Did Liquidity Providers Become Liquidity Seekers? Evidence from the CDS-Bond Basis During the 2008 Financial Crisis*

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This Version: May 2014

Abstract

The misalignment of corporate bond and credit default swap spreads (the CDS-bond basis) during the 2008 financial crisis is often attributed to corporate bond dealers' shedding inventories when liquidity was scarce. This paper documents evidence against this widespread perception. In the months following Lehman's collapse, corporate bond dealers, including proprietary trading desks in investment banks, provided liquidity in response to major selling activity on the part of clients. The dealers' bond inventories rose sharply as a result. Although providing liquidity, dealers did not trade aggressively enough to close the basis. We also show that declines in bond prices following Lehman's collapse were concentrated in bonds with available CDS contracts and high levels of activity in CDS-bond basis trades, indicating that the presence of derivative contracts can disrupt the underlying cash market. Overall, the unwinding of CDS-bond basis trades by non-dealer arbitrageurs, including hedge funds, was the main cause of the large negative basis and the disruption of the credit market.

*We thank Viral Acharya, Hank Bessembinder, Itamar Drechsler, Rob Engle, Mariassunta Giannetti, Joel Hasbrouck, Andrew Karolyi, Jongsub Lee, Changfeng Ma, Neil Pearson, Gunther Wuyts and seminar participants at the Copenhagen Business School, the Stockholm School of Economics, the University of Illinois, Yonsei Business School, the 2013 International Conference on Asia-Pacific Financial Markets, the 2014 South Carolina Fixed Income Conference, and the 2014 Swiss Winter Conference in Financial Intermediation for helpful comments and discussions. We also thank the DTCC for providing the data. The views expressed here are the authors' and do not necessarily represent the views of the Federal Reserve Bank of New York or of the Federal Reserve System.

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1 Introduction

In the months following Lehman Brothers' bankruptcy in 2008, the arbitrage relationship between corporate bonds and credit default swaps (CDS) broke down and the CDS-bond basis, the difference between CDS and bond spreads, widened to an unprecedented level. Many questioned the role of dealers in the corporate bond market as mispricing widened (e.g., Duffie 2010, Mitchell and Pulvino 2012, and Bai and Collin-Dufresne 2013). Given funding liquidity shocks following the Lehman collapse, dealers were forced to de-lever and sell assets at distressed prices (Brunnermeier and Pedersen 2009 and Shleifer and Vishny 2011). At the same time, corporate bond dealers as market makers are supposed to "lean against the wind" by absorbing liquidity shocks and providing immediacy to liquidity demanders (Weill 2007). Whether dealers performed their role as liquidity providers is an open empirical question.

Previous studies that examine this breakdown of no-arbitrage pricing argue that dealers did not provide liquidity and even destabilized the corporate bond and CDS markets. In particular, they point out that the unwinding of arbitrage trading by dealers was one of the main causes of the large negative basis. For example, Mitchell and Pulvino (2012) suggest that investment banks, typically being dealers in these over-the-counter (OTC) markets, were forced to sell large amounts of corporate bonds and unwind CDS positions, which led to the large negative CDS-bond basis. In addition, the aggregate holdings of primary dealers published by the Federal Reserve Bank of New York (see Figure 1) are occasionally taken as evidence of the excessive risk-taking of dealers followed by deleveraging, leading to dealers' failure to provide liquidity.[1]

In this paper, we tackle this issue by employing unique databases for CDS and corporate bond trades to investigate dealers' activity in these OTC markets. Contrary to the common perception, we show that corporate bond dealers traded against price dislocations and provided liquidity when demand for liquidity was at its extreme. Dealers' corporate bond holdings increased sharply as a result. The liquidity demand was most likely due to

[1]See, for example, "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).

the unwinding of basis trades by non-dealer arbitrageurs, e.g., hedge funds, as evidenced by our result that declines in bond prices were much more severe with more active basis arbitrage trades prior to the collapse of Lehman Brothers. These results are important in light of the recent regulatory debate over the Volcker rule and whether dealers should be given less discretion in providing liquidity.

First, we show that dealers in the corporate bond market were indeed deleveraging at the onset of the financial crisis. However, the unloading of bonds came to an end around the fall of Bear Stearns and dealers' bond inventories actually increased sharply during the period following the collapse of Lehman Brothers. This evidence suggests that dealers were performing their customary role as liquidity providers when their clients were demanding liquidity.

We then document strong evidence in favor of corporate bond dealers' providing liquidity when prices deviate from no-arbitrage pricing levels. Specifically, dealer trades are negatively associated with price deviations, an indication that dealers provided liquidity by trading against the tide when other traders drove mispricing. Corporate bond dealers provided liquidity even at the peak of the crisis, and liquidity provision is especially pronounced when bond prices are distressed relative to CDS spreads. These results contrast with the common perception that dealers dumped cash bonds after the Lehman collapse, as suggested by Singh and Aitken (2009) and Mitchell and Pulvino (2012). At the same time, we do not find that dealers traded aggressively enough to close the price gaps, possibly because of the limited balance-sheet capacity of dealer banks (Brunnermeier and Pedersen 2009 and Duffie 2010). This result is also consistent with Weill's (2007) theory, which shows that it is socially optimal for dealers to delay liquidity provision and let prices decline discretely at the time of a crash.

