Dealer Liquidity Provision and the Breakdown of the Law of One Price: Evidence from the CDS–Bond Basis*

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Abstract

We examine dealers' liquidity provision against mispricing in the corporate bond market from 2005 to 2009. Dealers serve as stabilizing liquidity providers by trading against widening price gaps between corporate bonds and credit default swaps (the CDS–bond basis). At the same time, dealers provide less liquidity provision as they suffer losses, consistent with the limited balance sheet capacity of financial intermediaries. We also show that the unwinding of basis arbitrage trading can amplify mispricing by documenting that bond returns following the Lehman collapse were substantially low for bonds with strong pre-existing basis arbitrage activity and for bonds underwritten by Lehman Brothers. In summary, liquidity demand due to the exit of arbitrageurs can be a major driver of disruption in credit markets.

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1 Introduction

Trading in over-the-counter (OTC) markets relies on intermediation by dealers, who provide immediacy to their clients. They are expected to lean against the wind and trade against mispricing, especially during market disruptions (Weill 2007). At the same time, dealers are also highly levered financial institutions and are susceptible to funding conditions and capital constraints. Due to their limited capital capacity, dealers can turn into liquidity seekers and be forced to unwind their positions, especially when mispricing is large.[1] Although there is a growing body of literature studying how the limited capital of levered arbitrageurs (e.g., hedge funds and dealers) can amplify mispricing,[2] little is known about how dealers as opposed to other arbitrageurs trade during market disruptions.

In this paper, we examine dealer liquidity provision in the corporate bond market, one of the largest OTC markets in the U.S. We compare liquidity provision from the normal period through the various phases of the 2008 financial crisis, as they are characterized by the apparent breakdown of no arbitrage pricing and thus provide a nice setting in which to test liquidity provision. In particular, we utilize mispricing between corporate bonds and credit default swaps (CDSs), or the CDS–bond basis, which is the difference between CDS and corporate bond spreads. The purpose of this paper is twofold. First, we contribute large-scale documentation of dealer liquidity provision under mispricing. In this connection, we examine how widening price gaps and dealer capital losses affect liquidity provision, thus testing the implications of theories on destabilizing effects of arbitrageurs, as in Brunnermeier and Pedersen (2009) and Gromb and Vayanos (2010b). Second, we examine how liquidity demand arising from unwinding CDS–bond basis trades can exacerbate mispricing in corporate bonds. In particular, we focus on how the failure of a major market maker, Lehman Brothers, would interact with liquidity demand from unwinding basis trading. Thus, this paper also contributes to the literature on the breakdown of the law of one price in the credit markets (e.g., Duffie 2010 and Bai and Collin-Dufresne 2013).

Corporate bond trades around large negative basis swings provide a nice setting in which

[1] A few studies of the 2008 crisis provide anecdotal evidence on how levered dealers become liquidity seekers. See, e.g., Brunnermeier (2009) and Shleifer and Vishny (2011).

[2] In addition to the papers cited in footnote 1, see also Weill (2007), Kondor (2009), Lagos, Rocheteau, and Weill (2011), and He and Krishnamurthy (2012), among many others.

to investigate how various groups of levered arbitrageurs can become destabilizing liquidity seekers. In normal times, the CDS–bond basis should be close to zero due to no-arbitrage pricing (Duffie 1999). During periods of tight funding liquidity, however, the basis can become negative (i.e., through lower bond prices or wider credit spreads than CDSs), because levered investors find it costly to hold bonds due to their having higher margin requirements than CDSs (Gârleanu and Pedersen 2011). Some levered players will become liquidity seekers by liquidating corporate bond positions, which will amplify underpricing in corporate bonds.

We examine dealers' liquidity provision for the period from 2005 through 2009, focusing on how they trade as the CDS–bond basis widens. We construct dealer buys and sells from transaction-level datasets, the Trading Reporting and Compliance Engine (TRACE) for corporate bonds and the Depository Trust and Clearing Corporation (DTCC) for CDSs. In regressions of daily dealer net buys on basis changes, we find strong evidence indicating liquidity provision by corporate bond dealers. As bond prices decline relative to CDS pricing (and thus the basis becomes more negative), dealers buy more bonds and thus trade against widening price dislocations. Dealers provided liquidity even at the peak of the crisis, albeit to a lesser extent. These results are surprising in light of many narratives of the financial crisis that describe market disruptions potentially caused by the deleveraging and fire sales of highly levered financial institutions, including dealer banks (see, e.g., Brunnermeier 2009 and Shleifer and Vishny 2011).

Furthermore, dealers are stabilizing liquidity providers during our sample period, in the sense that they provide liquidity to a greater extent when bond prices are distressed relative to CDS spreads. In contrast, non-dealer traders are destabilizing liquidity seekers because they trade in the direction of widening price gaps. For example, the selling of bonds by non-dealer traders is associated with more distressed bond prices, especially when bonds are cheap relative to CDSs. Nonetheless, dealer trades did not trade aggressively to close price gaps; the basis remained substantially negative during the crisis. Also, using our inventory data, we find that dealer liquidity provision tends to fall off as they suffer losses on their positions, especially during the peak of the crisis, consistent with the limited balance sheet capacity of financial intermediaries.

We then examine the potential source of large liquidity demand associated with the large negative basis during the financial crisis. We focus on the unwinding of CDS–bond basis trades, or a "run for the exit", by non-dealer arbitrageurs and examine its impact on bond prices and liquidity.[3] In a so-called negative basis arbitrage trade, arbitrageurs buy relatively cheap bonds with leverage and hedge the long position with CDS contracts. Large funding liquidity shocks might trigger the simultaneous exits of arbitrageurs, causing massive liquidity demand in the corporate bond market. If that occurs, we should observe that liquidity demand and price declines are greater for bonds with active basis arbitrage activity.

We find evidence consistent with the run-for-the-exit hypothesis. Following the Lehman collapse, liquidity demand from non-dealer traders was particularly strong for bonds with traded CDSs compared with bonds without traded CDSs. Hedge funds substantially unwound their long CDS positions, whereas dealers increased their CDS positions, consistent with the unwinding of basis arbitrage trades by non-dealer arbitragers. More importantly, price declines following the Lehman collapse were much greater for bonds with traded CDSs. In particular, returns on such bonds were 7% lower in September 2008 than returns on bonds without CDSs. Moreover, bond prices fell more steeply when the basis was more negative and the maturities of the bonds were close to five years at the end of August 2008, the month before the Lehman Brothers collapse. Since five-year maturity CDS contracts are the most prevalent, if a bond's maturity was close to five years at the end of August 2008 and its basis was also large and negative, active basis arbitrage trading was more likely involved with the bond. We also employ a measure of basis arbitrage based on Oehmke and Zawadowski (2015, 2017) and find that prices fell more sharply for bonds with strong basis arbitrage activity.

Finally, we examine liquidity demand for bonds with Lehman Brothers as a lead underwriter to further investigate interactions between dealers and other arbitrageurs. As Dick-Nielsen, Feldhütter, and Lando (2012) note, lead underwriters are major market makers for the bonds that they underwrite. Thus, liquidity provision during the crisis to bonds underwritten by Lehman Brothers should have been much weaker due to deteriorated funding situations. Furthermore, these bonds were more likely to have been rehypothecated through

[3] Mitchell and Pulvino (2012) provide anecdotal evidence on how the deleveraging of highly levered financial institutions, i.e., both dealers and hedge funds, instigated by failure in the rehypothecation lending market could be a reason for the liquidity demand in the corporate bond market following the Lehman collapse.

Lehman and thus should have been under extreme liquidity demand, as outlined in Mitchell and Pulvino (2012). Indeed, we find that these bonds experienced greater price decreases following the Lehman collapse, particularly when the bonds also had CDSs available. Also, dealer liquidity provision to these bonds was much less robust around the Lehman collapse.

Note that our finding that dealers did not become liquidity seekers while non-dealer arbitrageurs destabilized the market might be specific to this crisis episode. However, we also point out the importance of distinguishing the roles taken by various groups of arbitrageurs, which has been largely overlooked in the literature. Theoretical studies showing the destabilizing effects of arbitrageurs typically consider only an aggregate group of homogeneous arbitrageurs. In such models, arbitrageurs collectively destabilize prices, while outside investors provide liquidity.[4] Likewise, many papers providing the narratives of the financial crisis also tend to bundle these separate groups of levered arbitrageurs into one pool. Our paper makes a subtle point that aggregating these various groups of levered players can blur an important picture and miss their complex interactions and relationships. Also, their incentives and economic roles differ from each other. Dealers place their reputations at stake as market makers. It is in their interest and can be also socially beneficial for them to lean against the wind during crises (Weill 2007).

We also contribute to the growing body of literature on OTC market dealers. For example, Goldstein and Hotchkiss (2015) document dealer behaviors in corporate bond markets and show that dealers actively manage inventory holding-period risk. Bessembinder, Jacobsen, Maxwell, and Venkataraman (2016) show that dealer capital commitment worsened in recent years due to post-crisis regulations. Han and Wang (2014) document liquidity provision by corporate bond dealers to defaulted bonds. For equity, a large body of literature documents liquidity provision by market makers. Comerton-Forde, Hendershott, Jones, Moulton, and Seasholes (2010) and Hameed, Kang, and Viswanathan (2010) document evidence consistent with dealers' funding liquidity risk. Aragon and Strahan (2012), Ben-David, Franzoni, and Moussawi (2012), and Franzoni and Plazzi (2013) document hedge funds' liquidity demand in equity during the financial crisis. Anand, Irvine, Puckett, and Venkataraman (2013) show that stocks traded by liquidity-demanding institutions suffer greater deterioration in liquidity

[4] See, for example, a survey of the literature by Gromb and Vayanos (2010a)

and resiliency. For corporate bonds, Ellul, Jotikasthira, and Lundblad (2011) and Manconi, Massa, and Yasuda (2012) document fire sales by insurance companies and mutual funds. Also, in the commodities literature, Cheng, Kirilenko, and Xiong (2015) discuss how financial traders (e.g., hedge funds and dealers) reduce long positions as prices fall.

Our paper also adds to the literature on limits to arbitrage in credit markets during the 2008 financial crisis. Bai and Collin-Dufresne (2013) document that a slew of factors capturing limits to arbitrage have explanatory power in the cross section, although it remains unclear what drove the basis into negative territory. Gârleanu and Pedersen (2011) show that lower margin requirements for CDSs can explain the negative CDS–bond basis. Our study differs from theirs insofar as we provide empirical evidence pertaining to whether dealers traded against the widening basis and provided liquidity.

Lastly, our paper adds to the literature on the real side impact of CDS markets. For example, Bolton and Oehmke (2011) and Subrahmanyam, Tang, and Wang (2014) show the implications of empty creditor problems. Saretto and Tookes (2013) show that firms have lower financing costs and can lengthen debt maturity when there are available CDS contracts. Das, Kalimipalli, and Nayak (2014) document that the corporate bond market becomes more inefficient once CDS trading commences. Oehmke and Zawadowski (2015) show theoretically that, during times of tough financing conditions for basis traders, the basis can turn significantly negative, consistent with our findings.

2 Data Description and Variable Construction

2.1 Corporate Bond and CDS Data

Corporate bond prices and trades are obtained from an enhanced version of the TRACE. The enhanced TRACE specifies whether a trade is carried out between two dealers or between a customer and a dealer.[5] The dataset also includes untruncated volumes, information previously not disseminated to the public. These enhanced features allow us to track dealer net buys. We apply the data clean-up filters in Dick-Nielsen (2009) to correct errors in the

[5]Under the Rule 6700 series, FINRA member firms have a trade-reporting obligation. If member firms are also registered broker-dealers, their trades are recorded as dealer trades in TRACE.

TRACE and construct daily bond prices by weighting each trade by its size after eliminating retail trades, following Bessembinder, Kahle, Maxwell, and Xu (2009), to minimize the effect of the large bid-ask bounce associated with small trades. We supplement the TRACE with the Mergent Fixed Income Securities Database (FISD), which provides information on bond characteristics.

We use CDS spreads from the Markit Group on the quoted modified restructuring clause, which minimizes the impact of the cheapest-to-deliver option and was the most commonly traded until mid-2009. We match each single-name CDS contract to bonds issued by the same reference entities. Bonds issued by subsidiaries are matched to their own CDS contracts if available. If not, we match to CDS contracts of the parent company.[6]

Traded volumes of CDSs are obtained from a unique dataset provided by the DTCC. It contains all CDS transactions registered with the automated Trade Information Warehouse of the DTCC for 35 financial firms as reference entities.[7] Each CDS transaction record in the DTCC data contains information on reference entities, trade dates, maturities, buyer and seller types, notional amounts, and transaction types. The transaction types record whether a trade is a new trade or an assignment or termination of an existing trade.[8] We provide a detailed description of the database in Appendix A.

We obtain our main sample, which runs from March 2005 through June 2009, by merging the aforementioned data sets. The main sample includes 2,793 bond issues and 237,950 bond-day observations. The subsample of firms for which we also have CDS net order flows data is referred to as the financial sample and includes 1,465 bond issues and 99,036 bond-day observations. Our sample covers approximately 60% of straight bonds in the TRACE universe in terms of total bond amounts outstanding and is skewed towards relatively larger bonds.

[6]In unreported robustness checks, we replicate all our main results without matching subsidiaries to parent companies. The results are almost identical.

[7]According to weekly DTCC Trade Information Warehouse Reports, financial firms account for about 27% of the outstanding gross notional amount as of October 2008.

[8]In an assignment (or novation) of an existing trade, an original party in an existing CDS contract transfers its rights and obligations to a new party. All parties in the existing and new contracts should agree to the terms of the transfer.

2.2 Net Flows and Inventories

We construct dealers' net buys of corporate bond i on day t as:

$$q(\text{Bond}, i, t) := \sum_{n=1}^{N_t} (\text{Buy}(\text{Bond}, i, n) - \text{Sell}(\text{Bond}, i, n)) \tag{1}$$

where the buys and sells are defined from the dealers' perspective and N_t is the total number of transactions for the bond on day t. Using the daily net buys, we construct dealers' inventories of bond i as: $I(\text{Bond}, i, t) := I(\text{Bond}, i, 0) + \sum_{\tau=1}^{t} q(\text{Bond}, i, \tau)$ where $I(\text{Bond}, i, 0)$ is the initial inventory of bond i before the existence of the TRACE system. Since the initial inventory is unobservable in the TRACE, we use a demeaned version of the variable.

Similarly, for the financial sample we calculate the CDS net order flows of dealers as

$$q(\text{CDS}, i, t) := \sum_{n=1}^{N_t} (\text{Buy}(\text{CDS}, i, n) - \text{Sell}(\text{CDS}, i, n)) \,. \tag{2}$$

2.3 Calculation of the CDS–bond Basis

The CDS–bond basis is defined as the difference between the CDS spread, CDS(t), and the bond credit spread, CS(t): basis(t) = CDS(t) − CS(t). In a frictionless market, the basis between the CDS spread and the bond credit spread over the LIBOR of the same maturity floating rate bond should be zero due to no-arbitrage pricing (Duffie 1999). In normal times, the basis tends to be close to zero or slightly positive because of difficulty in short-selling corporate bonds (Blanco, Brennan, and Marsh 2005). However, under tight funding liquidity circumstances corporate bonds are underpriced and the basis becomes negative, because investors find it costly to hold corporate bonds because bond positions have higher funding costs than derivatives positions (Gârleanu and Pedersen 2011).

We calculate the basis by following the par-equivalent CDS spread (PECS) methodology of J. P. Morgan (Elizalde, Doctor, and Saltuk 2009), used also in other studies (e.g., Bai and Collin-Dufresne 2013). As mentioned in Elizalde et al. (2009), the PECS methodology produces a bond credit spread measure that is consistent with both the recovery rate and the term structure of default probabilities implied by the CDS market. To calculate the PECS, we apply a parallel shift of the term structure of survival probabilities extracted from CDS contracts to match the observed bond price with the present value of the bond's cash flows. We use swap rates as risk-free rates and assume a recovery rate of 40%. Once we match the bond price, we use the shifted survival probabilities to calculate implied CDS spreads, i.e., the PECS. Appendix B details the procedure of the PECS calculation.

