Number	Mean	Std	Min	Max	Mean	Std	Min	Max	Mean	Std	Min	Max
Industrial Firms													
Manufacturing	133	14	13	-20	35	-12	19	-56	23	-141	40	-214	71
Media/Commu	11	135	94	7	386	8	63	-142	100	-240	84	-443	31
Oil & Gas	20	-22	13	-53	5	-50	17	-105	-12	-196	53	-280	-60
Railroad	1	-50	17	-96	-19	-70	27	-134	5	-225	96	-494	-30
Retail	20	-33	10	-70	-14	-52	16	-92	-22	-170	45	-281	-52
Service/Leisure	26	-33	16	-52	44	-59	26	-112	25	-240	108	-473	-35
Transportation	7	-13	14	-56	15	-66	35	-144	11	-295	89	-530	-99
Telephone	2	-42	19	-69	9	-66	45	-160	38	96	652	-902	1104
Financial Firms													
Banking	6	-30	23	-60	80	26	45	-69	97	-227	84	-339	23
Credit/Financing	1	-30	17	-63	14	-161	105	-311	108	-678	570	-2253	9
Financial Service	4	12	16	-29	114	31	36	-59	153	-269	104	-641	36
Insurance	17	-34	7	-63	-16	-48	25	-114	36	-134	64	-356	26
Real Estate	13	-24	13	-47	5	0	26	-55	76	-308	215	-1071	100
Leasing	2	-54	19	-87	12	-32	77	-139	299	-770	970	-4141	64

Table 2
Correlation Matrix of Betas

This table shows the correlation values for betas that capture counterparty risk, funding cost risk, market risk and collateral quality betas. The descriptive statistics are shown for three phases: Phase 1 is the period before the subprime credit crisis, named "Before Crisis" (1/2/2006 - 6/30/2007), Phase 2 is the period between the subprime credit crisis and the bankruptcy of Lehman Brothers, called "Crisis I" (7/1/2007 - 8/31/2008), and Phase 3 is the period after Lehman Brothers' failure, "Crisis II" (9/1/2008 - 9/30/2009).

Full Sample (1/2/2006 - 9/30/2009)

	β_{cp}	$\beta_{fl}(repo)$	$\beta_{fl}(libor)$	β_{mkt}	Collateral
β_{cp}	1	-	-	-	-
$\beta_{fl}(repo)$	0.32	1	-	-	-
$\beta_{fl}(libor)$	0.38	0.62	1	-	-
β_{mkt}	0.80	0.20	0.32	1	-
Collateral	-0.16	-0.15	-0.33	-0.19	1

Before Crisis (1/2/2006 - 6/31/2007)

	β_{cp}	$\beta_{fl}(repo)$	$\beta_{fl}(libor)$	β_{mkt}	Collateral
β_{cp}	1	-	-	-	-
$\beta_{fl}(repo)$	-0.11	1	-	-	-
$\beta_{fl}(libor)$	0.07	0.08	1	-	-
β_{mkt}	0.29	-0.14	-0.07	1	-
Collateral	-0.01	0.23	-0.19	-0.14	1

Crisis I (7/1/2007 - 8/31/2008)

	β_{cp}	$\beta_{fl}(repo)$	$\beta_{fl}(libor)$	β_{mkt}	Collateral
β_{cp}	1	-	-	-	-
$\beta_{fl}(repo)$	0.37	1	-	-	-
$\beta_{fl}(libor)$	0.42	0.91	1	-	-
β_{mkt}	0.83	0.46	0.50	1	-
Collateral	-0.25	-0.19	-0.19	-0.28	1

Crisis II (9/1/2009 - 9/30/2009)

	β_{cp}	$\beta_{fl}(repo)$	$\beta_{fl}(libor)$	β_{mkt}	Collateral
β_{cp}	1	-	-	-	-
$\beta_{fl}(repo)$	0.42	1	-	-	-
$\beta_{fl}(libor)$	0.48	0.89	1	-	-
β_{mkt}	0.89	0.49	0.57	1	-
Collateral	-0.11	-0.07	-0.04	-0.16	1

Table 3
Cross-Sectional Regression of the CDS-Bond Basis on Risk Factors

This table shows the cross-sectional regression results of the CDS-Bond basis on the following variables:

$$Basis^i = \gamma_{cp}\beta^i_{cp} + \gamma_{fl}\beta^i_{fl} + \gamma_{mkt}\beta^i_{mkt} + \gamma_{col}\text{Collateral}^i + \gamma_{ind}\text{Industry}^{\ i} + \gamma\,\text{Sign}^i + \epsilon^i,$$

where

$$\beta^i_{fl_{repo}} = \frac{cov(\Delta CDS^i, \Delta RepoSpread)}{var(\Delta RepoSpread)},$$

$$\beta^i_{fl_{libor}} = \frac{cov(\Delta CDS^i, \Delta(libor - ois))}{var(\Delta(libor - ois))},$$

$$\beta^i_{cp} = \frac{cov(R^i, (R^{index} - R^{mkt})}{var(R^{index} - R^{mkt})},$$