Having examined dealers' liquidity provision, we ask who or what drove the negative basis. Proprietary trading desks at investment banks are unlikely to be the main culprit, since our measure of dealers' trades includes those of proprietary trading desks by the same dealer banks. We hypothesize that the unwinding of CDS-bond basis trades by non-dealer arbitrageurs, e.g., hedge funds, was the driver.[2] In a so-called negative basis trade, arbitrageurs buy relatively cheap cash bonds with funding and hedge the long position with CDS. Simultaneous exits of arbitrageurs following the Lehman Brothers collapse might have caused massive selling pressure in the corporate bond market. If that had occurred, we should observe that liquidity demand and price declines were greater for bonds with actively traded CDS contracts.

We find evidence consistent with this hypothesis. In particular, dealers' corporate bond inventories rose sharply for bonds with traded CDS contracts, compared with bonds without traded CDS. Hedge funds substantially unwound their long CDS positions, while dealers increased their long CDS positions, which suggests that hedge funds are likely to have unwound basis trades. Other institutional investors did not, however, exhibit strong demand for liquidity. For example, insurance companies were not the main liquidity seekers in the corporate bond market. Mutual funds sold bonds without associated traded CDS instead of bonds with traded CDS.

More important, we find that declines in bond prices following Lehman Brothers' collapse were much greater for bonds with available CDS contracts. Specifically, bond returns were 7% lower on average in September 2008 when CDS contracts were available for the bonds. Moreover, bond prices fell more when the basis was more negative and the maturity of the bonds was 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, it was more likely that active basis trading was involved with the bond. Following the negative funding shock in September 2008, price declines would have been concentrated for those bonds, which we confirm in our empirical analysis. These results combined suggest that the large negative basis was driven by non-dealer arbitrageurs. The results are also related to the findings of Ben-David et al. (2012) and Franzoni and Plazzi (2013), who document liquidity demand by hedge funds in the

[2] Mitchell and Pulvino (2012) describe how the deleveraging of highly levered hedge funds, instigated by the failure in the rehypothecation lending market, could be a reason for liquidity demand in the corporate bond market, following the Lehman collapse.

equity market during the financial crisis.

Our empirical evidence suggests that the disruption in the cash market was due to excessive arbitrage trading by hedge funds that was enabled by the presence of derivative contracts. This reveals a new aspect such that the CDS market can affect the cash bond market and adds to the growing literature on the impact of CDS on the real economy. For example, Bolton and Oehmke (2011) show the implications of the empty creditor problem when debtors have access to CDS contracts and Subrahmanyam et al. (2014) empirically document that CDS contracts exacerbate the credit risk of the reference entity. In addition, Saretto and Tookes (2013) show that firms have lower financing costs and can lengthen debt maturity when there are available CDS contracts. Das et al. (2014) document that the advent of CDS was largely detrimental to the liquidity and efficiency of the corporate bond market.

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 factors capturing limits to arbitrage have explanatory power in the cross section but also find that what drove the basis into the negative territory is unclear. Fontana (2011) also shows that variables proxying for limited arbitrage are related to time-series variation in the basis. Our study differs from theirs insofar as we examine whether dealers traded against the widening price dislocations and provided liquidity. Duffie (2010) and Mitchell and Pulvino (2012) explain how capital depletion in financial institutions and their deleveraging can drive the large negative basis. Along this line, practitioners, based on anecdotal evidence, point out dealers' deleveraging and the resulting price pressure in the cash bond market as the main cause for dramatic variation in the basis.[3] In contrast to these studies, we provide actual empirical evidence that non-dealer arbitrageurs (not including proprietary trading desks in investment banks) disrupted the market by exiting from the basis trades.

Our overall result has an important implication for the Volcker rule, the implementation of which is under way. The rule, aiming to rein in excessive risk-taking in the OTC markets, prohibits proprietary trading by banks except for market-making activities. As

[3]See, for example, "The basis monster that ate Wall Street" (D.E. Shaw 2009) and "Bond-CDS Basis Handbook" (J.P. Morgan 2009).

Duffie (2012) and Acharya and Richardson (2009) point out, however, once the proposed rule is fully implemented, market-makers' capacity to provide liquidity will be reduced. Eventually, other institutional investors, including hedge funds, will fill the void. This is not a very desirable outcome, because our evidence points out that the unwinding of arbitrage positions can be detrimental to the cash bond market, and thus to the funding costs of corporations. Since dealers are typically banks that are regulated by capital requirements, they would be in a better position to provide liquidity.

Our paper is organized as follows. Section 2 describes the main data sets and the sample construction. Section 3 illustrates dealers' corporate bond inventories throughout the financial crisis period. Section 4 examines more formally whether dealers provided liquidity through subsequent phases of the financial crisis. In Section 5, we propose an explanation for the existence of the large negative basis in September 2008. Section 6 concludes.

2 Data Description and Variable Construction

In this section, we first describe the data sources we exploit for our analysis of corporate bonds and single-name CDS contracts. We then describe the construction of key variables in our analysis, particularly dealer trades and the bond-CDS basis.

2.1 Corporate Bond and CDS Data

Corporate bond prices and trades are obtained from an enhanced version of the Trade Reporting and Compliance Engine (TRACE). The enhanced TRACE specifies whether a trade is carried out between two dealers or between a customer and a dealer, as well as indicating the dealer's trading direction.[4] The data set also includes untruncated volumes, information previously not disseminated to the public. These enhanced features allow us to track interdealer and dealer-client flows as well as the associated traded prices.