We exclude from the basis calculation bonds with embedded options or special pricing conditions, such as convertible, callable, or puttable bonds, and bonds with sinking-fund provisions. Since we calculate the basis for the most liquid five-year CDS contract, we include only bonds with 3-10 years remaining until maturity. In Figure 1, we plot the time series of the average basis for AAA and non-AAA bonds. Consistent with stylized facts reported in other papers (e.g., Fontana 2011, Augustin 2012, and Bai and Collin-Dufresne 2013), we find that the basis became significantly negative for non-AAA bonds. For AAA bonds, the basis became highly positive, suggesting potential flight-to-quality behavior among those holding these bonds.

3 Dealers' Aggregate Corporate Bond Holdings

Dealers accumulated highly levered positions during the credit boom and subsequently delevered over the course of the financial crisis. Anecdotes claim that this deleveraging by dealers is the main driver of significant underpricing in corporate bond markets following the Lehman collapse,[9] which is frequently supported using data on the aggregate holdings of dealers published by the Federal Reserve Bank of New York, which we reproduce in Figure 2 (dotted line). However, these holdings data also include bonds issued by non-federal agencies (e.g., GSEs) and thus disguise the distinct trend in corporate bond holdings by dealers.[10]

[9] See, for example, Mitchell and Pulvino (2012), Singh and Aitken (2009), "The basis monster that ate Wall Street" (D.E. Shaw 2009), "Dealers Slash Bond Holdings as Conviction in Rally Wanes: Credit Markets" (*Bloomberg*, July 15, 2010), and "Slimmer bond inventories as dealers reduce risk" (*Financial Times*, November 8, 2011).

[10] The Federal Reserve Bank of New York began collecting primary dealers' holdings of corporate bonds as a separate asset class only after April 3, 2013. Thus, the data from the Federal Reserve Bank do not provide dealers' exact corporate bond holdings because the Fed extrapolates corporate bond positions for the period leading up to April 3, 2013 using the composition of corporate bond holdings on that date.

Using our data, Figure 2 plots dealers' corporate bond positions separately from their positions in other fixed-income securities. Two stylized facts emerge from the figure. First, dealers' corporate bond holdings increase substantially, by more than \$40 billion, up to mid-2007. The long rise in holdings is often attributed to the expansion of balance sheets during the credit boom, driven by low interest rates and volatility, ample liquidity in the markets, and regulatory arbitrage by financial institutions, among many other factors.[11]

Second, after the summer of 2007 both corporate bond holdings (the solid line) and aggregate bond holdings (the dotted line) decline. Around the Bear Stearns collapse, however, the two lines diverge. Aggregate holdings continue to decline, while corporate bond holdings mostly flatten. After the Lehman collapse, corporate bond positions increase until the end of 2008. During this period, from the Lehman collapse through the end of 2008, the negative basis was the most severe for non-AAA bonds, as plotted in Figure 1. Dealers were buying bonds when bond prices were the most distressed, as indicated by the negative basis.

The increase in dealers' inventories following the Lehman collapse is not entirely surprising in light of anecdotal evidence, despite some crisis narratives that describe it otherwise, as in Shleifer and Vishny (2011). For example, many hedge funds were forced to sell their assets to meet margin calls from prime brokers, who in turn had to return cash to rehypothecation lenders (Aragon and Strahan 2012, and Mitchell and Pulvino 2012). Hedge funds then sold to their usual trading counterparties, i.e., dealers. In some extreme cases, hedge funds' collateral was even seized by dealers. Dealers could have unloaded these cash bonds to other investors, but they chose to keep them on their books.[12] In addition, although many dealers suffered from funding problems at the time of the Lehman collapse, they were soon able to increase their inventories thanks to the liquidity backstops provided by the Treasury and the Federal

[11] In 2004, the SEC loosened the minimum net capital requirement for big investment banks (the so-called Consolidated Supervised Entities). This amendment enabled large dealer banks to increase their leverage substantially and, in particular, to expand cash bond positions during the credit boom period. See, for example, "Agency's '04 Rule Let Banks Pile Up New Debt," *New York Times*, October 2, 2008.

[12] It is not likely that the increase in dealers' inventories was driven by the Lehman bankruptcy estate's seizing of hedge fund clients' collateral (i.e., corporate bonds). Lehman's brokerage unit became functional only days after the bankruptcy filing thanks to the Fed's liquidity facilities and advances by Barclays and thus was able to sell corporate bonds (Fleming and Sarkar 2014). In addition, most of clients' assets posted to Lehman's prime brokerage (Lehman Brothers Inc.) were transferred to Lehman Brothers International (Europe) according to the margin- and securities-lending agreements with Lehman Brothers Inc. These assets were taken mostly by rehypothecation lenders and thus are recorded as sales from dealers in the TRACE. See, for example, "Trends in Prime Brokerage," April 2010, Practical Law Company.

Reserve.

4 Documenting Dealers' Liquidity Provision

In studies that describe the destabilizing behaviors of arbitrageurs (e.g., Gromb and Vayanos 2002 and Brunnermeier and Pedersen 2009), liquidity providers are arbitrageurs who trade against price dislocations. Liquidity demanders, on the other hand, trade for liquidity reasons and move prices in the direction of their trades.[13] In this section, we formally examine dealer liquidity provision and test whether dealers are destabilizing during our sample period.

4.1 Baseline Regression

4.1.1 Specification

In the baseline model we regress daily net buys of dealers on daily basis changes:

$$\begin{aligned} q(\text{Bond}, t) &= c_1 + \beta_1 \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{1t} && (3)\\ &= c_1 + \beta_1 \left(\Delta p(\text{CDS}, t) - \Delta p(\text{Bond}, t)\right) + \text{ctrls} + \varepsilon_{1t} \\ q(\text{CDS}, t) &= c_2 + \beta_2 \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{2t} && (4)\\ &= c_2 + \beta_2 \left(\Delta p(\text{CDS}, t) - \Delta p(\text{Bond}, t)\right) + \text{ctrls} + \varepsilon_{2t} \end{aligned}$$

where $q(\text{Bond}, t)$ is dealers' corporate bond net order flow (buys minus sells) and $q(\text{CDS}, t)$ is dealers' net order flow in CDSs. For easier interpretation of economic magnitude, both $q(\text{Bond}, t)$ and $q(\text{CDS}, t)$ are normalized using their sample standard deviations. The basis, $basis(t)$, is the difference between the CDS spread, $p(\text{CDS}, t)$, and the PECS, $p(\text{Bond}, t)$. As control variables, we include changes in VIX, LIBOR-OIS spreads, and aggregate returns on primary dealers, because dealers' trading motives can depend on aggregate uncertainty, funding conditions, and dealers' financial soundness (i.e., counterparty risk).[14] We also include a lagged basis and its change. If bond or CDS prices deviate from each other and the basis

[13] Keim and Madhavan (1997), Campbell, Ramadorai, and Schwartz (2009), Puckett and Yan (2011), and Franzoni and Plazzi (2013) also employ a similar notion for liquidity provision.

[14] The aggregate returns on primary dealers are constructed following Bai and Collin-Dufresne (2013). Specifically, we use value-weighted daily stock returns of primary dealers designated by the Federal Reserve Bank of New York.

widens, there could be order flows coming from convergence trading (Blanco et al., 2005). The lagged basis will capture this effect.

Negative values of β_1 and β_2 imply that dealers trade against price deviations, indicating liquidity provision. When β_1 is negative in (3), for example, dealers' buys are associated with negative changes in the basis, which in turn means that dealers buy bonds when bond spreads increase (or bond prices decrease) relative to CDS spreads. Similarly, a negative β_2 in (4) implies that dealers buy when CDS spreads narrow relative to bonds, also signaling that dealers trade against price deviations.

Using the CDS–bond basis has advantages over using bond or CDS spreads alone, since the basis is a cleaner measure of price deviation from fundamentals, driven mostly by liquidity demand in tight funding situations. In particular, during the crisis, funding costs in bonds became notably higher than derivatives (Gârleanu and Pedersen 2011 and Shen, Yan, and Zhang 2014), which led to forced unloading by levered arbitrageurs. Thus, examining dealer trades given basis changes is particularly informative about liquidity provision for corporate bond markets. Also, using basis changes enables us to test whether dealer trades are destabilizing by exacerbating relative mispricing, as in Section 4.2.

As a robustness check, we also use as independent variables bond spread changes alone or both bond and CDS spread changes instead of basis changes. Using these spread changes addresses the concern that the basis might change due to counterparty risk in CDSs (i.e., the basis becomes negative if counterparty risk rises) or arbitrage frictions (i.e., Nashikkar, Subrahmanyam, and Mahanti 2011) rather than due to relative mispricing.[15] Note also that our regression shows correlations and does not identify a causal relationship. However, our analysis still has advantages by exploiting changes in the basis, which supposedly is a clear measure of mispricing due to liquidity selling, and also by using detailed data on dealer inventories and trading and, thus, enabling us to provide wide-scale documentation of dealer liquidity provision.

We divide the sample period into normal (pre-crisis) and crisis periods. *Pre-crisis* covers

[15] In results reported later, coefficient estimates from this robustness check are quite similar to those from the main regressions. This result is consistent with that of Du, Gadgil, Gordy, and Vega 2016, who show that counterparty risk did not significantly affect CDS pricing during the financial crisis.

from March 2005 through June 2007 and *CrisisAll* covers the period from July 2007 through June 2009. We further divide the *CrisisAll* period into three sub-periods. The first sub-period, *Crisis 1*, runs from July 1, 2007 through September 14, 2008. The second sub-period, *Crisis 2*, begins on September 15, 2008 (the Lehman collapse) and runs through January 2009, during which period the basis was the most negative. The third, *Crisis 3*, is the recovery period, running from February 2009 through June 2009. Table 1 provides the summary statistics of bond and CDS trades for which we have basis data available. On average, bond dealer buys are \$2-\$8 million per bond each day. Corporate bond dealers tended to sell more in periods other than *Crisis 2*. However, during the *Crisis 2* period, buy quantities in non-AAA bonds are greater than sell quantities, indicating that bond dealers tended to be net buyers during the post-Lehman period.

4.1.2 Baseline Regression Results

Table 2 reports regression results from Equations (3) and (4). The results show liquidity provision by bond dealers for both the normal and crisis periods. Panel A reports the results for *Pre-crisis*. In Column (1) in which we regress bond dealer net buys $q(\text{Bond})$ on bond price changes (i.e., the negative of bond spread changes $-\Delta p(\text{Bond}, t)$), the coefficient estimate is negative (–0.401) and statistically significant at the 1% level. However, this result does not necessarily mean that dealers trade against mispricing. To examine whether this is the case, we include CDS spread changes as an additional explanatory variable in Column (2). The coefficient estimates on $-\Delta p(\text{Bond}, t)$ and $\Delta p(\text{CDS}, t)$ are similar in magnitude and are both statistically significant, suggesting that bond dealers actually trade against relative mispricing. In Column (3), we thus employ basis changes, $\Delta\text{basis}(t)$, and the coefficient estimate is similar to those in Column (2).

During *CrisisAll*, reported in Columns (7) through (12), we find similar results, although the magnitudes of coefficient estimates on price changes are much smaller. Thus, bond dealers provided liquidity even during the crisis, albeit to a lesser extent compared with the pre-crisis period. During *CrisisAll*, for example, a one-standard-deviation change in the basis change (0.94%) is associated with 6.9% of a one-standard-deviation change in net order flows, whereas during *Pre-crisis*, a one-standard-deviation change in the basis change (0.20%) is associated with 8.3% of a one-standard-deviation change in net order flows. In contrast to the bond market results, we find no indication that CDS dealers trade against basis changes when we examine dealers' CDS net order flows for the financial sample. Although we find negative estimates on the spread changes during *CrisisAll*, they are statistically insignificant.

In Panel B of Table 2, we further examine dealer liquidity provision for the three sub-periods of the financial crisis. Consistent with the results shown in Panel A of Table 2, we find that bond dealer net buys are always negatively associated with basis changes in each sub-period. These results show that dealers trade against mispricing, although liquidity provision fades in *Crisis 2* and *Crisis 3*. The coefficient estimates on the basis changes are highly statistically significant and their economic magnitudes are also sizable. During *Crisis 1*, for example, a one-standard-deviation change in the basis change (0.94%) is associated with 14% of a one-standard-deviation change in net order flows. Thus, bond dealers serve as liquidity providers when bond prices deviate from CDS pricings. The flip side of this result is that non-dealers were driving prices away, or widening the basis. In unreported robustness checks, we estimate (3) and (4) using the TRACE universe and also using weekly data instead of daily data. The results are qualitatively similar to those shown in Table 2. In summary, although liquidity provision fell off during the peak of the financial crisis, our results show evidence of liquidity provision by bond dealers throughout our sample period.

4.2 Stabilizing vs. Destabilizing Liquidity-Seeking

Depending on the sign of the basis, liquidity-seeking does not necessarily widen the bond-CDS price gaps. For example, when the basis is negative (bond prices are relatively distressed), liquidity-seeking buys in bonds will drive bond prices up, which can be viewed as stabilizing liquidity-seeking, in the sense that these trades narrow the CDS–bond basis. In contrast, if traders sell bonds and drive bond prices down further when the basis is negative, this liquidity demand can be seen as destabilizing, because it exacerbates price gaps. Since dealers are typically highly leveraged institutions relying on short-term funding, we cannot rule out the possibility that they were engaged in destabilizing liquidity-seeking and thereby drove the basis deeper into negative territory.

To investigate this possibility, we divide the sample into positive and negative basis cases and examine how increases and decreases in the basis are associated with dealer trading. Specifically, we run the following regressions separately for subsamples in which the lagged basis, basis$(t-1)$, is positive and negative:

$$q(\text{Bond}, t) = c_1 + \beta_1 \Delta\text{basis}(t) \cdot Inc + \beta_2 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{1t} \tag{5}$$

$$q(\text{CDS}, t) = c_2 + \beta_3 \Delta\text{basis}(t) \cdot Inc + \beta_4 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{2t} \tag{6}$$

where $Inc(\equiv 1_{\Delta\text{basis}(t)\geq 0})$ is an indicator variable that takes the value of one if the basis change is positive. $Dec(\equiv 1_{\Delta\text{basis}(t)<0})$ is defined similarly when the basis change is negative.

When the lagged basis is positive, positive coefficients on basis increases ($\Delta\text{basis}(t) \cdot Inc$) imply destabilizing liquidity-seeking, because dealers make the basis more positive (the basis widens). If these coefficients are negative, dealers are trading against destabilizing liquidity seekers. On the other hand, positive coefficients on basis decreases ($\Delta\text{basis}(t) \cdot Dec$) indicate stabilizing liquidity-seeking, because these trades tend to narrow the basis. Interpretation of the coefficients is similar when the lagged basis is negative. In this case, positive coefficients on basis decreases indicate destabilizing liquidity-seeking that makes the basis more negative, while positive coefficients on basis increases indicate stabilizing liquidity-seeking.

Table 3 provides the results of regressions (5) and (6). Panel A shows that we find no evidence that dealers are engaged in destabilizing liquidity-seeking in the bond market either in *Pre-crisis* or *CrisisAll*. Rather, dealers trade against destabilizing liquidity seekers. In cases where the basis further widens (see the cells in boldface), the coefficient estimates are mostly negative. When the lagged basis is negative in *CrisisAll*, for example, the coefficient on $\Delta\text{basis}(t) \cdot Dec$ is –0.08 and highly statistically significant, which reveals bond dealers' liquidity provision given further deterioration in the basis. In Panel B, we further test for destabilizing liquidity-seeking for the three sub-phases of the crisis. Even during the peak of the crisis (i.e., *Crisis 2*), the coefficient estimate on $\Delta\text{basis}(t) \cdot Dec$ is –0.07 with a t-statistic of –4.87. In other words, when bond prices were severely distressed following the Lehman collapse, clients dumped corporate bonds and drove the basis even farther into negative territory, while dealers tended to stabilize the market by trading against them.

In the CDS market, we find some evidence of liquidity-seeking by dealers. When the lagged basis is negative during *CrisisAll* in Panel A, CDS dealers tend to buy, given an increase in the basis (see the positive coefficients on $\Delta\text{basis}(t) \cdot Inc$). However, this result indicates stabilizing liquidity-seeking by dealers, because such CDS buys narrow the basis. We find destabilizing liquidity-seeking in the *Crisis 3* period (shown in Panel B) when the lagged basis is negative, when CDS dealers' sells could exacerbate the negative basis. Although there is some evidence of destabilizing liquidity-seeking by CDS dealers, the results show that dealers were, overall, stabilizing liquidity providers, especially in corporate bond markets.