$$\beta^i_{mkt} = \frac{cov(R^i, R^{mkt})}{var(R^{mkt})},$$

Collateral is an index measuring the collateral quality of each reference entity, composed of firm size, leverage, rating, tangible ratio, CDS level and CDS volatility. **Industry** is a dummy variable which equals to 1 if the reference entity has investment grade rating. The control variable **Sign** is a dummy variable which equals to 1 if basis is positive and 0 for negative basis. Panel A reports the result for the whole sample; Panel B - D presents the cross-sectional regression results for three phases: Phase 1 is the period before the subprime credit crisis, named "Before Crisis" (1/2/2006 - 6/30/2007), Phase 2 is the period between the subprime credit crisis and the bankruptcy of Lehman Brothers, called "Crisis I" (7/1/2007 - 8/31/2008), and Phase 3 is the period after Lehman Brothers' failure, "Crisis II" (9/1/2008 - 9/30/2009). The t-statistic is reported in the parentheses. $**$, $*$ respectively denote the statistical significance at the level of 1%, and 5%.

Panel A: Full Sample (1/2/2006 - 9/30/2009)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
γ_{cp}	-1.31**					-0.79**	-0.61**	-0.67**
	(0.29)					(0.29)	(0.17)	(0.17)
$\gamma_{fl_{repo}}$		-1.11**				0.38		1.30**
		(0.50)				(0.34)		(0.25)
$\gamma_{fl_{libor}}$			-1.33**				-0.83**	-0.81**
			(0.33)				(0.25)	(0.25)
γ_{mkt}				-0.94**		-0.25**	-0.10	-0.09
				(0.21)		(0.10)	(0.08)	(0.09)
$\gamma_{collateral}$					0.25**	0.18**	0.15**	0.15**
					(0.07)	(0.05)	(0.05)	(0.05)
Constant	3.69**	2.97**	3.12**	3.90**	2.54**	3.43**	3.32**	3.36**
	(0.39)	(0.38)	(0.36)	(0.43)	(0.39)	(0.41)	(0.42)	(0.41)
R^2_{adj}	0.30	0.29	0.30	0.27	0.26	0.35	0.35	0.35

Panel B: Before Crisis (1/2/2006 - 6/31/2007)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
γ_{cp}	-0.03					-0.05**	0.02	-0.03
	(0.02)					(0.02)	(0.02)	(0.02)
$\gamma_{fl_{repo}}$		1.46**				1.60**		1.78**
		(0.25)				(0.25)		(0.27)
$\gamma_{fl_{libor}}$			0.28**				0.34**	0.41**
			(0.06)				(0.06)	(0.06)
γ_{mkt}				-0.05		-0.07*	-0.07*	-0.06*
				(0.03)		(0.03)	(0.02)	(0.02)
$\gamma_{collateral}$					-0.05	-0.05	-0.05	-0.06
					(0.08)	(0.75)	(0.75)	(0.76)
Constant	1.82**	1.81**	1.77**	1.79**	1.56**	1.60**	1.58**	1.60**
	(0.15)	(0.14)	(0.15)	(0.18)	(0.15)	(0.21)	(0.22)	(0.22)
R^2_{adj}	0.32	0.33	0.32	0.32	0.31	0.31	0.30	0.31

Panel C: Crisis I (7/1/2007 - 8/31/2009)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
γ_{cp}	-0.43**					-0.49**	-0.36**	-0.41**
	(0.06)					(0.06)	(0.06)	(0.06)
$\gamma_{fl_{repo}}$		-0.22				1.40**		1.58**
		(0.39)				(0.30)		(0.31)
$\gamma_{fl_{libor}}$			-0.67**				-0.25*	-0.36**
			(0.11)				(0.13)	(0.13)
γ_{mkt}				-0.32**		-0.06*	-0.04	-0.04
				(0.06)		(0.06)	(0.07)	(0.07)
$\gamma_{collateral}$					0.04*	0.02	0.02	0.02
					(0.02)	(0.02)	(0.02)	(0.02)
Constant	2.65**	1.99**	1.99**	2.75**	1.95**	2.48**	2.44**	2.48**
	(0.29)	(0.19)	(0.19)	(0.35)	(0.18)	(0.25)	(0.25)	(0.25)
R^2_{adj}	0.24	0.32	0.32	0.22	0.37	0.38	0.38	0.38

Panel D: Crisis II (9/1/2008 - 9/30/2009)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
γ_{cp}	-4.06**					-2.15**	-1.75**	-1.82**
	(0.52)					(0.51)	(0.45)	(0.47)
$\gamma_{fl_{repo}}$		-5.65**				-2.41**		0.32
		(0.75)				(0.64)		(0.64)
$\gamma_{fl_{libor}}$			-4.28**				-3.09**	-3.01**
			(0.58)				(0.46)	(0.48)
γ_{mkt}				-2.86**		-0.73*	-0.22	-0.20
				(0.37)		(0.32)	(0.29)	(0.30)
$\gamma_{collateral}$					0.87**	0.68**	0.59**	0.60**
					(0.10)	(0.07)	(0.07)	(0.07)
Constant	5.90**	3.35**	3.25**	7.26**	2.79	6.28**	6.19**	6.20**
	(1.36)	(1.44)	(1.42)	(1.36)	(1.73)	(1.65)	(1.68)	(1.68)
R^2_{adj}	0.23	0.11	0.13	0.26	0.17	0.29	0.29	0.29