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

To obtain daily prices and traded quantities, we eliminate duplicate records and reversed and canceled trades, as described in Dick-Nielsen (2009). We also eliminate potential influential outliers in terms of price and/or trade size that deviate from the surrounding reports. These outliers usually result from manual errors in which the decimal point was entered incorrectly. After applying these filters, we construct daily bond prices by weighting each trade by its size after eliminating retail trades (trade size less than $100,000), following the recommendation of Bessembinder et al. (2009).[5] We also construct daily client-dealer order flows, using all transactions.

We supplement the corporate bond transactions data with the Mergent FISD, which provides bond characteristics as well as issuance and redemption information on publicly traded corporate bonds in the United States. We obtain the terms and conditions, amount outstanding, ratings, and other relevant information on corporate bonds from this database.

Data on CDS spreads are provided by the Markit Group. We use CDS spreads on quoted modified restructuring clauses.[6] We exploit the full term structure of CDS spreads in our calculation of the basis. Since the basis calculation requires the price difference between bonds and CDS on the same underlying company, we carefully 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 they have CDS contracts available. If not, they are matched to CDS contracts on the parent company.

Traded quantities of CDS are obtained from a unique transaction-level data set, provided by the Depository Trust & Clearing Corporation (DTCC), which provides clearing, settlement and information services for OTC derivatives. The data set covers 35 financial firms as reference entities for the period between February 2007 and June 2009.[7] It provides all CDS transactions that are registered with the automated Trade Information

[5]Bessembinder et al. (2009) recommend this procedure for the construction of daily bond prices to minimize the effect of the large bid-ask bounce associated with small trades.

[6]We use the modified restructuring clause, since it was the most commonly traded until April 2009, which is the heart of our sample period, and it also minimizes the impact of the cheapest-to-deliver option.

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

Warehouse of the DTCC.[8]

Each CDS transaction record in the DTCC database contains the following information: reference entity, trade date and effective date, maturity of the contract, anonymized identities of buyer/seller, type of buyer/seller (dealer, hedge fund, insurance firm, asset manager, financial services, banks, and "other"; "other" accounts for less than 3% of the notional amount traded by non-dealer parties), notional amount of the contract, and transaction type. The different transaction types track the evolution of a trade: new trade; full/partial termination; full/partial assignment (one party in an existing bilateral contract assigns its pre-existing position to one or more parties). Using this transaction-level data, we compute the change in the aggregate inventory of dealers and hedge funds. In the calculation of the daily order flow, we account for all types of transactions and their "correct" timing. For example, while backloads are submitted at a date later than the date of their execution, the notional amount is taken into account at the actual trade date, rather than the submission date. Moreover, days when trade compression cycles occur were excluded from the data set, since these trades are not price-forming trades. The objective of a trade compression is to maintain the same risk profile, while reducing the number of contracts and gross notional values held by participants. During a compression cycle, old transactions are terminated (in full) and replaced by new trades.

We obtain our main data set by merging the aforementioned databases. Our sample period runs from July 2007 through June 2009, the period spanning the financial crisis.

2.2 Construction of Key Variables

2.2.1 Net Flows and Inventory

We construct the net order flows of corporate bond dealers using the enhanced TRACE with untruncated trade size. Since each transaction identifies whether the reported trade is a buy, a sell, or an interdealer trade, we define the net order flow of bond issue i at day

[8] For further details on the data set, see Shachar (2013).

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 buy and sell orders reflect the dealer's perspective and N_t is the total number of transactions on day t. Note that our measure of dealers' net flows include those of proprietary trading desks by the same dealer banks.

Using the daily net flows, we then construct the dealers' inventories at the bond issue level, i:

$$I(\text{Bond}, i, t) := I(\text{Bond}, i, 0) + \sum_{\tau=1}^{t} q(\text{Bond}, i, \tau) \tag{2}$$

where $I(\text{Bond}, i, 0)$ is the initial inventory of bond i, before the existence of the TRACE system and therefore is unobservable. Since our analyses later focus on the variation in dealer inventories, not observing the initial level of dealers' inventory does not pose a concern.

Similarly, on the CDS market front, we calculate net order flows and inventories of dealers as

$$q(\text{CDS}, i, t) := \sum_{n=1}^{N_t} (\text{Buy}(\text{CDS}, i, n) - \text{Sell}(\text{CDS}, i, n)) \tag{3}$$

$$I(\text{CDS}, i, t) := I(\text{CDS}, i, 0) + \sum_{\tau=1}^{t} q(\text{CDS}, i, \tau) \tag{4}$$

where $I(\text{CDS}, i, 0)$ is the initial position of CDS i before it was reported to the DTCC.

2.2.2 The CDS-Bond Basis

The CDS-bond basis at time-t is defined as the difference between the CDS premium, CDS(t), and the bond credit spread, CS(t): basis(t) = CDS(t) − CS(t). In calculating the basis, there are several methodologies to calculate the bond spread, including the Z-spread, par asset swap spread, and par-equivalent CDS spread (PECS). Blanco et al.