4.3 Losses on Inventories and Liquidity Provision

Continued sell-offs in the bond market and a resulting widening negative basis together imply that liquidity-providing dealers can suffer losses in their positions. Their capital capacity will be reduced and they might even turn to seeking liquidity, risking consequences similar to the destabilizing effects of capital-constrained arbitrageurs. Indeed, Comerton-Forde et al. (2010) and Hameed et al. (2010) show that stock market liquidity worsens after large market declines or when market makers suffer losses to their inventories.

Exploiting our data on inventories, we examine the extent to which losses to dealer positions affect liquidity provision. In particular, we interact a change in the basis with a lagged loss on dealers' current positions:

$$q(\text{Bond}, t) = c_1 + (\beta_1 + \beta_2 \cdot Loss_{t-1})\, \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{1t} \tag{7}$$

where the bond dealer loss at time t, $Loss_t$, is defined as a change in the basis, $\Delta\text{basis}(t)$, times bond inventories $I(Bond, t-1)$ times the duration of the bond D_{t-1}: $Loss_t \equiv \Delta\text{basis}(t) \cdot I(Bond, t-1) \cdot D_{t-1}$. Thus, $Loss_t$ is a proxy for a one-day loss for a dealer whose bond position is hedged with CDS contracts. We assume a hedged position to isolate the effect of relative price changes in corporate bonds.[16] We define a loss measure for CDS dealers in a similar fashion: $-\Delta\text{basis}(t) \cdot I(CDS, t-1) \cdot D_{t-1}$ where $I(CDS, t-1)$ is the inventory of

[16] The results are largely similar without the CDS hedging assumption.

CDS dealers.

The results are provided in Table 4. During the normal period (*Pre-crisis* in Panel A), the coefficient estimate on $\Delta\text{basis}(t) \cdot Loss_{t-1}$ is positive but not statistically significant at conventional levels. In *CrisisAll*, however, we find a positive coefficient (0.02) on $\Delta\text{basis}(t) \cdot Loss_{t-1}$ with a t-statistic of 3.37 for bond dealers, showing a more reliable result indicating that dealer liquidity provision falls after losses during the crisis. In Panel B, we further examine the sub-periods of the crisis. Dealer losses weaken liquidity provision particularly after the Lehman collapse (*Crisis 2*). The coefficient on $\Delta\text{basis}(t) \cdot Loss_{t-1}$ is 0.04 for bond dealers in *Crisis 2*, which is positive and strongly statistically significant. However, this result does not necessarily imply that bond dealers become liquidity seekers and exacerbate bond underpricing. A one-standard-deviation change in $Loss_{t-1}$ is approximately 0.14 during *Crisis 2* and thus the overall coefficient of the change in the basis, $((-0.05+0.04 \cdot Loss_{t-1}))$, is negative unless the loss on dealers is huge, i.e., as large as a nine-standard-deviation change. This observation applies also to bond dealers during *Crisis 3*. Interestingly, the coefficients on the interaction term $\Delta\text{basis}(t) \cdot Loss_{t-1}$ are not statistically significant during *Crisis 1*, indicating that before the Lehman collapse dealers' balance sheet capacity was not a serious concern. Overall, the results in Table 4 suggest that corporate bond dealers tended to provide liquidity, albeit to a lesser extent after they suffered losses on their inventory positions.

4.4 Graphical Illustration of Dealer Liquidity Provision Using Nonparametric Regressions

Figure 3 plots fitted graphs of nonparametric regressions of dealer daily net buys of bonds against daily changes in the basis. We utilize kernel-weighted local polynomial smoothing as a method for carrying out nonparametric regressions. (see, e.g., Fan 1992 and Fan and Gijbels 1996)

Panel A of Figure 3 plots dealer net buys against basis changes in *Pre-crisis*. Basis changes during this period are relatively small, all within the –1.5%-to-1.5% range. Also, the slope is negative and steep for small basis changes (running approximately from –0.2% through 1%), showing strong liquidity provision from the dealer side. Although we find much flatter lines for larger basis changes, the flatter tails are relatively short and limited.

Panel B of Figure 3 plots dealer net buys against basis changes in *CrisisAll*. Compared with the *Pre-crisis* period, basis changes in *CrisisAll* are much larger, mostly ranging between –7% and 7%, showing greater volatilities in this period. Also, although we find a negative slope for relatively small basis changes (e.g., less than 1% in magnitude), it is much less pronounced than in the *Pre-crisis* period. Thus, dealers did not trade as aggressively given basis changes (i.e., there was less robust liquidity provision by dealers). More interestingly, liquidity provision becomes almost nonexistent for large basis changes, i.e., the tails are much longer and noisier. Specifically, the fitted line almost flattens out beyond the 1% basis bounds. These graphs show that liquidity provision declined during the crisis periods, especially after large basis changes, consistent with our results provided in previous sections.

4.5 Linking Evidence to Theory

Although dealers provided liquidity against mispricing in our sample period, they did not appear to trade aggressively; large price gaps persisted. These facts might seem puzzling, but they are consistent with optimal liquidity provision under limited capital supply, as shown theoretically by Weill (2007) and Lagos et al. (2011). According to Weill (2007), socially optimal asset allocation implies that dealers start providing liquidity only after prices fall substantially, because forcing dealers to hold assets too long is costly. Lagos et al. (2011) predict that dealers will start unloading inventories as a recovery from mispricing begins, instead of continuing to increase inventories until mispricing disappears. Thus mispricing can widen even when dealers provide liquidity.

On a similar note, Kondor (2009) shows that optimal allocation of capital by arbitrageurs can increase mispricing. Since mispricing can widen and provide a better investment opportunity in the future, dealers do not invest all the way in the current period even without binding capital constraints. In this sense, the widening of the basis can imply that dealers are actively trading against mispricing (and providing liquidity). In summary, in the aforementioned models the basis, or mispricing in general, widens not because arbitrageurs amplify mispricing but because they are actively trading against it.

5 Liquidity-Seeking from Unwinding Basis Arbitrage

The results reported thus far show substantial liquidity demand coming from non-dealer traders. Still, these results do not tell us what drove the large negative basis and the apparent breakdown of the law of one price. Several studies have tackled this question, e.g., Gârleanu and Pedersen (2011) and Bai and Collin-Dufresne (2013). Although their conclusions differ, the common theme is that many factors, including funding costs and trading liquidity, matter but also fail to explain the basis completely.

In this section, we reveal a channel that can help explain the large negative basis during the financial crisis. We focus on the unwinding of negative CDS–bond basis trades, or the run for the exit by highly levered non-dealer arbitrageurs. In negative basis trades, arbitrageurs buy distressed bonds, hedge the associated default risk with long-position CDS contracts, and make profits when the basis narrows. Given the large funding liquidity shock at the time of the Lehman collapse, these basis arbitrageurs had to liquidate their positions (i.e., sell bonds and unwind CDS positions) and thus became destabilizing liquidity seekers.

We test the following two implications of the run-for-the-exit story. First, liquidity demand from non-dealers is concentrated in bonds with available CDSs. For these bonds, basis arbitrageurs unwind corporate bond positions following the Lehman collapse and dealers provide liquidity by buying the bonds dumped by these basis arbitrageurs. In contrast, bonds without CDSs did not experience strong liquidity demand. Second, after the Lehman collapse the data should show lower prices for bonds with active pre-existing basis arbitrage trades.

5.1 Dealer Inventories of Bonds with and without CDSs

Figure 4 plots dealers' inventories of bonds with and without CDSs. It clearly indicates that dealers increased inventories only for bonds with CDSs after the Lehman collapse, which in turn means that clients sold such bonds. This pattern is consistent with the hypothesis that substantial liquidity demand associated with the widening negative basis resulted from the unwinding of the basis trades undertaken by non-dealer arbitrageurs.

In Figure 5, we plot mutual funds' holdings of corporate bonds, as provided by the Morningstar database. Specifically, we compare their holdings of bonds with available CDSs with those without. Mutual funds did not significantly change their holdings of bonds with CDS contracts.[17] Rather, they sold non-CDS bonds, leading to the conclusion that mutual funds are unlikely to have driven the negative basis following the Lehman collapse.

Figures 4 and 5 suggest that bonds with CDSs were sold in great volumes after the Lehman collapse by non-dealers other than mutual funds. The results reported in Appendix C also show that insurance companies were not the main liquidity seekers. Who, then, were those liquidity-demanding investors? We conjecture that they were basis arbitrageurs, who are typically hedge funds or proprietary traders in investment banks. Our measures for dealer trades from the TRACE include trades made by proprietary trading desks in investment banks and the granularity of our data does not allow us to separate these proprietary trading desks from their bank entities.[18] While there is anecdotal evidence that some proprietary trading desks unwound their positions and became liquidity seekers,[19] dealers in aggregate provided liquidity, as shown by our results, leaving hedge funds as the most likely liquidity demander group. Aragon and Strahan (2012) and Mitchell and Pulvino (2012) demonstrate in greater detail how hedge funds became liquidity demanders after the failure of the rehypothecation market following the Lehman collapse.

Another piece of evidence pointing to non-dealer arbitrageurs is indicated by Figure 6, which plots aggregate positions in CDSs held by dealers, hedge funds, and insurance companies, using the financial sample. The CDS positions of hedge funds are almost the mirror image of those of dealers, indicating that hedge funds are the major counterparty to dealers. More importantly, hedge funds' CDS positions decline significantly after the Lehman Brothers collapse. Although it is based on the financial company sample, this result also suggests that hedge funds substantially unwound negative basis trades.

[17] This result is consistent with Massa and Zhang (2012). They argue that CDSs provide hedging values and reduce fire sale pressure for insurance companies and mutual funds who are long-only investors, unlike dealers or hedge funds.

[18] Although investment management companies that are subsidiaries of FINRA member firms are subject to the dual reporting obligation under Rule 6700, their trades are not recorded as dealer trades if the companies are not registered dealers. See http://www.finra.org/Industry/Compliance/MarketTransparency/TRACE/FAQ.

[19] For example, the Saba Principal Strategies of Deutsche Bank reportedly lost $1.8 billion in total from various credit strategies (e.g., capital structure arbitrage, basis arbitrage, and so on). See https://www.wsj.com/articles/SB123387976335254731.

5.2 The Impact of Unwinding Basis Trades on Bond Returns

According to our hypothesis that the unwinding of the basis arbitrage drove the negative basis, we should find steeper price declines following the Lehman collapse for bonds with strong basis arbitrage trading. We first plot cumulative returns through 2008 for bonds with CDSs versus those without.[20] Figure 7 shows that, consistent with our hypothesis, decline in bond prices is much more severe for bonds with CDSs, by almost 5%. Around the end of January 2009, their prices rebound, and the recovery is also stronger.

To test the hypothesis more formally, we run the following regression in Table 5:

$$R_{t+1} \quad = \quad c_1 + \beta_1 \mathrm{CDS}^{\mathrm{YES}} + \beta_2 \mathrm{BasisArb}_t + \mathrm{ctrls} + \varepsilon_{t+1} \tag{8}$$

where R_{t+1} is monthly bond returns constructed from the TRACE; $\mathrm{CDS}^{\mathrm{YES}}$ is a dummy variable that equals one if the bond has a CDS contract with a quote in Markit from January 2002 to August 2008 and zero otherwise; and BasisArb is a measure of CDS–bond arbitrage activity.

We employ two measures for basis arbitrage activity. The first, BasisArb1, is defined as the negative of the basis level at the end of August 2008, −basis(Aug), times an indicator variable, Mat5Y(Aug), which takes the value of one if the bond's maturity at the end of August 2008 is in the range of 4.5 to 5.5 years and zero otherwise. This measure is a proxy for basis trading activity at the end of August 2008, the month before the Lehman collapse. CDS contracts with five-year maturity are the most prevalent. If the bond maturity is close to five years in August 2008 and the bond's basis is also large and negative, it is more likely that active basis arbitrage trading was involved with the bond. We attach the negative sign to the product term to interpret coefficients more intuitively.

The second measure for basis arbitrage, BasisArb2, is based on Oehmke and Zawadowski (2015, 2017). Specifically, Oehmke and Zawadowski (2017) show that the size of basis trading is proportional to the product of the magnitude of the negative basis and the strength of basis arbitrage trading given a negative basis, which is negatively related with bond issue frag-

[20] Our measure of CDS availability is based on Saretto and Tookes (2013), who assume that a CDS exists if they find a quote in Bloomberg.

mentation, the roundtrip trading cost of a bond, the TED spread, and disagreement between analyst earnings forecasts, by testing the model implications of Oehmke and Zawadowski (2015). We compute BasisArb2 as a bond-level measure of basis arbitrage activity, using the regression coefficients in Oehmke and Zawadowski (2017).[21] Due to the availability of the analysis disagreement measure, we have the smaller number of observations for BasisArb2.

We control for various liquidity and credit-risk variables in (8). Bond-specific controls include the illiquidity measures of Amihud (2002) and Bao, Pan, and Wang (2011), time to maturity, and rating dummy variables.[22] Firm-specific controls include market leverage and monthly stock volatility. Since firm-specific variables are available only for public firms, the sample shrinks when we include them.[23] We also control for the VIX to capture market-wide uncertainty. We run the regression for the period spanning from September 2008 through December 2008, since that was when bond prices experienced the heaviest selling pressure.

Table 5 details the regression results. Panel A shows that bonds with CDS contracts experience much lower returns than bonds without, consistent with our hypothesis. Specifically, the coefficient on CDS^{YES} in the first column is –0.02, which is statistically significant at the 5% confidence level, showing that bond returns are 2% lower per month for the period of September 2008 through December 2008. The result is robust to adding the control variables in the fourth and fifth columns.

Furthermore, bond returns are negatively related with our measures of basis arbitrage activity. For example, we find negative coefficients for BasisArb1 in Panel A, although they becomes statistically insignificant when we control for firm-level variables in the fifth column. Also, we find negative coefficients for BasisArb2, which are statistically significant at the 1% confidence level in all specifications. Thus, bond returns are lower if amounts of negative basis trading in the previous month are larger. The economic magnitude of estimates is also sizable. In Column (3), for example, given a one-standard-deviation increase in BasisArb2

[21] Specifically, we calculate $\text{BasisArb2}_t \equiv (0.267 - 0.084 \cdot TED_t - 0.158 \cdot Fragmentation_t - 0.0729 \cdot Roundtrip_t - 0.721 \cdot Disagreement_t) \cdot |\text{basis}(t) \cdot 1_{\text{basis}(t)<0}|$ where TED is the TED spread; $Fragmentation$ is negative log(*issuer bond Herfindahl*) orthogonalized with respect to log(*bond amounts*) where *issuer bond Herfindahl* is the Herfindahl index of a firm's bond issues; *Roundtrip* is the implied round-trip cost from Feldhütter (2012); and $Disagreement$ is the standard deviation of analyst forecasts on two-year earnings from IBES divided by the CRSP stock price. $|\text{basis}(t) \cdot 1_{\text{basis}(t)<0}|$ is set to be zero if a bond has no available CDSs.

[22] The number of observations shrinks due to availability of lagged illiquidity measures.

[23] In our return analyses, 94 out of 282 issuers are private firms.

(0.34), the monthly return drops by about 2.5%. Overall, the results support the hypothesis that the unwinding of basis trading caused the large negative basis during the financial crisis.

Panels B and C of Table 5 provide regression results for each month during the financial crisis. Panel B shows that, before the Lehman collapse (Column *Aug*), CDS availability has no effect on bond returns (CDS^{YES}), while BasisArb1 is positively related to bond returns. This result for BasisArb1 suggests that more basis trading is associated with higher bond returns, consistent with the idea that basis arbitrage helps close price gaps in normal times (e.g., Kim, Li, and Zhang 2014 and Oehmke and Zawadowski 2017). Moving on to the subsequent month, we find that both the presence of CDS contracts and the proxy for CDS arbitrage activity are strongly associated with bond returns. In September, bonds with CDSs yield on average 6.7% lower returns than bonds without CDSs in Panel B, although the effect is insignificant after controlling for BasisArb2 in Panel C. Bonds with heavy basis trading experienced steep price declines, as can be seen from the negative, statistically significant coefficient estimates for both BasisArb1 and BasisArb2 in September. In October, bonds with heavy basis trading yielded higher returns, as can be seen from positive coefficients on both BasisArb1 and BasisArb2, suggesting the return of arbitrageurs.