(2005) and Fontana (2011) use the difference between the CDS price and the credit spread, which is calculated as the difference between the interpolated 5-year yield on risky bonds and the 5-year swap rate. We follow the PECS methodology of J.P. Morgan (Elizalde et al., 2009), which is also used in other studies (e.g., Bai and Collin-Dufresne 2013).[9]

The PECS is essentially a bond credit spread that is consistent with the term structure of default probabilities priced in the CDS contracts of the issuer. Specifically, we apply a parallel shift to the survival probability curve that is extracted from the CDS contracts to match the observed bond price with the present value of the bond's cash flows. We use LIBOR/swap rates as benchmark 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., PECS. The detailed procedures for the PECS calculation are provided in the Appendix.

Consistent with common practice in the literature, we exclude from the basis calculation bonds with embedded options or special pricing conditions such as convertible, callable or putable bonds, and bonds with sinking fund provisions in order to eliminate pricing impacts from contractual differences. Since we calculate the basis for the most liquid five-year CDS contract, we include in the PECS calculation only bonds with 3-10 years remaining until maturity.

3 Corporate Bond Position of Dealers during the Financial Crisis

It is commonly hypothesized that dealers accumulated highly levered positions in the cash bond market during the credit boom period and subsequently de-levered significantly over the course of the financial crisis (e.g., Adrian and Shin 2010, Acharya and Viswanathan 2011, Shleifer and Vishny 2011). This argument is frequently supported by the data on

[9] According to J.P. Morgan credit derivatives research (Elizalde et al. 2009), the PECS methodology is a more suitable approach to measuring the CDS-bond basis than the asset swap spread or Z-spread methodologies, because the PECS is a bond credit spread measure consistent with the recovery rate and the term structure of default probabilities implied by the CDS market.

the aggregate holdings of primary dealers, published by the Federal Reserve Bank of New York, which we reproduce in Figure 1 (dotted line). However, these holdings data also include bonds issued by non-federal agencies (e.g. GSEs) and thus disguise the distinct trend of corporate bond holdings by dealers.[10]

Nonetheless, potential deleveraging by dealers has been suggested as the main driver of the negative basis during the financial crisis (Singh and Aitken 2009, Duffie 2010, and Mitchell and Pulvino 2012). Large negative shocks can force levered financial institutions, including dealers, to unload bond positions. Given initially high long positions, the unwinding of corporate bonds might have placed heavy selling pressure during the period in which many investors were selling and demanding liquidity. If dealers who are supposed to lean against the wind also sell, bond prices will drop significantly and potentially deviate from no-arbitrage pricing. This mechanism is often pointed out as the main reason for the large negative basis of non-AAA bonds, as plotted in Figure 2.

Using our database, we document evidence against this widespread perception. The advantage of our database is that we can analyze dealers' corporate bond positions throughout the financial crisis period, whereas the data published by the Federal Reserve Bank of New York are based largely on the aggregate bond positions, including MBS issued by non-federal agencies and GSEs.

In Figure 1, we plot the time series for the corporate bond inventories of dealers by cumulating dealer transactions from the TRACE database (solid line). Since the dealers' initial position in corporate bonds is unavailable, we begin the plot at zero in Figure 1. Consistent with the notion that dealers accumulated cash bond positions, we find that the dealers' corporate bond holdings increase substantially (by more than $40 billion) until the summer of 2007, the period leading to the financial crisis.

After the summer of 2007, we observe a large decline in dealers' corporate bond holdings, again consistent with the deleveraging hypothesis. However, the unloading of cor-

[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 the exact corporate bond holdings of dealers, because the Fed extrapolates the corporate bond positions for the period leading up to April 3, 2013 using the composition of corporate bond holdings on that date.

porate bonds suddenly ceases around the time of the Bear Stearns collapse. The dealers' positions remain within that range until the collapse of Lehman Brothers. After the Lehman Brothers collapse, the corporate bond positions start to increase rapidly and continue to do so until the end of 2008. It was during this period, from Lehman Brothers' collapse (September 2008) through the end of 2008, that the negative basis was the most severe for non-AAA investment grade bonds, as plotted in Figure 2. Dealers were buying bonds when bond prices were the most distressed as indicated by the negative basis.

Note that the basis widened significantly even though dealers provided liquidity. One may view this as inadequate liquidity provision, given that dealers are supposed to smooth price fluctuations. The balance-sheet capacity of dealers might have been depleted at the peak of the financial crisis, and thus the dealers were not able to exploit the arbitrage opportunities (Duffie 2010). Alternatively, the wide basis is also consistent with optimal liquidity provision by dealers, as suggested by Weill (2007). According to Weill (2007), socially optimal asset allocation implies that dealers start providing liquidity only after price falls discretely at the time of a shock, because forcing dealers to hold assets too long is costly if the shock is persistent, as we saw in the 2008 financial crisis.

Overall, the pattern in dealers' positions suggests that, contrary to the common notion that dealers demanded liquidity during the financial crisis, dealers in fact provided liquidity when corporate bond prices were in the state of greatest distress. It was clients, not dealers, who sold large quantities of corporate bonds and demanded liquidity. We examine dealers' liquidity provision in greater depth in the next section.

4 Liquidity Provision by Dealers During the Financial Crisis

The results reported in the previous section show that corporate bond dealers increased inventories sharply after the Lehman collapse, suggesting that dealers provided liquidity when there was massive selling in the corporate bond market. In this section, we examine dealers' liquidity provision more formally.

We take our notion of liquidity provision and demand from the literature on the limits of arbitrage.[11] For example, in Brunnermeier and Pedersen (2009), liquidity providers are arbitrageurs who smooth price fluctuations when the price and fundamental values diverge due to liquidity shocks. Thus, liquidity providers tend to trade against price dislocations (lean against the wind). They buy low when prices fall and sell high when prices rise. Liquidity demanders, on the other hand, demand immediacy and move prices in the direction of their trades. Keim and Madhavan (1997), Campbell et al. (2009), Puckett and Yan (2011), and Franzoni and Plazzi (2013) also employ a similar notion of liquidity provision.

Using this notion of liquidity provision, we examine how dealers trade against price pressure that drives corporate bond and CDS prices away from each other. Specifically, we examine how dealers' net buys (buy minus sell) are associated with changes in price deviations, or the CDS-bond basis.

4.1 Baseline Regression

4.1.1 Specification

The baseline model regresses daily net buys by dealers on daily changes in the basis. Specifically, we consider the following specifications:

$$
\begin{aligned}
q(\text{Bond}, t) &= c_1 + \beta_1 \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{1t} && (5)\\
&\equiv c_1 + \beta_1 \left(\Delta p(\text{CDS}, t) - \Delta p(\text{Bond}, t)\right) + \text{ctrls} + \varepsilon_{1t} \\
q(\text{CDS}, t) &= c_2 + \beta_2 \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{2t} && (6)\\
&\equiv c_2 + \beta_2 \left(\Delta p(\text{CDS}, t) - \Delta p(\text{Bond}, t)\right) + \text{ctrls} + \varepsilon_{2t}
\end{aligned}
$$

where $q(\text{Bond}, t)$ is the corporate bond net order flow of dealers (buy minus sell volumes) and $q(\text{CDS}, t)$ is the CDS net order flow of dealers on day t. For easier interpretation of economic magnitude, both $q(\text{Bond}, t)$ and $q(\text{CDS}, t)$ are normalized using their standard deviations, respectively. The basis ($\text{basis}(t) \equiv p(\text{CDS}, t) - p(\text{Bond}, t)$) is the difference

[11] See Shleifer and Vishny (1997) and Vayanos and Gromb (2010) among many others.

between the CDS spread, $p(\text{CDS}, t)$, and the PECS, $p(\text{Bond}, t)$. Since the five-year maturity CDS is the most liquid, we use five-year maturity PECS and CDS spreads. 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.[12] We also include a lagged basis and its change. If bond or CDS prices deviate from each other and the basis widens, there could be order flows coming from convergence trading (Blanco et al., 2005). The lagged basis will capture this effect.

The two specifications (5) and (6) allow us to analyze whether dealers trade against price deviations and provide liquidity in each market. Negative signs on β_1 and β_2 imply that dealers trade to "lean against the wind," indicating liquidity provision. In (5), for example, a negative value for β_1 implies that dealers' buys are associated with negative changes in basis, which in turn means that dealers buy bonds when bond spreads increase (or bond prices decrease) relative to CDS spreads. Similarly in (6), a negative β_2 implies that dealers tend to buy CDS when the CDS spread with respect to the bond spread narrows, also signaling that dealers trade against price deviations.

We prefer using basis changes to using bond or CDS spread changes alone in (5) or (6) to capture liquidity provision with respect to price dislocations. The basis change is supposedly a cleaner measure of price deviation from fundamentals. At the same time, we are aware of the limitation of this interpretation insofar as the basis can deviate from zero for reasons other than mispricing. The basis can be driven by illiquidity or the funding costs of corporate bonds (Longstaff et al. 2005 and Gârleanu and Pedersen 2011). Trading liquidity, funding cost, and counterparty risk can explain the cross-sectional variation in the basis (Bai and Collin-Dufresne 2013). For this reason, we also include as explanatory variables both bond and CDS spread changes instead of basis changes only, to better understand whether dealer trades are associated with relative mispricing.

We divide the sample period into three sub-periods of the financial crisis. The first

[12]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.

sub-period, *Crisis 1*, runs from July 1, 2007 through September 15, 2008 when Lehman Brothers' collapsed. This period marks the beginning of the meltdown of the financial market and includes the collapse of Bear Stearns. Although volatility was elevated, the CDS-bond basis was in a moderate range. The second period, *Crisis 2*, is the period from the Lehman collapse when the basis was large and negative. The third period, *Crisis 3*, is the recovery period running from February 2009 through June 2009, during which large gaps in basis started to narrow.

4.1.2 Baseline Regression Results

We first provide summary statistics on dealer trades in Table 1. We report averages and standard deviations for the basis, CDS spreads, PECS, and dealers' gross buy and sell quantities. On average, bond dealers buy $3-$5 million worth of bonds at face value each day. Corporate bond dealers tend to sell more in periods other than *Crisis 2*, which is consistent with the idea of deleveraging. However, in the *Crisis 2* period, buy quantities in non-AAA bonds are greater than sell quantities, indicating that bond dealers tend to be net buyers during the post-Lehman period.

In Table 2, we report regression results from (5) and (6) for each sub-period of the financial crisis. The results show liquidity provision by dealers, especially in the bond market. In the first columns of each sub-period, bond dealers' trades are always negatively associated with basis changes, indicating that dealers trade against price changes, although liquidity provision becomes weaker 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.