Massa and Zhang (2012) argue that CDSs might improve liquidity by mitigating fire sale pressures for bondholders because of hedging values. Our results do not necessarily contradict theirs. Massa and Zhang (2012) focus on mostly long-only investors, e.g., insurance companies, mutual funds, and pension funds. Unlike these investors with limited leverage, however, highly levered basis arbitrageurs can suffer from reduced funding liquidity in their cash positions (i.e., corporate bonds) even with CDS protections. As the deviation of corporate bond prices from CDS prices widens, these arbitrageurs might have to liquidate their positions with substantial losses because funding situations deteriorate. In addition, after the Lehman bankruptcy substantial amounts of corporate bonds in the long position of basis arbitrageurs ended up in the hands of rehypothecation lenders who seized the assets posted as collateral (i.e., corporate bonds) by prime brokers (Mitchell and Pulvino 2012). Since the CDS–bond arbitrage link was broken, CDSs no longer provided hedging values to the arbitrageurs.

In summary, our results suggest that the exit of basis arbitrageurs help explain the severe negative basis during the financial crisis.

5.3 Liquidity Demand for Bonds Underwritten by Lehman Brothers

In this section, we further investigate potential interactions between dealers and arbitrageurs, focusing on bonds with Lehman Brothers as a lead underwriter. According to Mitchell and Pulvino (2012), the prime brokerage financing of hedge funds, particularly rehypothecation, played a key role in amplifying market disruption after the Lehman collapse. The retraction of rehypothecation lending tightened funding support for prime brokers, triggering huge liquidity demand from CDS–bond basis arbitrageurs. In addition, rehypothecation lenders engaged in the fire sale of corporate bonds provided as collateral that they seized after the Lehman collapse because of the high risk associated with those bonds. Thus, bonds that were rehypothecated through Lehman Brothers or bonds for which Lehman Brothers acted as market makers faced large liquidity demand. Aragon and Strahan (2012) show that stocks held by Lehman's hedge fund clients suffered huge losses in liquidity after the Lehman collapse.

We examine liquidity demand for bonds whose lead underwriter is Lehman Brothers. As Dick-Nielsen et al. (2012) note, the original lead underwriter of a bond typically acts as a market maker. Liquidity provision to Lehman-underwritten bonds should significantly weaker around the Lehman collapse. Also, since counterparties that have a trading relationship with Lehman also held such bonds, Lehman's hedge fund clients also more likely to hold these bonds in their prime broker accounts with Lehman, which might have been rehypothecated before bankruptcy. Thus, bonds underwritten by Lehman should experience steeper price decreases particularly in September 2008. Furthermore, price declines would be concentrated on bonds with CDSs available because they are more likely to be held by basis arbitrageurs whose bonds are rehypothecated through Lehman.

In Table 6, we examine returns on bonds underwritten by Lehman for each month from Aug 2008 through Dec 2008.[24] We regress bond returns on a dummy variable indicating that

[24] There are 812 bonds in our sample with at least one monthly return observation available between Aug 2008 and Dec 2008, of which 136 bonds are issued with Lehman Brothers as one of lead underwriters.

Lehman is the lead underwriter (LU), a dummy variable for CDS availability (CDS^{YES}), and the interaction between LU and CDS^{YES}. We see that, in September, bonds underwritten by Lehman Brothers yield unconditionally 2.8% lower returns than other bonds (Column (3)). In Column (4), we find that the negative returns on Lehman-underwritten bonds are mostly driven by bonds with CDSs, since the coefficient estimate on $\text{LU} \cdot \text{CDS}^{\text{YES}}$ is negative 4% and statistically significant at the 10% level. These results show that bonds underwritten by Lehman Brothers with available CDSs experienced steeper declines in returns, particularly during September 2008.

Table 7 examines the extent to which the Lehman collapse affects dealer liquidity provision. Since Lehman was likely to be a market maker for Lehman-underwritten bonds, negative funding liquidity shocks to Lehman might have reduced liquidity provision to those bonds. Also, other dealers would have cut liquidity provision for bonds underwritten by Lehman, because these bonds were likely associated with increased liquidity risk.

Table 7 provides the regression results of dealer net buys on basis changes, dummy variable LU, and their interactions as well as the controls that we employ in (3). We estimate the regressions each month during the period between three months before and three months after the Lehman collapse. We find evidence that dealers reduce liquidity provision on Lehman-underwritten bonds. In particular, the coefficient estimates on $\Delta\text{basis}(t) \cdot \text{LU}$ are positive and statistically significant from $m(-2)$ through $m(+1)$, which covers July 2008 through October 2008. Notably, the magnitude of the coefficient estimate on the interaction term is highest in the month immediately before the Lehman collapse (see Column $m(-1)$), suggesting that funding liquidity to Lehman Brothers, one of the major market makers for these bonds, might have fallen off significantly.

Also, dealer liquidity provision hits bottom in the month following the Lehman collapse and then slowly recovers, as can be seen from the sum of the coefficients on $\Delta\text{basis}(t) \cdot \text{LU}$ and $\Delta\text{basis}(t)$. For example, a one-standard-deviation change in the basis (0.94%) is associated with 21.1%, 6.2%, 2.4%, 0.1%, 3.2%, and 4.0% of one-standard-deviation changes in dealer net buys in $m(-3)$, $m(-2)$, $m(-1)$, $m(+1)$, $m(+2)$, and $m(+3)$, respectively.

In summary, our results show that bonds with CDSs available suffered steeper losses when the lead underwriter was Lehman Brothers. Also, dealers reduced liquidity provision for these bonds around the Lehman collapse.

5.4 Are Bonds with Available CDSs More Liquid?

Although we control for the liquidity of bonds in the return regressions in Table 5, the results might be due to the fact that bonds with CDSs are more liquid and investors sold liquid bonds following the Lehman collapse instead of selling illiquid bonds. Lou and Sadka (2011) and Manconi et al. (2012) find, for example, that during the financial crisis investors sold liquid assets before illiquid assets. While Das et al. (2014) argue that the introduction of CDS contracts negatively affect the liquidity of underlying bonds due to the migration of traders to the CDS market, their evidence does not necessarily imply that in the cross section CDS-referenced bonds are less liquid than other bonds. To address this issue, we compare the illiquidity of corporate bonds with and without CDSs during the crisis period.

Figure 8 plots the time series of illiquidity for bonds with and without CDS contracts. We employ three illiquidity measures based on Amihud (2002), Bao et al. (2011), and Feldhütter (2012). The three measures provide consistent results. In our sample, corporate bonds with available CDS contracts are actually more illiquid than those without CDS contracts. Illiquidity sharply increases after the Lehman collapse, but bonds with available CDS contracts maintain higher levels of illiquidity throughout 2008 than bonds with no CDS contracts available. In Table 8, the results shown also indicate that differences in illiquidity between bonds with CDS contracts and bonds without CDS contracts are always positive and are highly statistically significant for most months between August and December 2008. These results show that, in our sample, bonds with CDS contracts are actually more illiquid than bonds without CDS contracts. Overall, liquidity demand for bonds with CDS contracts, which is documented in the previous section, is not likely to be driven by investors' preference to sell more liquid bonds during the financial crisis.

6 Conclusion

We show that dealer liquidity provision in the corporate bond market occurred during the period from 2005 to 2009. Liquidity provision tends to become weaker for large basis changes and when dealers suffer losses on their balance sheets. We also show that declines in bond prices are concentrated in bonds with high levels of activity in basis trades, indicating that the exits of arbitrageurs from pre-existing basis trades triggered the large negative basis following Lehman Brothers' collapse. Finally, we find evidence that bonds with Lehman Brothers as lead underwriter suffer steeper declines in market prices and dealer liquidity provision around the Lehman collapse. Overall, our results show the role of dealers as liquidity providers in the corporate bond market and explain how liquidity demand from unwinding arbitrage trades can add to the breakdown of the CDS–bond arbitrage relationship.

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A The DTCC Database

The DTCC provides clearing, settlement and information services for OTC derivatives. Since November 2006, the vast majority of CDS contracts traded have been registered in the automated Trade Information Warehouse, which is DTCC's electronic central registry for CDS contracts.

Our data from the DTCC cover all transacted CDS contracts of 35 financial firms for our sample period. Each transaction contains the following information: the name of the reference entity, the trade date and the effective date, the (expected) maturity of the contract, anonymized identities of the participating counterparties including the type (dealer or end-user), and the executed notional amount. The data also contain a finer classification of the end-users: asset managers, banks, financial services, hedge funds, insurance firms, and other (the last group accounts for less than 3% of the notional volume traded by end-users).

An important feature of the dataset is the specification of the type of transaction, which determines the traded notional amounts and exposures. Specifically, a transaction can be a new trade, an assignment of an already existing trade, or a termination of an existing trade. When an investor wants to enter into a CDS contract he can either enter into a new contract or find a counterparty that wishes to assign his position to him. When an investor wants to unwind an existing contract, the investor faces three alternatives: enter into a new offsetting transaction, assign the contract to a new counterparty, or terminate the transaction with the original CDS counterparty.

B Calculating the Bond-CDS Basis

The bond–CDS basis, which measures the credit risk pricing discrepancy between the two markets, is the difference between a CDS spread and a bond spread with the same maturity. While calculating the CDS spread minus the bond spread might seem to be a simple difference calculation, making two very different instruments comparable is a more intricate task in practice than it may appear. CDSs are readily available in spread form and a full term structure is observable.[25] Bond spreads, on the other hand, are a theoretical measure that needs to be backed out from a unique bond price.

The Par-Equivalent CDS Spread (PECS) Methodology , proposed by J. P. Morgan back in 2005, uses the market price of a bond to calculate a spread based on implied default probabilities. These default probabilities can then be transformed into an implied CDS spread, which is referred to as a PECS. In other words, the PECS is the shift made in the term structure of CDS spreads to match the price of the bond.

To get the PECS, we start by bootstrapping the default probabilities from the full CDS curve traded in the market. Then, we take as inputs the derived term structure of default probabilities and assume some recovery rate (in this paper, we use a fixed recovery rate assumption at 40% as well as Markit's reported recovery assumption), and we calculate a CDS-implied bond price as follows:

$$\text{Bond Price} = C\sum_{n=1}^{N}(t_n - t_{n-1})PS(t_n)Z(0,t_n) + PS(t_N)Z(0,t_N) + R\sum_{n=1}^{N}PD(t_{n-1},t_n)Z(0,t_n)$$

where C is the bond coupon, $(t_n - t_{n-1})$ is the length of time period n in years, $PS(t_n)$ is the probability of survival to time t_n at time t_0, $PD(t_n)$ is the probability of default at time t_n at time t_0, $Z(0, t_n)$ is the risk-free discount factor to time t_n, and R is the recovery rate upon default assumed for pricing CDS contracts referencing the same firm.

The resulting CDS-implied bond price is going to differ from the traded dirty price of the bond. So, we apply a parallel shift in those default probabilities while maintaining the recovery rate assumption, until we match with the market price of the bond. Given these bond-implied survival probabilities, we convert them back into a CDS spread using the usual CDS pricing equation:

$$S(N) = \frac{(1-R)\sum_{n=1}^{N}PD(t_n)DF(t_n)}{\sum_{n=1}^{N}(t_n - t_{n-1})PS(t_n)DF(t_n) + \text{Accrued Interest}}$$

The resulting spread, $S(N)$, is the PECS, and the basis is CDS Spread − PECS. Note that unlike the Z-spread, which is one number, the PECS is an entire curve and we are therefore

[25]HY reference entities are often traded on an upfront basis but they can be converted to a running spread.

able to calculate the basis at any maturity.

C Liquidity-Seeking by Insurance Companies

We investigate the daily trading behavior of insurance companies, using their corporate bond trades in the secondary market, as recorded in the NAIC database, and their CDS trades provided in the DTCC database.

In Panel A of Table A-1, we investigate insurance companies' liquidity demand by estimating the specification in (5) and (6). Positive estimates in the boldface cells indicate destabilizing liquidity-seeking, i.e., trades that further widened the basis. We find that insurance companies are destabilizing liquidity seekers in the bond market, especially when bond prices are distressed, i.e., when the basis is negative. In *Crisis 2* and when the basis is negative, for example, the regression coefficient of net bond buys on $\Delta \text{basis}(t)Dec$ is 0.07, which is statistically significant at the 10% level. Although it is only marginally significant, this evidence might suggest that insurance companies were mainly responsible for the large negative basis after the Lehman collapse.

To investigate this possibility, we investigate dealers' liquidity provision in the subsamples of days when insurance companies traded (Panel B) and when insurance companies did not trade (Panel C). The results indicate that insurance companies are not likely to be the main liquidity-seekers in the bond market during the *Crisis 2* and *Crisis 3* periods. First, the coefficients on $\Delta \text{basis}(t)Dec$ are shown to be greater in magnitude in Panel B than in Panel A, showing that there are liquidity seekers other than insurance companies. For example, bond dealers' liquidity provision in the destabilizing case in *Crisis 2* is -0.14, whereas insurance companies' liquidity-seeking for the corresponding case is 0.07. Second, as can be seen from Panel C, dealers provide liquidity even when there is no insurance company trading. Further, the number of non-insurance company trading days shown in Panel C is much larger than the number of insurance company trading days shown in Panel B. This implies that the most of the liquidity-seeking during the financial crisis was not caused by insurance companies. Overall, the results shown in Table A-1 suggest that insurance companies were likely not the main liquidity seekers following the Lehman collapse.

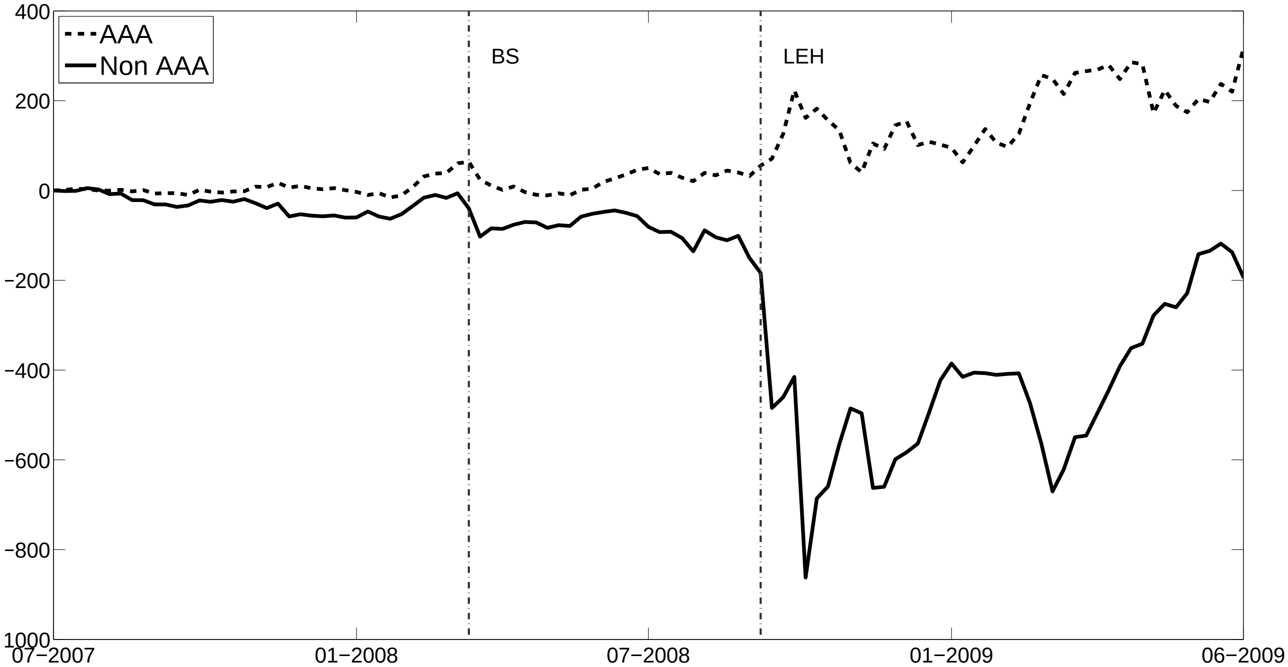


Figure 1: CDS-Corporate Bond Basis

This figure depicts the time series of the CDS–bond basis for AAA and non-AAA grade (including high-yield) bonds. The basis is defined as CDS spreads minus par-equivalent CDS spreads following the methodology of J.P. Morgan. Both the CDS and par-equivalent spreads are of five-year maturity. We plot the weekly average values in basis points.