In the second columns of each sub-period panel, we include both bond and CDS spread changes, $\Delta p(\text{CDS}, t)$ and $-\Delta p(\text{Bond}, t)$, as explanatory variables. This analysis allows us to further investigate whether dealers trade against relative mispricing. The coefficients on the CDS and bond spread changes are similar in magnitude and both are statistically significant during *Crisis 1* and *Crisis 2*. This result shows that bond dealers serve as a liquidity provider, especially when bond spreads deviate away from CDS spreads. The flip side of this result is that non-dealers in the bond markets were driving prices away, or widening the basis. Overall, the results are inconsistent with the notion that bond dealers exacerbated mispricing during the crisis.

In contrast to the bond market results, we find no indication that CDS dealers trade against basis changes. Instead, their trades are largely negatively associated with CDS spread changes only. For example, in the fourth column of the sub-period panel *Crisis 3*, the coefficient on the CDS spread change is negative and statistically significant, showing that CDS dealers provide liquidity mainly to changes in CDS prices. The result also suggests that the basis is likely to be due to dislocation in bond prices.

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, liquidity seeking buys in bonds will drive bond prices up, which can be viewed as stabilizing liquidity seeking in the sense that these trades move prices back to the parity relationship between bond and CDS prices. In contrast, if traders sell bonds and drive bond prices further down when the basis is negative, this liquidity demand can be seen as destabilizing, because it exacerbates the breakdown of the law of one price.

Although dealers provide liquidity on average, it is possible that they are engaged in destabilizing liquidity seeking and thereby drive the basis deeper into negative territory. To investigate this possibility, we divide the sample into positive and negative basis cases and examine how an increase and a decrease in the basis are associated with dealers' net buys. Specifically, we investigate the following regression specification, separately for cases in which the lagged basis, basis$(t-1)$, is positive and negative:

$$q(\text{Bond}, t) = c_1 + \beta_1 \Delta\text{basis}(t) \cdot Inc + \beta_2 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{1t} \quad (7)$$

$$q(\text{CDS}, t) = c_3 + \beta_3 \Delta\text{basis}(t) \cdot Inc + \beta_4 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{3t} \quad (8)$$

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 trade 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 close down the basis. Interpretation of the coefficients is similar when the lagged basis is negative. 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 (7) and (8). We find no evidence that dealers are engaged in destabilizing liquidity seeking in the bond market. Rather, the 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 *Crisis 2*, for example, the coefficient on $\Delta\text{basis}(t)Dec$ is –0.07 and highly statistically significant, which shows bond dealers' liquidity provision given further deterioration in the basis. 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.

For the CDS market, we find some evidence of liquidity seeking by dealers. For example, when the lagged basis is negative in *Crisis 1* and *Crisis 2*, CDS dealers tend to buy given an increase in the basis (see the positive coefficients on $\Delta\text{basis}(t)Inc$). However, this result indicates stabilizing liquidity seeking by dealers, because such CDS buys tend to narrow the basis. We also find destabilizing liquidity seeking in the *Crisis 3* period when the lagged basis is negative, in which case CDS dealers' sells could exacerbate the negative basis.

Although there is some evidence of destabilizing liquidity seeking by CDS dealers, the overall results show that dealers provided liquidity and tended to stabilize the basis, especially in the corporate bond market.

4.3 Liquidity Provision When Mispricing Is Large

In this section, we investigate whether dealers provide liquidity when the market needs it most or when bond prices are severely distressed relative to CDS spreads. Given large sell-offs in the bond market and a resulting large negative basis, dealers could have suffered from reduced funding liquidity and started selling bonds in the market, similar to the liquidity spiral channel of Brunnermeier and Pedersen (2009). This mechanism implies that dealers might seek liquidity when the basis is very negative.

To explore this possibility, we interact a lagged absolute basis with changes in the basis:

$$q(\text{Bond}, t) = c_1 + (\beta_1 + \beta_2 \cdot |\text{basis}(t-1)|)\, \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{1t}$$
$$q(\text{CDS}, t) = c_3 + (\beta_3 + \beta_4 \cdot |\text{basis}(t-1)|)\, \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{3t}$$

where the absolute value of the basis, $|\text{basis}(t-1)|$, is normalized using its standard deviation for easier interpretation of economic significance. As in the previous section, we estimate this model for both positive and negative lagged basis cases to separately examine when bonds are relatively expensive (positive basis) versus cheap (negative basis). If liquidity provision is stronger when the basis is larger, we expect the coefficients of the interaction terms (β_2 and β_4) to be negative.

The results are provided in Table 4. We find that bond dealers' liquidity provision indeed tends to be weaker when the basis becomes more negative. However, this result does not necessarily mean that bond dealers become liquidity seekers. Since the coefficients on the interaction terms (Δbasis$(t)|$basis$(t-1)|$) are small numbers, bond dealers are still likely to provide liquidity even when bond prices are severely distressed relative to CDS. In *Crisis 2*, for example, the coefficient estimate for the interaction term is only 0.01, which means that the overall coefficient of the change in the basis, $(\beta_1 + \beta_2 \cdot |\text{basis}(t-1)|)$, is likely negative even with a few standard deviation changes in the absolute basis. This observation is also the case for the other crisis periods. In sum, bond dealers still provide liquidity, albeit to a lesser degree, when bond prices are severely distressed.