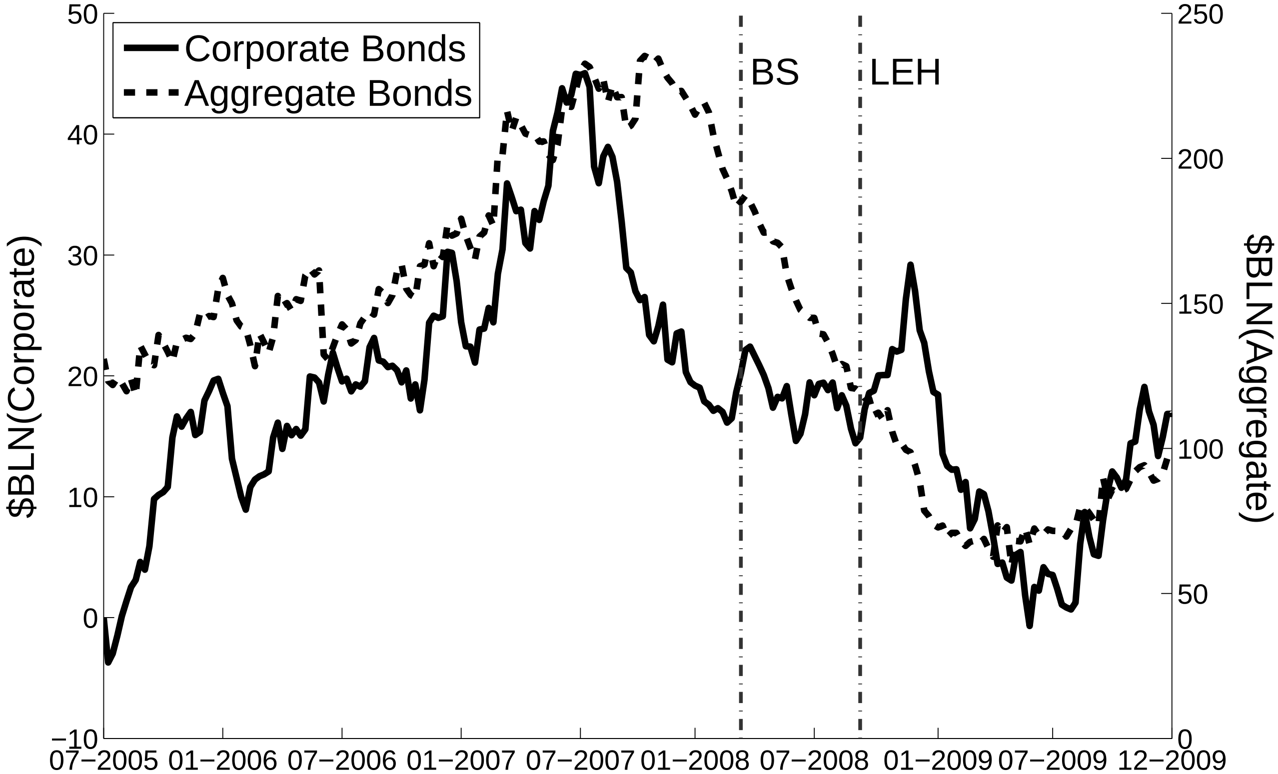


Figure 2: Long-Term Corporate Securities Position of Dealers

This figure plots primary dealers' aggregate positions in corporate securities with maturity greater than one year as reported in the Federal Reserve Bank of New York's weekly survey (the y-axis on the right) and also plots FINRA member dealers' aggregate positions in corporate bonds with maturity greater than one year as constructed from trades reported in the TRACE (the y-axis on the left). The plot constructed from the TRACE begins at zero, since the initial position is unavailable. The aggregate position reported in the Federal Reserve Bank survey includes non-federal agency and GSE-issued mortgage-backed securities (MBSs) . The aggregate position constructed from the TRACE includes only TRACE-eligible corporate bonds.

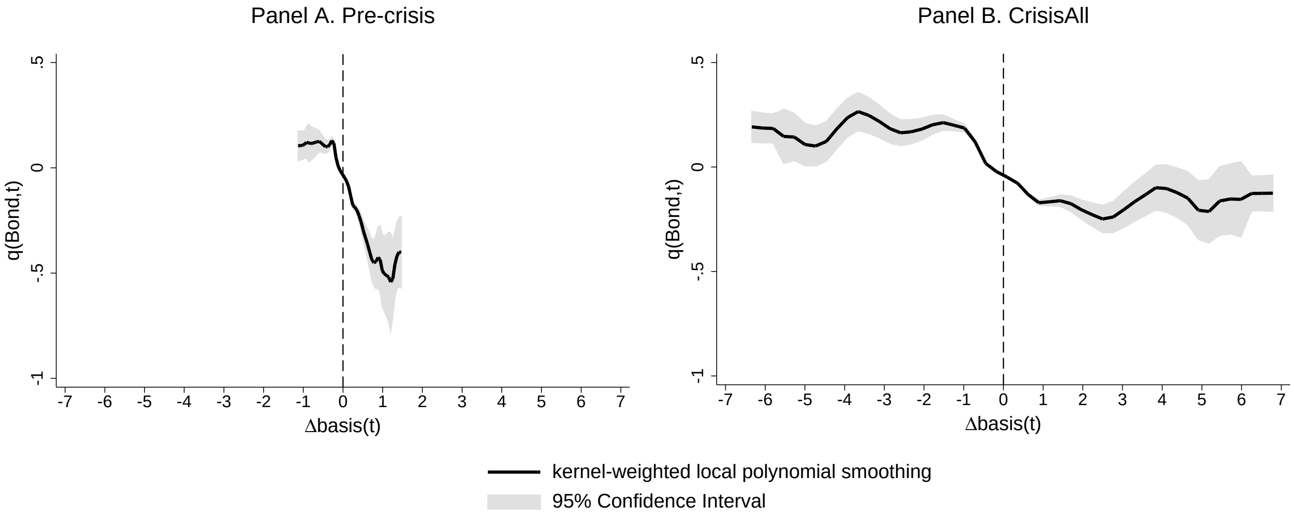


Figure 3: Nonparametric Regressions of Dealer Bond Net Buys against Basis Changes

This figure plots fitted lines from nonparametric regressions of daily dealer net buys, $q(\text{Bond}, t)$, on daily basis changes, $\Delta\text{basis}(t)$, for *Pre-crisis* and *CrisisAll* periods. We use kernel-weighted local polynomial smoothing with the Epanechnikov kernel function in, e.g., Fan (1992) and Fan and Gijbels (1996). $q(\text{Bond}, t)$ is normalized using its sample standard deviation. $basis(t)$ is defined as the CDS spreads minus the par-equivalent CDS spreads (PECS) in percentage points. Basis changes are winsorized at 0.25% at both the top and the bottom. The shaded area represents the 95% confidence bands.

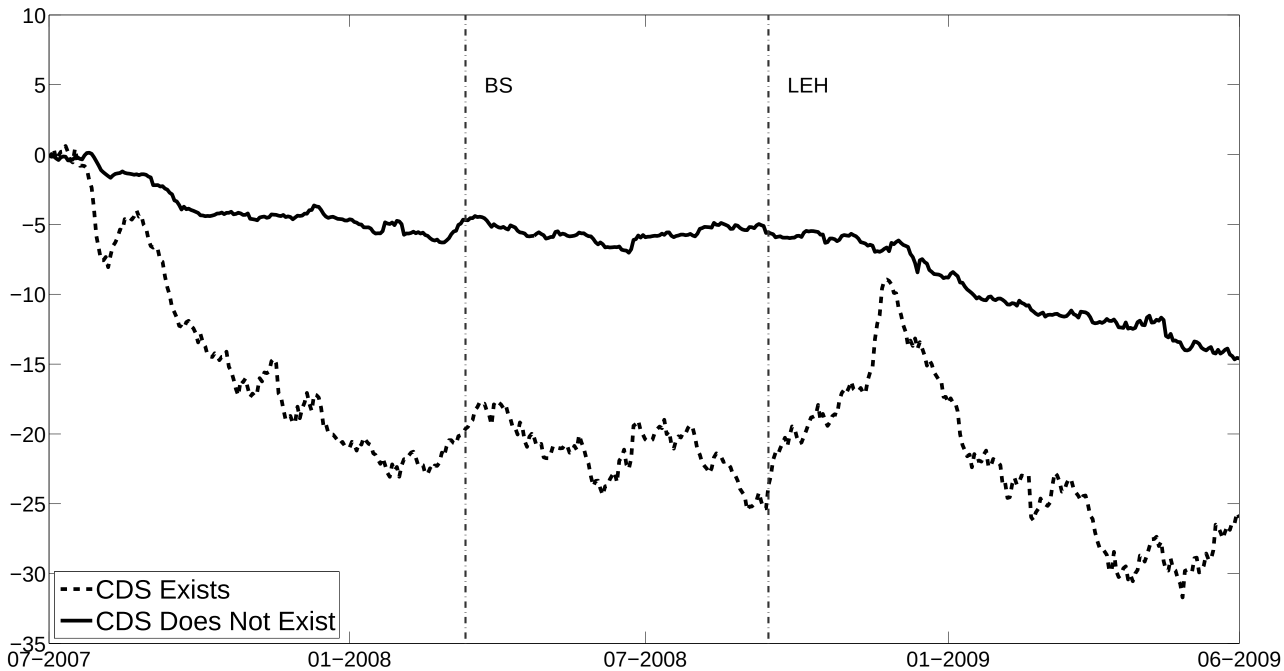


Figure 4: Inventory of Corporate Bonds with Available CDS vs. Corporate Bonds Without Available CDS

This figure plots the aggregate inventories of dealers both for bonds with available CDSs and bonds without available CDSs. The availability of CDSs is determined by the presence of a CDS spread quote for the period running from January 2002 through August 2008 in the Markit database. We begin the plot at zero, since dealers' initial positions in corporate bonds are unavailable.

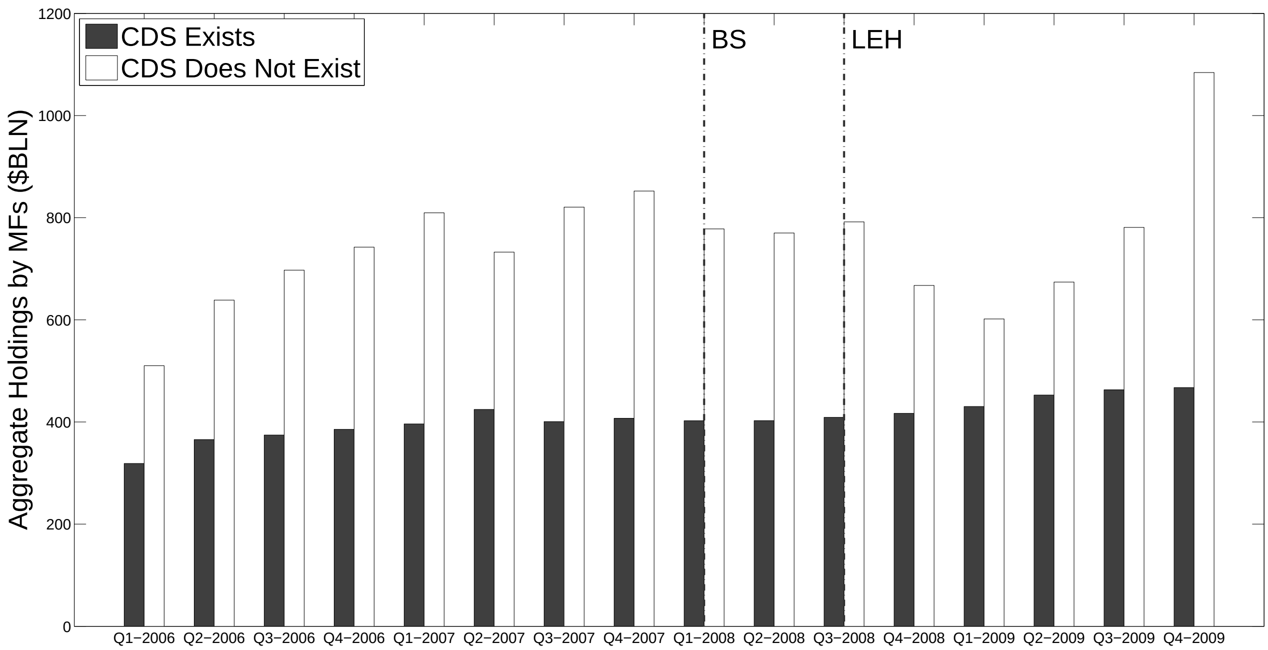


Figure 5: Mutual Funds' Holdings of Corporate Bonds with Available CDS vs. Corporate Bonds Without Available CDS

This figure shows the holdings of mutual funds in corporate bonds as reported in the MorningStar database. The figure contrasts the inventories of corporate bonds with available CDSs with the inventories of corporate bonds without available CDSs. The availability of a CDS is determined by the existence of a quote in Markit for the period running from January 2002 through August 2008.

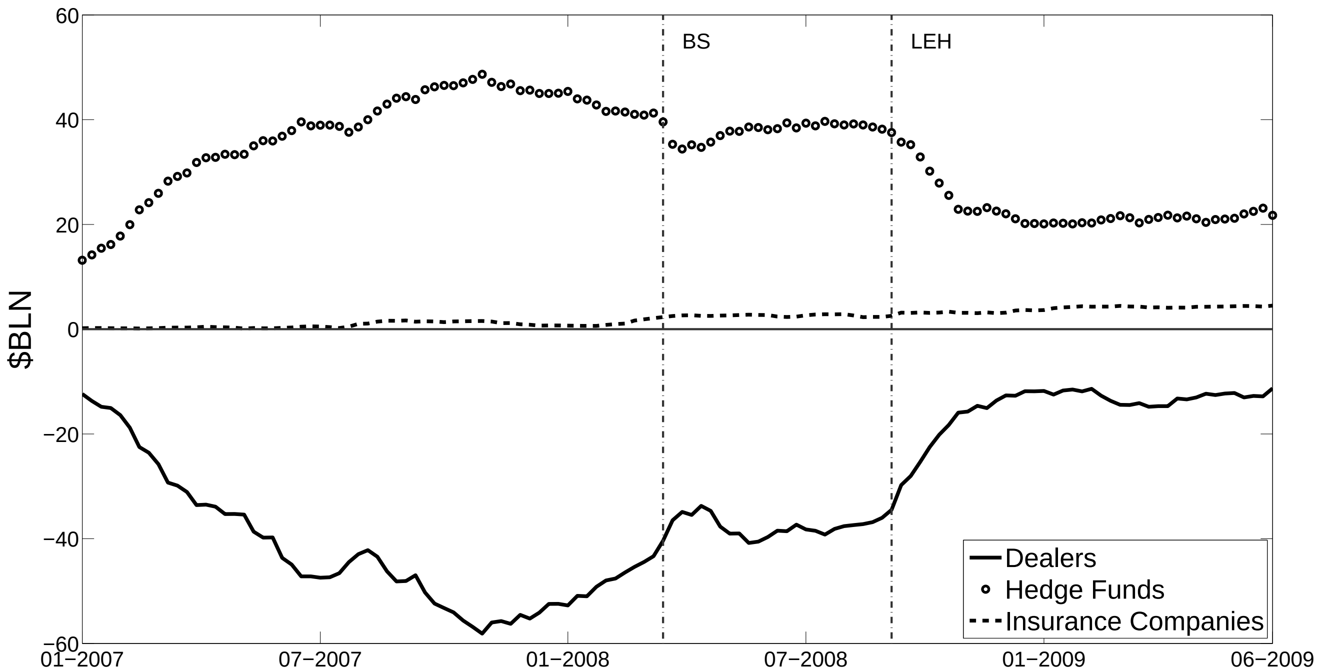


Figure 6: Aggregate CDS Positions by Dealers, Insurance Companies, and Hedge Funds

This figure shows CDS positions held by dealers, insurance companies, and hedge funds, as reported in DTCC. We plot aggregate holdings of single name CDS contracts across all maturities in notional amounts. The underlying reference entities are financial firms.