When the lagged basis is positive, the results in Table 4 exhibit liquidity seeking on the part of corporate bond dealers. The coefficients for the interaction terms are quite sizable. In *Crisis 2*, for example, the coefficient estimate for Δbasis$(t)|$basis$(t-1)|$ is 0.15, implying that bond dealers may become liquidity seekers if bond prices rise substantially relative to CDS. Note that the positive basis is concentrated in AAA bonds, which can suggest that this liquidity seeking for the positive basis can be due to a flight-to-quality after the Lehman collapse. Since AAA bonds were coveted and dealers were also chasing these AAA bonds, the price of AAA bonds went up compared to the CDS prices.

In the CDS market, we find weaker results for liquidity seeking as the basis widens. Only in the *Crisis 1* period when the basis is positive, we find CDS dealers become liquidity seekers when the basis is large. In other cases, we do not find that dealers' liquidity provision substantially depends on the size of the basis. Overall, the results again suggest that dealers in both markets tended to provide liquidity when the market needed it most, except for the possible flight-to-quality cases for AAA bonds.

4.4 Liquidity Seeking by Insurance Companies

The results so far demonstrate that, contrary to common perception, dealers in the corporate bond markets provided liquidity when others were seeking liquidity during the financial crisis. Who are these other investors who seek liquidity?

Insurance companies, pension companies, mutual funds, and hedge funds are major investors in the corporate bond market. Among these players, we investigate the daily trading behavior of insurance companies, using their corporate bond trades in the secondary market as recorded in the NAIC database. The database provides information on whether insurance companies are buyers or sellers as well as transaction prices and dollar amounts. We also examine insurance companies' CDS trades provided in the DTCC database.

In Panel A of Table 5, we investigate liquidity demand by insurance companies by estimating the specification in (7) and (8). Positive estimates in the boldface cells indicate destabilizing liquidity seeking, i.e., trades that further widen 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 the basis is negative, for example, the regression coefficient of net bond buys on $\Delta\text{basis}(t) \cdot Dec$ is 0.07, statistically significant at the 10% level. Although only marginally significant, this evidence can 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 trade (Panel B) and when insurance companies do 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 larger in magnitude in Panel B than those 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 strongly provide liquidity even when there is no insurance company trade. Further, the number of non-insurance company trading days in Panel C is much larger than the number of insurance company trading days in Panel B. This implies that the majority of liquidity seeking during the financial crisis is not caused by insurance companies. Overall, the results in Table 5 suggest that insurance companies are not likely to be the main liquidity seekers following the Lehman collapse.

5 The Unwinding of Negative Basis Trades During the Financial Crisis

The results discussed in the previous section show strong liquidity demand by non-dealer corporate bond traders. Still, these results do not answer the question as to what drove the negative basis during the financial crisis. Several studies have tackled this question, for example, Gârleanu and Pedersen (2011), Fontana (2011), and Bai and Collin-Dufresne (2013). Although the conclusions of the papers differ slightly, the common theme is that many factors that might have driven the basis were not able to resolve the question completely.

In this section, we uncover a channel that can help explain the large negative basis during the financial crisis. We focus on the unwinding of CDS-bond basis trades by highly levered non-dealer investors. Specifically, we show that the high level of liquidity seeking was concentrated in bonds with available CDS contracts. For these bonds, basis arbitrage traders, most likely hedge funds, had to de-lever their corporate bond positions due to funding liquidity shocks after Lehman Brothers' collapse, and as a result, dealers provided liquidity by buying the bonds dumped by the basis traders. In contrast, bonds with no CDS contracts available might not have experienced heavy selling pressure from non-dealer traders and the corresponding price declines might not have been severe. We provide results supporting this hypothesis.

5.1 Dealers' Inventory of Bonds with Available CDS vs. Those Without Available CDS

In Figure 3, we show the difference between dealers' holdings of corporate bonds with available CDS and those without available CDS. The pattern in the figure clearly indicates that dealers increased inventory only for bonds with available CDS after Lehman Brothers' collapse, which in turn means that clients sold such bonds. The pattern is consistent with the hypothesis that the wide basis deviation during the financial crisis resulted from the unwinding undertaken by basis arbitrageurs.

In Figure 4, we examine the holdings of corporate bonds by open-end domestic mutual funds, as provided in the MorningStar database. Specifically, we plot mutual funds' holdings of bonds with CDS available vs. those with CDS unavailable. We find that mutual funds did not significantly change their holdings of bonds with CDS contracts available. 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.

The evidence so far suggests that bonds with CDS contracts available were sold in great volumes after the Lehman collapse and were not sold by dealers or mutual funds. The results in the previous section also show that insurance companies were not the main liquidity seekers. Then, who were those liquidity-demanding investors? Most likely, they were non-dealer basis arbitrageurs. Typically, basis arbitrageurs are dealers, proprietary trading desks in investment banks, or hedge funds. Our measures for dealer trades obtained from the TRACE include those trades made by proprietary trading desks in investment banks, which leaves hedge funds as the most likely liquidity demanders during the months following the Lehman collapse. Mitchell and Pulvino (2012) demonstrate in greater detail how hedge funds demanded liquidity.