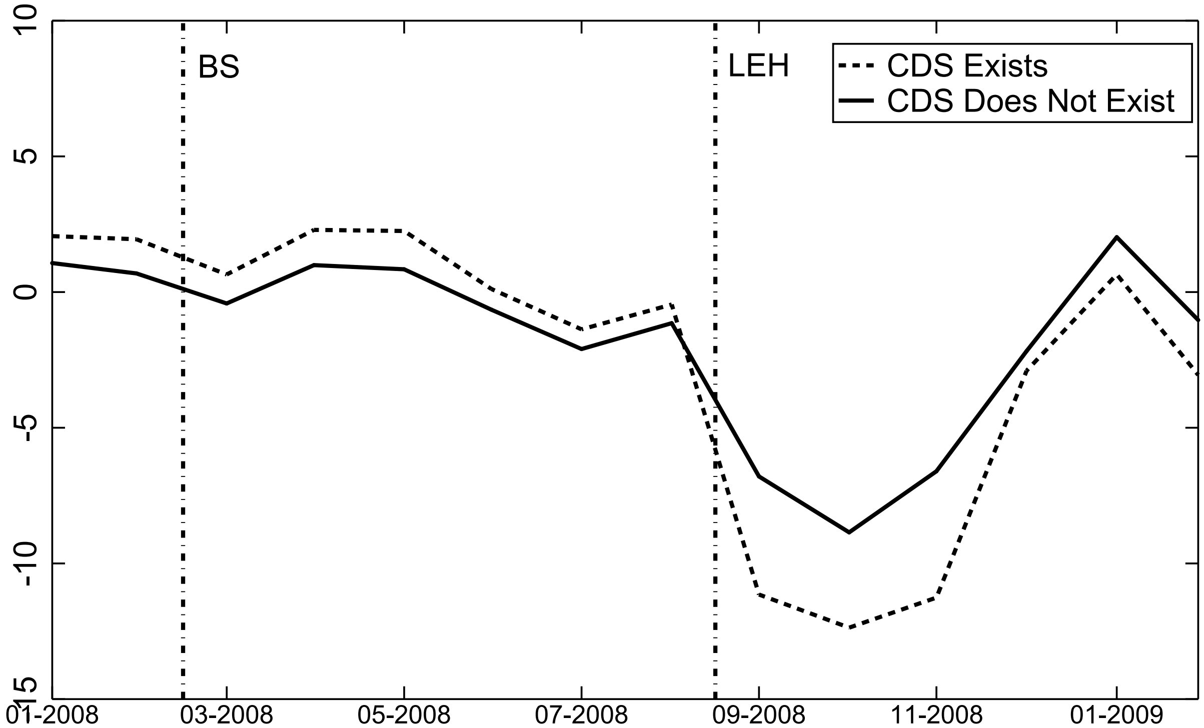
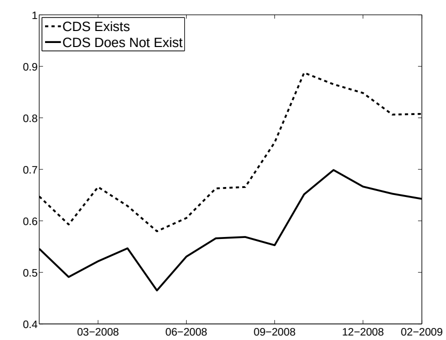


Figure 7: Cumulative Returns for Corporate Bonds with CDSs Available vs. Unavailable

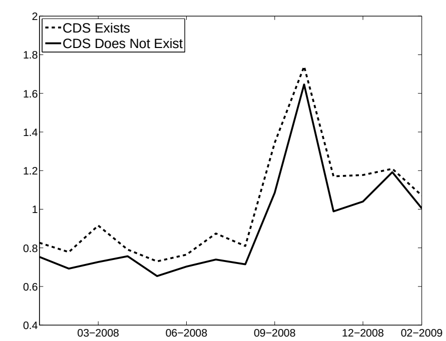
This figure plots cumulative monthly corporate bond returns available from the TRACE for the period from Jan 2008 through Feb 2009. Monthly bond returns are constructed using last available daily prices within a week from the end of the months and accrued interest. We plot two return series based on the availability of CDS quotes in Markit. The dashed line plots returns on bonds that have available CDS contracts and the solid line plots those that do not have available CDS contracts. The availability of a CDS is determined by the existence of a quote in Markit for the period January 2002 through August 2008. Tick marks on the x-axis represent the end of each month.

Figure 8: Time Series of Illiquidity for Bonds with CDSs Available vs. Unavailable

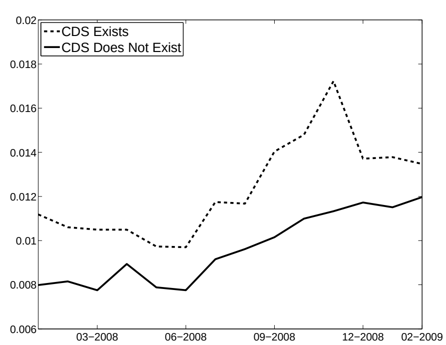
This figure plots monthly illiquidity measures of corporate bonds for the period from Jan 2008 through Feb 2009. The monthly illiquidity measures are obtained by taking cross-sectional averages of illiquidity measures of individual bonds. The solid line plots the average illiquidity of bonds that do not have available CDS contracts and the dashed line plots the average illiquidity of bonds with available CDS contracts. The plotted illiquidity measures are based on (a) $ILLIQ$ of Amihud (2002), (b) γ of Bao et al. (2011), and (c) the imputed round trip cost (IRC) of Feldhütter (2012). $ILLIQ$ is obtained each month by first taking daily averages of absolute returns divided by trade volumes (in millions of dollars) and then taking the median of these daily averages within the month. γ is constructed following the procedure in Bao et al. (2011). IRC is the monthly median of daily imputed round-trip costs, which are calculated using transactions on the same bond with the same trade volume on the same day when there are no other trades with the same volume on that day.



(a) Amihud (2002)



(b) Bao, Pan, and Wang (2011)



(c) Feldhütter (2011)

Table 1
Summary Statistics

This table provides summary statistics for the following four periods: *Pre-crisis* from March 2005 through June 2007; *Crisis 1* from July 2007 through September 14, 2008; *Crisis 2* from September 15, 2008 through January 2009; and *Crisis 3* from February 2009 through June 2009. $basis (\equiv p(\text{CDS}) - p(\text{Bond}))$ is the CDS–bond basis in percentage points. $p(\text{CDS})$ is the CDS spread and $p(\text{Bond})$ is the par-equivalent CDS spread (PECS) in percentage points. $q(\text{CDS, buy})$ and $q(\text{CDS, sell})$ are daily gross quantities (in millions of dollars) bought and sold by dealers in the CDS market, respectively. $q(\text{Bond, buy})$ and $q(\text{Bond, sell})$ are daily gross quantities (in millions of dollars) bought and sold by dealers in the corporate bond market, respectively.

Panel A: AAA

	Pre-crisis			Crisis 1			Crisis 2			Crisis 3		
	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N
basis	0.12	0.13	13,121	0.29	0.40	7,362	1.47	1.28	3,023	2.28	1.50	4,160
$p(\text{CDS})$	0.17	0.06	13,121	0.90	0.49	7,362	4.12	1.38	3,023	4.56	2.36	4,160
$p(\text{Bond})$	0.05	0.13	13,121	0.62	0.46	7,362	2.64	1.45	3,023	2.20	2.47	4,160
$q(\text{CDS, buy})$	8.03	24.84	11,168	47.04	55.09	6,418	100.21	130.46	2,585	43.52	62.01	3,733
$q(\text{CDS, sell})$	8.67	27.63	10,456	27.43	33.92	6,332	72.83	95.39	2,450	41.62	63.74	3,567
$q(\text{Bond, buy})$	2.57	10.49	13,121	3.35	10.17	7,362	5.85	17.51	3,023	8.12	22.75	4,160
$q(\text{Bond, sell})$	2.84	9.03	13,121	3.66	10.39	7,362	5.86	16.02	3,023	8.21	19.14	4,160

Panel B: Investment Grade excluding AAA

	Pre-crisis			Crisis 1			Crisis 2			Crisis 3		
	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N
basis	0.05	0.30	103,082	-0.32	1.45	50,188	-3.31	5.76	15,572	-2.09	4.09	19,321
$p(\text{CDS})$	0.33	0.62	103,082	1.47	1.66	50,188	3.63	4.25	15,572	3.83	3.90	19,321
$p(\text{Bond})$	0.29	0.57	103,082	1.79	2.41	50,188	6.99	9.33	15,572	5.84	6.59	19,321
$q(\text{CDS, buy})$	6.38	26.19	69,942	53.63	82.59	39,156	53.97	103.25	12,808	32.09	61.21	15,960
$q(\text{CDS, sell})$	12.29	35.74	53,129	59.80	86.28	34,268	61.13	93.85	10,578	38.07	67.91	13,908
$q(\text{Bond, buy})$	2.61	8.36	103,082	3.02	8.94	50,188	3.84	11.02	15,572	3.27	8.29	19,321
$q(\text{Bond, sell})$	2.82	8.12	103,082	3.16	8.69	50,188	3.75	10.49	15,572	3.42	9.78	19,321

Panel C: High Yield

	Pre-crisis			Crisis 1			Crisis 2			Crisis 3		
	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N
basis	-0.74	4.81	20,340	-0.41	2.81	6,460	-11.13	7.21	1,926	-7.99	6.63	2,809
$p(\text{CDS})$	9.03	17.26	20,340	7.48	4.39	6,460	28.02	23.79	1,926	21.68	28.00	2,809
$p(\text{Bond})$	6.78	8.12	20,340	7.98	6.64	6,460	38.20	22.63	1,926	26.62	19.92	2,809
$q(\text{CDS, buy})$	31.17	52.69	602	42.18	63.38	3,059	35.09	41.35	799	14.69	28.13	1,400
$q(\text{CDS, sell})$	24.00	50.27	583	40.34	56.56	2,987	34.39	33.85	794	19.29	31.99	1,058
$q(\text{Bond, buy})$	4.59	12.71	20,340	3.74	8.40	6,460	5.14	16.48	1,926	3.45	7.18	2,809
$q(\text{Bond, sell})$	4.62	12.94	20,340	4.05	9.40	6,460	5.07	15.42	1,926	3.52	7.65	2,809

Table 2
Liquidity Provision by Dealers

This table provides the estimation results of the following regressions:

$$
\begin{aligned}
q(\text{Bond}, t) &= c_1 + \beta_1 \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{1t} \\
&\equiv c_1 + \beta_1 \left(\Delta p(\text{CDS}, t) - \Delta p(\text{Bond}, t)\right) + \text{ctrls} + \varepsilon_{1t} \\
q(\text{CDS}, t) &= c_2 + \beta_2 \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{2t} \\
&\equiv c_2 + \beta_2 \left(\Delta p(\text{CDS}, t) - \Delta p(\text{Bond}, t)\right) + \text{ctrls} + \varepsilon_{2t}
\end{aligned}
$$

where $q(\text{Bond}, t)$ and $q(\text{CDS}, t)$ are daily net order flows (buy minus sell volumes) by dealers in the corporate bond and CDS markets, respectively, and $p(\text{Bond}, t)$ and $p(\text{CDS}, t)$ are par-equivalent CDS spreads (PECS) and CDS spreads. $q(\text{Bond}, t)$ and $q(\text{CDS}, t)$ are normalized using their standard deviations. $basis(t)$ is $p(\text{CDS}, t) - p(\text{Bond}, t)$. Changes in PECS, CDS, and basis are measured at daily frequencies and are winsorized at 0.25% at both the top and the bottom. The control variables, $ctrls$, include: the lagged basis, basis$(t-1)$; lagged changes in basis, Δbasis$(t-1)$; changes in the VIX, Δvix_t; changes in overnight index swap (OIS) spreads, Δois_t, where the OIS spread is LIBOR minus overnight index swap rates; and aggregate stock returns on primary dealers $ret_{dealer,t}$. In Panel A, the sample sub-periods are: *Pre-crisis* from March 2005 through June 2007 and *CrisisAll* from July 2007 through June 2009. In Panel B, the sample sub-periods are: *Crisis 1* from July 2007 through September 14, 2008; *Crisis 2* from September 15, 2008 through January 2009; and *Crisis 3* from February 2009 through June 2009. When q(CDS) is the dependent variable (the second half of the columns under each sub-period), we use the financial sample because of the availability of CDS net order flows. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The numbers in parentheses are t-statistics using standard errors clustered at the issuing firm level.

Panel A: Before and During the Crisis

	Pre-crisis						CrisisAll					
	q(Bond) (1)	q(Bond) (2)	q(Bond) (3)	q(CDS) (4)	q(CDS) (5)	q(CDS) (6)	q(Bond) (7)	q(Bond) (8)	q(Bond) (9)	q(CDS) (10)	q(CDS) (11)	q(CDS) (12)
$-\Delta p(\text{Bond}, t)$	-0.401***	-0.435***			0.070		-0.065***	-0.072***			-0.009	
	(-4.512)	(-4.230)			(0.897)		(-6.065)	(-6.551)			(-0.777)	
$\Delta p(\text{CDS}, t)$		-0.365**		1.735	1.805			-0.063***		-0.082	-0.092	
		(-2.246)		(1.300)	(1.307)			(-3.181)		(-1.276)	(-1.355)	
$\Delta\text{basis}(t)$			-0.415***			0.055			-0.073***			-0.009
			(-3.949)			(0.767)			(-6.779)			(-0.761)
basis$(t-1)$	-0.001	-0.002	-0.004*	0.135	0.139	0.142	-0.000	-0.000	-0.000	0.015**	0.015**	0.015**
	(-0.226)	(-1.079)	(-1.657)	(1.270)	(1.272)	(1.297)	(-0.048)	(-0.225)	(-0.203)	(2.363)	(2.358)	(2.351)
Δbasis$(t-1)$	-0.138**	-0.138**	-0.132**	-0.017	0.001	-0.003	-0.011	-0.013	-0.014	-0.008	-0.010	-0.008
	(-2.558)	(-2.544)	(-2.412)	(-0.285)	(0.022)	(-0.048)	(-1.106)	(-1.301)	(-1.403)	(-1.299)	(-1.465)	(-1.274)
Δvix_t	-0.003	-0.001	-0.001	-0.023	-0.023	-0.020	0.001	0.002*	0.002**	-0.002	-0.002	-0.004
	(-0.551)	(-0.300)	(-0.123)	(-0.823)	(-0.828)	(-0.734)	(0.945)	(1.793)	(1.968)	(-0.493)	(-0.484)	(-0.882)
Δois_t	0.988***	1.000***	1.009***	2.033	2.024	2.115	0.142***	0.160***	0.164***	0.638***	0.638***	0.604***
	(4.170)	(4.218)	(4.214)	(0.929)	(0.924)	(0.959)	(2.852)	(3.282)	(3.320)	(4.669)	(4.665)	(4.972)
$ret_{dealer,t}$	-0.698	-0.747	-0.731	-1.870	-1.869	-1.979	-0.004	-0.008	-0.005	0.087	0.087	0.103
	(-1.504)	(-1.605)	(-1.577)	(-0.511)	(-0.511)	(-0.534)	(-0.106)	(-0.243)	(-0.152)	(0.591)	(0.591)	(0.671)
R^2	0.6%	0.7%	0.6%	0.2%	0.2%	0.1%	0.5%	0.5%	0.5%	0.6%	0.6%	0.5%
N	125,506	125,506	125,506	29,895	29,895	29,895	112,444	112,444	112,444	69,141	69,141	69,141

Panel B: Three Sub-periods of the Crisis

	Crisis 1				Crisis 2				Crisis 3			
	q(Bond) (1)	q(Bond) (2)	q(CDS) (3)	q(CDS) (4)	q(Bond) (5)	q(Bond) (6)	q(CDS) (7)	q(CDS) (8)	q(Bond) (9)	q(Bond) (10)	q(CDS) (11)	q(CDS) (12)
$-\Delta p(\text{Bond}, t)$	-0.146***		-0.033		-0.051***		-0.008		-0.070***		0.006	
	(-5.325)		(-0.961)		(-3.999)		(-0.462)		(-5.999)		(0.824)	
$\Delta p(\text{CDS}, t)$	-0.190***		0.151		-0.050*		-0.175		-0.024		-0.126**	
	(-4.063)		(1.402)		(-1.816)		(-1.416)		(-1.187)		(-2.274)	
$\Delta\text{basis}(t)$		-0.149***		-0.030		-0.052***		-0.003		-0.071***		0.004
		(-5.275)		(-0.943)		(-4.223)		(-0.203)		(-6.133)		(0.505)
$\text{basis}(t-1)$	0.004	0.003	0.047*	0.048**	0.000	0.000	0.019**	0.018**	-0.000	0.000	0.012**	0.012**
	(0.916)	(0.840)	(1.909)	(1.967)	(0.304)	(0.256)	(2.110)	(2.073)	(-0.273)	(0.014)	(2.273)	(2.228)
$\Delta\text{basis}(t-1)$	-0.032*	-0.032*	-0.019	-0.022	-0.019	-0.019	-0.012	-0.007	-0.001	-0.002	-0.010	-0.008
	(-1.895)	(-1.928)	(-1.084)	(-1.313)	(-0.972)	(-1.013)	(-0.921)	(-0.675)	(-0.128)	(-0.410)	(-1.588)	(-1.223)
Δvix_t	-0.004	-0.004	0.005	0.006	0.002	0.002	0.003	0.000	0.009*	0.008*	-0.055***	-0.054***
	(-1.384)	(-1.481)	(0.406)	(0.540)	(1.403)	(1.581)	(0.619)	(0.023)	(1.821)	(1.690)	(-4.511)	(-4.413)
Δois_t	0.215***	0.208***	-0.111	-0.080	0.150*	0.152**	1.215***	1.124***	0.482	0.540	-1.236	-1.452
	(3.255)	(3.159)	(-0.309)	(-0.224)	(1.958)	(2.039)	(6.055)	(5.198)	(1.358)	(1.456)	(-1.356)	(-1.540)
$ret_{dealer,t}$	-0.464***	-0.408**	1.257***	0.997*	0.003	0.007	-0.003	0.001	0.110	0.022	-0.578	-0.289
	(-2.946)	(-2.546)	(2.589)	(1.888)	(0.099)	(0.187)	(-0.023)	(0.006)	(0.625)	(0.126)	(-1.053)	(-0.580)
R^2	0.6%	0.6%	0.5%	0.4%	0.6%	0.6%	2.4%	2.0%	0.9%	0.9%	2.7%	2.3%
N	63,258	63,258	39,681	39,681	21,543	21,543	13,071	13,071	27,643	27,643	16,389	16,389

Table 3
Destabilizing vs. Stabilizing Liquidity-Seeking

This table provides the estimation results of the following regressions for the positive lagged basis (basis$(t-1) > 0$) and negative lagged basis cases (basis$(t-1) < 0$) separately:

$$q(\text{Bond}, t) = c_1 + \beta_1 \Delta\text{basis}(t) \cdot Inc + \beta_2 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{1t}$$
$$q(\text{CDS}, t) = c_2 + \beta_3 \Delta\text{basis}(t) \cdot Inc + \beta_4 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{2t}$$

where $q(\text{Bond}, t)$ and $q(\text{CDS}, t)$ are daily net order flows by dealers in the bond and CDS markets, respectively. $q(\text{Bond}, t)$ and $q(\text{CDS}, t)$ are normalized using their standard deviations. *basis*(t) is the difference between the CDS spreads and the par-equivalent CDS spreads (PECS) of bonds ($p(\text{CDS}, t) - p(\text{Bond}, t)$). $Inc (\equiv 1_{\Delta\text{basis}(t)\geq 0})$ is an indicator variable that takes the value of one if Δbasis(t) is positive. $Dec (\equiv 1_{\Delta\text{basis}(t)<0})$ is defined similarly when Δbasis(t) is negative. The control variables, *ctrls*, include: the lagged basis, basis$(t-1)$; lagged changes in basis, Δbasis$(t-1)$; changes in the VIX, Δvix_t; changes in overnight index swap (OIS) spreads, Δois_t, where the OIS spread is LIBOR minus overnight index swap rates; and aggregate stock returns on primary dealers $ret_{dealer,t}$. In Panel A, the sample sub-periods are: *Pre-crisis* from March 2005 through June 2007 and *CrisisAll* from July 2007 through June 2009. In Panel B, the sample sub-periods are: *Crisis 1* from July 2007 through September 14, 2008; *Crisis 2* from September 15, 2008 through January 2009; and *Crisis 3* from February 2009 through June 2009. The cells in boldface are the cases in which the basis becomes wider; negative estimates on these cells indicate stabilizing liquidity-seeking, while positive estimates indicate destabilizing liquidity-seeking. When q(CDS) is the dependent variable (second and fourth columns in each sub-period), we use the financial sample because of the availability of CDS net order flows. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The numbers in parentheses are t-statistics using standard errors clustered at the issuing firm level.

Panel A: Before and During the Crisis

	Pre-crisis				CrisisAll			
	basis$(t-1) > 0$		basis$(t-1) < 0$		basis$(t-1) > 0$		basis$(t-1) < 0$	
	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δbasis$(t) Inc$	**-0.49*** **	**0.24**	-0.39**	0.38	**-0.13*** **	**-0.03**	-0.04***	0.06***
	(-5.92)	**(1.51)**	(-2.05)	(1.36)	**(-6.12)**	**(-0.41)**	(-4.17)	(3.40)
Δbasis$(t) Dec$	-0.53***	-0.12	**-0.21**	**-0.48** **	-0.16***	-0.14***	**-0.08*** **	**-0.04** **
	(-9.08)	(-1.16)	**(-1.56)**	**(-2.13)**	(-6.19)	(-3.29)	**(-6.81)**	**(-2.17)**
basis$(t-1)$	0.01	0.02	-0.01**	0.08	-0.00	0.02	0.00	0.01***
	(0.71)	(0.20)	(-2.41)	(0.93)	(-0.39)	(1.14)	(1.22)	(5.05)
Δbasis$(t-1)$	-0.18***	0.04	-0.13	-0.20*	-0.07*	-0.03**	-0.01	-0.00
	(-4.88)	(0.47)	(-1.51)	(-1.84)	(-1.79)	(-2.00)	(-1.17)	(-0.75)
Δvix_t	-0.00	-0.01	0.01	-0.03	0.00	-0.01***	0.00	0.00
	(-0.52)	(-0.47)	(0.83)	(-1.04)	(1.18)	(-4.17)	(1.52)	(0.14)
Δois_t	1.01***	1.82	0.96**	2.96**	0.24***	0.43	0.12*	0.63***
	(3.54)	(0.67)	(2.12)	(2.29)	(3.30)	(1.10)	(1.93)	(4.68)
$ret_{dealer,t}$	-0.80	-1.53	-0.35	-2.75	-0.02	0.50**	-0.01	0.01
	(-1.27)	(-0.35)	(-0.40)	(-0.89)	(-0.30)	(2.19)	(-0.19)	(0.13)
R^2	0.7%	0.1%	0.6%	0.3%	0.8%	0.8%	0.6%	0.5%
N	88,892	21,425	36,614	8,470	37,636	25,294	74,808	43,847

Panel B: Three Sub-periods of the Crisis

	Crisis 1				Crisis 2				Crisis 3			
	basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$	
	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Δbasis$(t)Inc$	**-0.27*** **	**-0.04**	-0.07**	0.12***	**-0.03**	**-0.07**	-0.03*	0.07**	**-0.09*** **	**-0.07**	-0.06***	-0.01
	(-7.15)	**(-0.38)**	(-2.51)	(2.92)	**(-0.46)**	**(-1.07)**	(-1.69)	(2.49)	**(-5.70)**	**(-1.20)**	(-4.05)	(-0.94)
Δbasis$(t)Dec$	-0.26***	-0.13	**-0.15*** **	**-0.09**	-0.14***	-0.16*	**-0.07*** **	**-0.05***	-0.09***	-0.04	**-0.07*** **	**0.04** **
	(-5.53)	(-1.09)	**(-4.47)**	**(-1.63)**	(-2.89)	(-1.84)	**(-4.87)**	**(-1.76)**	(-3.98)	(-1.44)	**(-6.12)**	**(2.49)**
basis$(t-1)$	-0.00	0.09	0.01	0.01***	-0.01	0.03	0.00	0.02***	0.00	0.01	0.00	0.00
	(-0.05)	(1.62)	(0.99)	(2.72)	(-0.31)	(0.62)	(1.40)	(4.16)	(0.52)	(0.74)	(0.29)	(0.84)
Δbasis$(t-1)$	-0.09***	-0.07	-0.02	0.01	-0.15	-0.05	-0.01	-0.00	-0.02	-0.03***	-0.00	-0.00
	(-3.68)	(-1.63)	(-0.80)	(0.26)	(-1.03)	(-1.43)	(-1.00)	(-0.23)	(-1.01)	(-2.68)	(-0.06)	(-0.57)
Δvix_t	-0.01***	-0.01	0.00	0.02**	0.00*	-0.02***	0.00	0.01	0.02**	-0.04***	0.00	-0.06***
	(-2.81)	(-0.49)	(0.78)	(1.98)	(1.95)	(-5.08)	(0.77)	(0.95)	(2.10)	(-3.52)	(0.67)	(-3.94)
Δois_t	0.37***	-0.14	0.12	-0.09	0.24	0.83***	0.10	1.07***	0.20	-0.50	0.67*	-1.76
	(3.31)	(-0.26)	(1.26)	(-0.22)	(1.50)	(4.85)	(1.19)	(4.13)	(0.25)	(-0.62)	(1.71)	(-1.46)
$ret_{dealer,t}$	-0.44*	-0.23	-0.32	2.07***	0.08	0.49***	-0.01	-0.08	0.19	0.35	-0.05	-0.62
	(-1.81)	(-0.26)	(-1.28)	(3.75)	(0.95)	(4.53)	(-0.18)	(-0.67)	(0.64)	(0.93)	(-0.22)	(-1.04)
R^2	1.2%	0.5%	0.4%	0.4%	1.1%	2.9%	0.7%	2.2%	0.7%	2.4%	1.0%	2.0%
N	26,077	17,403	37,181	22,278	4,015	2,779	17,528	10,292	7,544	5,112	20,099	11,277

Table 4
Liquidity Provision and Dealer Losses on Inventories

This table provides the estimation results of the following regressions:

$$q(\text{Bond},t) = c_1 + (\beta_1 + \beta_2 \cdot Loss_{t-1})\,\Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{1t}$$
$$q(\text{CDS},t) = c_2 + (\beta_3 + \beta_4 \cdot Loss_{t-1})\,\Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{2t}$$

where $q(\text{Bond},t)$ and $q(\text{CDS},t)$ are daily net order flows by dealers in the bond and CDS markets, respectively. $q(\text{Bond},t)$ and $q(\text{CDS},t)$ are normalized using their standard deviations. $basis(t)$ is the difference between the CDS spreads and the par-equivalent CDS spreads (PECS) of bonds $(p(\text{CDS},t) - p(\text{Bond},t))$. Losses for bond dealers $Loss_t$ are defined as $\Delta\text{basis}(t) \cdot I(t) \cdot D_t$ where D_t and $I(t)$ are the duration of the bond and dealers' inventories of the bond, respectively. Losses for CDS dealers are defined similarly using the inventory of CDS dealers. The control variables, *ctrls*, include: the lagged basis, basis$(t-1)$; lagged changes in basis, Δbasis$(t-1)$; changes in the VIX, Δvix_t; changes in overnight index swap (OIS) spreads, Δois_t, where the OIS spread is LIBOR minus overnight index swap rates; and aggregate stock returns on primary dealers $ret_{dealer,t}$. In Panel A, the sample sub-periods are: *Pre-crisis* from March 2005 through June 2007 and *CrisisAll* from July 2007 through June 2009. In Panel B, the sample sub-periods are: *Crisis 1* from July 2007 through September 14, 2008; *Crisis 2* from September 15, 2008 through January 2009; and *Crisis 3* from February 2009 through June 2009. When q(CDS) is the dependent variable (second column in each sub-period), we use the financial sample because of the availability of CDS net order flows. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The numbers in parentheses are t-statistics using standard errors clustered at the issuing firm level.

	Panel A: Before and During the Crisis				Panel B: Three Sub-periods of the Crisis					
	Pre-crisis		CrisisAll		Crisis 1		Crisis 2		Crisis 3	
	q(Bond) (1)	q(CDS) (2)	q(Bond) (3)	q(CDS) (4)	q(Bond) (5)	q(CDS) (6)	q(Bond) (7)	q(CDS) (8)	q(Bond) (9)	q(CDS) (10)
Δbasis(t)	-0.42***	0.07	-0.07***	-0.01	-0.15***	-0.03	-0.05***	-0.00	-0.07***	0.00
	(-3.95)	(0.97)	(-6.78)	(-0.80)	(-5.25)	(-0.93)	(-4.23)	(-0.23)	(-6.09)	(0.46)
Δbasis$(t) \cdot Loss_{t-1}$	0.17	3.50	0.02***	0.01	-0.00	0.22	0.04***	-0.01	0.01*	0.02*
	(1.49)	(1.23)	(3.37)	(1.01)	(-0.37)	(0.58)	(3.09)	(-0.63)	(1.65)	(1.82)
$Loss_{t-1}$	0.08	2.73	-0.04	-0.12	0.19	-0.36	-0.06	-0.22	0.01	-0.06
	(0.24)	(1.58)	(-1.20)	(-1.41)	(0.56)	(-0.79)	(-0.49)	(-1.15)	(0.12)	(-0.75)
basis$(t-1)$	-0.00*	0.13	-0.00	0.01**	0.00	0.05**	0.00	0.02**	-0.00	0.01**
	(-1.67)	(1.23)	(-0.21)	(2.35)	(0.83)	(1.97)	(0.27)	(2.05)	(-0.00)	(2.24)
Δbasis$(t-1)$	-0.13**	-0.02	-0.01	-0.01	-0.03*	-0.02	-0.02	-0.01	-0.00	-0.01
	(-2.42)	(-0.33)	(-1.41)	(-1.54)	(-1.88)	(-1.19)	(-1.03)	(-1.04)	(-0.47)	(-1.20)
Δvix_t	-0.00	-0.02	0.00**	-0.00	-0.00	0.01	0.00	0.00	0.01*	-0.05***
	(-0.12)	(-0.72)	(1.97)	(-0.89)	(-1.49)	(0.54)	(1.59)	(0.01)	(1.69)	(-4.40)
Δois_t	1.01***	2.11	0.16***	0.60***	0.21***	-0.08	0.15**	1.13***	0.54	-1.45
	(4.22)	(0.96)	(3.31)	(4.99)	(3.16)	(-0.22)	(2.02)	(5.22)	(1.45)	(-1.54)
$ret_{dealer,t}$	-0.73	-1.89	-0.01	0.10	-0.41**	1.00*	0.01	-0.00	0.02	-0.29
	(-1.57)	(-0.51)	(-0.15)	(0.67)	(-2.54)	(1.88)	(0.20)	(-0.01)	(0.13)	(-0.58)
R^2	0.6%	0.2%	0.6%	0.5%	0.6%	0.4%	0.6%	2.0%	0.9%	2.3%
N	125,504	29,891	112,441	69,141	63,255	39,681	21,543	13,071	27,643	16,389

Table 5
Returns on Corporate Bonds and Basis Arbitrage Activity

This table provides the regression results for the following model:

$$R_{t+1} \quad = \quad c_1 + \beta_1 \text{CDS}^{\text{YES}} + \beta_2 \text{BasisArb}_t + \text{ctrls} + \varepsilon_{t+1}$$

where R_{t+1} is monthly corporate bond returns constructed from the TRACE using the last available daily price within a week of the end of the month. CDS^{YES} is an indicator variable that takes the value of one if the bond has a CDS contract available in Markit prior to September 2008 and zero otherwise. BasisArb1 is $-\text{basis(Aug)} \cdot \text{Mat5Y(Aug)}$ where $-\text{basis(Aug)}$ is the negative of the CDS–bond basis at the end of August 2008 and Mat5Y(Aug) is an indicator variable that takes the value of one if the maturity of the bond at the end of August 2008 is between 4.5 and 5.5 years and zero otherwise. BasisArb2 is $(0.267 - 0.084 \cdot TED - 0.158 \cdot Fragmentation - 0.0729 \cdot Roundtrip - 0.721 \cdot Disagreement) \cdot |\text{basis}(t) \cdot 1_{\text{basis}(t)<0}|$ where TED is the TED spreads, $Fragmentation$ is defined as negative $log(issuer\ bond\ Herfindahl)$ orthogonalized with respect to $log(bond\ amounts)$ where *issuer bond Herfindahl* is the Herfindahl index of a firm's bond issues, *Roundtrip* is the imputed round-trip cost from Feldhütter (2012), $Disagreement$ is the standard deviation of analyst forecasts on two-year earnings from IBES divided by the CRSP stock price, and the coefficients are obtained from Column 7 of Table 5 in Oehmke and Zawadowski (2017). In Panel A, we use the control variables, *ctrls*, which include: time to maturity of bonds, TTM; the VIX, VIX; two illiquidity measures, $ILLIQ1$ by Amihud (2002) and $ILLIQ2$ by Bao et al. (2011); market leverage, LEV; and monthly stock return volatility estimated using daily stock returns, VOL. All control variables are lagged by one month. We also include issue-level credit-rating dummies from S&P. In Panel A, the sample period is September 2008 to December 2008. In Panel B and C, we separately examine each month from August 2008 through December 2008. The numbers in parenthesis are t-statistics clustered at the issuing firm level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Pooled Regressions from September 2008 to December 2008

	Bond Return						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CDS^{YES}	-0.020**			-0.018*	-0.037**	0.015	0.019
	(-2.387)			(-1.690)	(-2.268)	(1.210)	(0.959)
BasisArb1		-1.333**		-1.573**	-0.228		
		(-2.271)		(-2.165)	(-0.255)		
BasisArb2			-0.073***			-0.061***	-0.057***
			(-9.318)			(-8.131)	(-10.190)
TTM_t				0.001	0.000	0.000	0.001*
				(1.262)	(0.298)	(0.925)	(1.941)
VIX_t				0.003***	0.003***	0.003***	0.002***
				(10.769)	(8.917)	(10.567)	(8.485)
$ILLIQ1_t$				0.108	0.091	-0.182	-0.405
				(0.547)	(0.435)	(-0.844)	(-1.234)
$ILLIQ2_t$				0.005*	0.002	0.005	0.001
				(1.728)	(0.667)	(0.876)	(0.265)
LEV_t					-0.001		-0.002***
					(-1.352)		(-5.156)
VOL_t					-0.356		-0.046
					(-1.496)		(-0.186)
$LEV_t \cdot VOL_t$					0.024***		0.032***
					(3.454)		(4.318)
R^2	12.2%	12.0%	18.0%	37.1%	48.5%	52.6%	56.7%
N	1,960	1,933	659	1,466	1,140	538	526
Rating Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Month-by-Month Analysis (BasisArb1)					
	Bond Return				
	Aug	Sep	Oct	Nov	Dec
CDS^{YES}	-0.001	-0.067***	-0.009	-0.003	-0.003
	(-0.419)	(-2.892)	(-0.706)	(-0.369)	(-0.162)
BasisArb1	0.303**	-4.252***	3.378*	-0.507	0.470
	(2.211)	(-2.867)	(1.795)	(-0.700)	(0.344)
R^2	12.8%	24.1%	41.9%	42.5%	10.4%
N	567	503	539	529	362
Rating Dummy	Yes	Yes	Yes	Yes	Yes

Panel C: Month-by-Month Analysis (BasisArb2)					
	Bond Return				
	Aug	Sep	Oct	Nov	Dec
CDS^{YES}	0.006	0.013	-0.030	0.038***	-0.041*
	(0.687)	(0.775)	(-1.424)	(4.484)	(-1.732)
BasisArb2	-0.273	-2.692***	0.234***	0.078***	-0.007
	(-1.069)	(-6.364)	(2.853)	(5.936)	(-0.815)
$R2$	6.5%	30.4%	43.5%	36.1%	8.6%
N	176	165	173	180	141
Rating Dummy	Yes	Yes	Yes	Yes	Yes

Table 6
Returns on Lehman-Underwritten Bonds

This table provides the regression results for the following model for each month from August 2008 to December 2008:

$$R_{t+1} = c_1 + \beta_1 \mathrm{LU} + \beta_2 \mathrm{CDS}^{\mathrm{YES}} + \beta_3 \mathrm{LU} \cdot \mathrm{CDS}^{\mathrm{YES}} + \varepsilon_{t+1}$$

where R_{t+1} is the monthly corporate bond returns constructed from the TRACE using the last available daily price within a week of the end of the month, $\mathrm{CDS}^{\mathrm{YES}}$ is an indicator variable that takes the value of one if the bond has a CDS contract available in Markit prior to September 2008 and zero otherwise, and LU is an indicator variable that takes the value of one if the bond has Lehman Brothers as a lead underwriter. We obtain the lead underwriter information from the Mergent FISD. We include issue-level credit-rating dummies from S&P. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The numbers in parenthesis are t-statistics using standard errors clustered at the issuing firm level.

	Bond Return									
	Aug		Sep		Oct		Nov		Dec	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
LU	-0.003	-0.009	-0.028**	0.007	0.009	-0.017	-0.004	-0.020	0.022***	0.017
	(-0.840)	(-1.512)	(-2.562)	(0.374)	(0.727)	(-0.794)	(-0.475)	(-1.077)	(2.817)	(0.877)
$\mathrm{CDS}^{\mathrm{YES}}$		-0.002		-0.021**		-0.006		-0.009		-0.001
		(-0.600)		(-2.202)		(-0.468)		(-1.111)		(-0.053)
$\mathrm{LU} \cdot \mathrm{CDS}^{\mathrm{YES}}$		0.007		-0.040*		0.030		0.020		0.005
		(0.969)		(-1.702)		(1.109)		(0.933)		(0.229)
R^2	11.6%	11.7%	18.2%	21.5%	30.6%	30.9%	28.8%	29.1%	12.6%	12.6%
N	573	573	511	511	546	546	537	537	366	366
Rating Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 7
Liquidity Provision on Bonds Underwritten by Lehman Brothers

This table provides the regression results for the following model:

$$q(\text{Bond}, t) \quad = \quad c_1 + \beta_1 \Delta \text{basis}(t) \cdot \text{LU} + \beta_2 \Delta \text{basis}(t) + \beta_3 \text{LU} + \text{ctrls} + \varepsilon_{t+1}$$

where $q(\text{Bond}, t)$ is daily net order flows by dealers normalized using the standard deviation, and $basis(t)$ is the CDS spreads minus the par-equivalent CDS spreads (PECS). Changes in the basis are measured at daily frequencies and are winsorized at 0.25% at both the top and the bottom. LU is an indicator variable that takes the value of one if the bond has Lehman Brothers as a lead underwriter. The control variables, $ctrls$, include: the lagged basis, basis$(t-1)$; lagged changes in basis, Δbasis$(t-1)$; changes in the VIX, Δvix_t; changes in overnight index swap (OIS) spreads, Δois_t, where the OIS spread is LIBOR minus overnight index swap rates; and aggregate stock returns on primary dealers $ret_{dealer,t}$. The sample sub-periods are: $m(-3)$ for June 2008; $m(-2)$ for July 2008; $m(-1)$ from August 2008 through September 14, 2008; $m(+1)$ from September 15, 2008 through October 2008; $m(+2)$ for November 2008; and $m(+3)$ for December 2008. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The numbers in parentheses are t-statistics using standard errors clustered at the issuing firm level.

	Before the Lehman Collapse			After the Lehman Collapse		
	q(Bond)	q(Bond)	q(Bond)	q(Bond)	q(Bond)	q(Bond)
	$m(-3)$	$m(-2)$	$m(-1)$	$m(+1)$	$m(+2)$	$m(+3)$
Δbasis$(t) \cdot$ LU	0.002	0.058*	0.068***	0.042**	0.011	0.005
	(0.020)	(1.710)	(3.252)	(2.545)	(0.817)	(0.168)
Δbasis(t)	-0.226***	-0.124***	-0.093***	-0.043***	-0.045***	-0.048***
	(-4.187)	(-4.951)	(-5.052)	(-5.363)	(-3.491)	(-2.880)
LU	-0.010	0.018	0.021	-0.036	-0.010	0.062**
	(-0.368)	(0.613)	(1.419)	(-1.360)	(-0.421)	(2.068)
basis$(t-1)$	0.012	0.010	0.007*	-0.003	0.003**	-0.000
	(0.812)	(1.061)	(1.919)	(-1.597)	(1.982)	(-0.086)
Δbasis$(t-1)$	0.028	-0.093***	0.024	0.002	-0.004	-0.003
	(0.921)	(-3.321)	(0.857)	(0.312)	(-0.524)	(-0.220)
Δvix_t	0.016	-0.041***	-0.011	-0.003	0.003	0.005
	(1.501)	(-3.650)	(-0.796)	(-1.362)	(1.270)	(0.821)
Δois_t	0.958**	1.026	2.147*	-0.013	0.457***	-0.128
	(2.028)	(0.816)	(1.701)	(-0.139)	(3.135)	(-0.686)
$ret_{dealer,t}$	-0.472	-1.215**	-0.571	-0.497***	0.028	0.237
	(-0.758)	(-2.157)	(-1.088)	(-2.631)	(0.852)	(0.572)
R^2	1.5%	1.7%	1.0%	0.8%	1.0%	0.6%
N	5,124	4,885	6,008	7,558	4,164	4,688

Table 8
Illiquidity of Corporate Bonds with Available CDS vs. Unavailable CDS

This table provides the illiquidity measures of bonds with available CDS contracts (CDS) and bonds that do not have CDS contracts ($NonCDS$). We report cross-sectional averages of illiquidity measures from August 2008 through December 2008. $ILLIQ$ is the illiquidity measure based on Amihud (2002) (Panel A), γ is from Bao et al. (2011), and the imputed round-trip cost (IRC) is from Feldhütter (2012) (Panel C). $ILLIQ$ is obtained each month by first taking daily averages of absolute returns divided by trade sizes (in million dollars) and then taking the median of these daily averages within the month. γ is constructed following the procedure in Bao et al. (2011). IRC is the monthly median of daily imputed round-trip costs, which are calculated using transactions on the same bond with the same trade size on the same day when there are no other trades with the same size on that day. We winsorize the measures at the top and bottom 1% levels each month. The third row in each panel reports the differences in illiquidity measures between bonds with CDS contracts and those without CDS contracts. The fourth row in each panel reports t-statistics of the differences in illiquidity.

Panel A: $ILLIQ$ (Amihud 2002)					
	Aug	Sep	Oct	Nov	Dec
$ILLIQ(CDS)$	0.67	0.75	0.89	0.87	0.85
$ILLIQ(NonCDS)$	0.57	0.55	0.65	0.70	0.67
$ILLIQ(CDS) - ILLIQ(NonCDS)$	0.10	0.20	0.24	0.17	0.18
	(2.83)	(5.86)	(6.06)	(3.98)	(4.70)
Panel B: γ (Bao, Pan, and Wang 2012)					
	Aug	Sep	Oct	Nov	Dec
$\gamma(CDS)$	0.81	1.34	1.74	1.17	1.18
$\gamma(NonCDS)$	0.71	1.09	1.65	0.99	1.04
$\gamma(CDS) - \gamma(NonCDS)$	0.09	0.26	0.09	0.18	0.14
	(1.66)	(2.92)	(0.71)	(2.37)	(1.78)
Panel C: IRC (Feldhutter 2012)					
	Aug	Sep	Oct	Nov	Dec
$IRC(CDS)$	1.17%	1.40%	1.48%	1.72%	1.37%
$IRC(NonCDS)$	0.96%	1.02%	1.10%	1.13%	1.17%
$IRC(CDS) - IRC(NonCDS)$	0.21%	0.39%	0.38%	0.59%	0.20%
	(3.65)	(6.68)	(6.78)	(8.72)	(3.49)

Table A-1
Liquidity Demand by Insurance Companies

This table provides the estimation results of the following regressions for the positive and negative lagged basis cases separately:

$$q(\text{Bond}, t) = c_1 + \beta_1 \Delta\text{basis}(t) \cdot Inc + \beta_2 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{1t}$$
$$q(\text{CDS}, t) = c_2 + \beta_3 \Delta\text{basis}(t) \cdot Inc + \beta_4 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{2t}$$

where $q(\text{Bond}, t)$ and $q(\text{CDS}, t)$ are daily net order flows by dealers, normalized using their standard deviations. $basis(t)$ is the difference between the CDS spreads and the PECS of bonds. $Inc(\equiv 1_{\Delta\text{basis}(t)\geq 0})$ is an indicator variable that takes the value of one if $\Delta\text{basis}(t)$ is positive. $Dec(\equiv 1_{\Delta\text{basis}(t)<0})$ is defined similarly. The control variables *ctrls* are the lagged basis, lagged changes in basis, changes in the VIX, changes in overnight index swap (OIS) spreads, and aggregate stock returns on primary dealers. We omit coefficient estimates for the control variables to save space. The sample sub-periods are: *Crisis 1* from July 2007 through September 14, 2008, *Crisis 2* from September 15, 2008 through January 2009, and *Crisis 3* from February 2009 through June 2009. Panel A reports estimation results for the subsample of insurance company trades. Panel B reports subsample results where both dealer and insurance company trades are available. Panel C reports subsample results where only dealer trades are available. The cells in boldface are the cases in which the basis becomes wider; negative estimates on these cells indicate stabilizing liquidity seeking, while positive estimates indicate destabilizing liquidity seeking. When $q(\text{CDS})$ is the dependent variable, we use the financial sample because of the availability of CDS net order flows. The numbers in parentheses are t-statistics using standard errors clustered at the issuing firm level.

	Crisis 1				Crisis 2				Crisis 3			
	basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$	
	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)
Panel A: Insurance Company Trades												
Δbasis$(t)Inc$	**-0.14**	**0.20**	-0.12**	0.23*	**-0.12****	**-0.25**	-0.09**	-0.15	**-0.11****	**-0.83*****	-0.05*	0.24
	(-1.13)	**(0.92)**	(-2.14)	(1.73)	**(-2.05)**	**(-1.42)**	(-2.15)	(-1.04)	**(-2.52)**	**(-2.97)**	(-1.78)	(1.34)
Δbasis$(t)Dec$	0.31***	-0.35**	**0.21*****	**-0.01**	0.04	-0.02	**0.07***	**0.37****	0.28***	0.62***	**0.09****	**-0.06**
	(2.60)	(-2.00)	**(3.30)**	**(-0.08)**	(0.67)	(-0.12)	**(1.66)**	**(2.21)**	(3.53)	(3.38)	**(2.23)**	**(-0.33)**
R^2	1.0%	2.3%	1.3%	1.5%	1.2%	13.6%	1.4%	0.9%	3.8%	15.3%	3.1%	2.1%
N	2,720	3,478	4,673	3,564	485	709	1,939	2,151	927	611	2,376	1,638
Panel B: Dealer Trades on Days with Insurance Company Trading												
	basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$	
	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)
Δbasis$(t)Inc$	**-0.46****	**-0.05**	0.13*	0.11	**0.14**	**-0.46****	0.03	0.04	**-0.08***	**0.31**	-0.18***	-0.05
	(-2.16)	**(-0.35)**	(1.75)	(1.63)	**(1.19)**	**(-2.01)**	(0.70)	(1.02)	**(-1.70)**	**(1.44)**	(-2.77)	(-1.36)
Δbasis$(t)Dec$	-0.69***	-0.09	**-0.18***	**-0.11**	-0.18**	-0.15	**-0.14****	**-0.05**	-0.14*	-0.15	**-0.12*****	**0.11*****
	(-5.67)	(-0.52)	**(-1.73)**	**(-1.06)**	(-2.53)	(-0.80)	**(-2.46)**	**(-0.84)**	(-1.94)	(-0.94)	**(-3.08)**	**(4.00)**
R^2	2.5%	1.4%	0.4%	2.2%	1.5%	9.3%	1.1%	7.6%	1.4%	10.3%	2.0%	5.8%
N	2,701	3,453	4,621	3,521	483	709	1,920	2,151	925	609	2,354	1,611
Panel C: Dealer Trades on Days with No Insurance Company Trading												
	basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$		basis$(t-1)>0$		basis$(t-1)<0$	
	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)	q(Bond)	q(CDS)
Δbasis$(t)Inc$	**-0.25*****	**-0.04**	-0.09***	0.14***	**-0.07**	**0.04**	-0.04*	0.09**	**-0.08*****	**-0.09**	-0.05***	0.00
	(-7.68)	**(-0.36)**	(-3.65)	(3.06)	**(-1.30)**	**(1.25)**	(-1.95)	(2.47)	**(-4.62)**	**(-1.17)**	(-3.53)	(0.34)
Δbasis$(t)Dec$	-0.21***	-0.13	**-0.15*****	**-0.08***	-0.13***	-0.11**	**-0.06*****	**-0.06****	-0.08***	-0.04*	**-0.07*****	**0.01**
	(-5.30)	(-1.31)	**(-5.09)**	**(-1.66)**	(-2.80)	(-2.09)	**(-5.70)**	**(-2.00)**	(-3.78)	(-1.90)	**(-5.84)**	**(0.67)**
R^2	1.1%	0.5%	0.6%	0.2%	1.3%	3.1%	0.7%	1.8%	0.9%	1.8%	0.9%	1.7%
N	23,376	13,950	32,560	18,757	3,532	2,070	15,608	8,141	6,619	4,503	17,745	9,666