Another piece of evidence pointing to hedge funds comes from Figure 5, which plots positions in CDS whose reference entities are financial firms available in the DTCC database.[13] We plot aggregate positions held by dealers, hedge funds, and insurance companies, separately. We find that CDS positions of hedge funds are almost the mirror image of those of the dealers, indicating that, at least in the CDS market, hedge funds are the major counterparty to dealers. More important, hedge funds' CDS positions decline significantly after the Lehman Brothers collapse. Although based on CDS contracts on financial companies, this result is also consistent with the idea that hedge funds substantially unwound negative basis trades.

[13]The plot excludes positions in CDS contracts whose reference entities are Lehman Brothers or Bear Stearns.

5.2 Bond Returns and the Unwinding of Basis Trades Following Lehman Brothers' Collapse

We compare returns on corporate bonds with CDS available with those with CDS unavailable following the Lehman Brothers collapse. According to our hypothesis that the unwinding of the basis arbitrage drove the negative basis, price declines should be more severe for the bonds with CDS contracts available following the collapse. Our measure for CDS availability is based on Saretto and Tookes (2013), who assume that a CDS exists if they find a quote in Bloomberg.

In addition, we also employ a measure for basis arbitrage activity. If the unwinding of basis arbitrage triggers the sell-off, then the greater the arbitrage activity, the stronger the selling pressure on corporate bonds. We use the maturity of the bonds interacted with the basis at the end of August 2008 as a proxy for basis trading activity. CDS contracts with five year maturity are the most prevalent ones. If the bond maturity is five-years at the end of August 2008 and the basis is also large and negative, it is more likely that basis arbitrage trading was involved with the bond and the subsequent exits by arbitrageurs might have been more severe.

We first plot cumulative returns through 2008 for corporate bonds with available CDS and unavailable CDS. Figure 6 shows that bond prices fell dramatically following the Lehman Brothers collapse. Moreover, consistent with our hypothesis, the decline in bond price is more severe for bonds with CDS contracts, by almost 8%. Around the end of January 2009, the bond prices rebound, and the recovery is stronger for bonds with CDS available.

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

$$R_{t+1} = c_1 + \beta_1 \text{CDS}^{\text{YES}} + \beta_2 \text{basis(Aug)} \cdot \text{Mat5Y(Aug)} + \text{ctrls} + \varepsilon_{t+1} \quad (9)$$

where R_{t+1} is monthly bond returns constructed from TRACE; CDS^{YES} is a dummy variable that equals 1 if the bond has a CDS contract with a quote in Markit from January 2002 to August 2008, and zero otherwise; and $\text{basis(Aug)} \cdot \text{Mat5Y(Aug)}$ is the basis level at the end of August 2008 (basis(Aug)) times an indicator variable that takes the value of 1 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 (Mat5Y(Aug)).

As control variables, we include various liquidity and credit risk measures. For bond-specific variables, we control for the illiquidity measures of Amihud (2002) and Bao et al. (2011) and also time-to-maturity. For firm-specific measures, we include market leverage, monthly stock volatility, and the interaction of leverage and the volatility. Since these firm-specific variables are available only for public firms, the sample shrinks substantially when we include them. For market-wide variables, we control for the VIX. We also include bond-level rating dummy variables. We run the regression for the period September 2008 through December 2008, since that was the period when bond prices experienced the heaviest selling pressure following Lehman Brothers' bankruptcy.

Table 6 details the regression results. We find that bonds with available CDS contracts experience much lower returns than bonds without available CDS contracts, consistent with our hypothesis. Specifically, the coefficient on CDS^{YES} in the first column is –0.02 and statistically significant at the 1% confidence level, showing that bond returns are 2% lower monthly for the period September 2008 through December 2008. The result is robust to adding the control variables in the third and fourth columns.

Furthermore, we find positive coefficients for the interaction term basis(Aug)Mat5Y(Aug) in Table 6, although the estimate becomes statistically insignificant when we control for firm-level variables in the fourth column. This result shows that bond returns tend to be lower if the bonds' maturity is close to five years and the basis is more negative at the end of August 2008, in which case there is supposedly active basis trading before Lehman Brothers' collapse. Overall, the results support the hypothesis that the unwinding of basis trading caused the large negative basis during the financial crisis.

One might argue that these results might be due to the fact that bonds with available CDS are more liquid and investors sold liquid bonds following the Lehman collapse instead of selling illiquid bonds. However, it is not likely that this liquidity channel drives our results. Das et al. (2014) document that bonds with CDS contracts available actually suffer a deterioration in market liquidity. In addition, our results are largely unaffected by market liquidity control variables such as those in Amihud (2002) and Bao et al. (2011) in the third column of Table 6.

In Table 7, we perform the regression separately for each month from August 2008 through December 2008. Before the Lehman Brothers collapse (column *Aug*), there is no effect of CDS availability on bond returns (CDS^{YES}). Arbitrage activity (Mat5Y(Aug)) is negatively related to bond returns. This latter result suggests that more basis trading is associated with higher bond returns, consistent with the idea that basis arbitrage helps close down price gaps in normal times (Kim et al. 2014).

Moving on to the subsequent month, however, we find that the presence of CDS contracts and the proxy for CDS arbitrage activity are strongly associated with bond returns. In September, bonds with CDS available yield on average 7% lower returns than bonds with CDS unavailable. Furthermore, bonds with heavy basis trading experienced large price declines, as can be seen from the positive, statistically significant coefficient estimate for Mat5Y(Aug). In the following months, as the selling pressure calms down, we do not find significant negative returns for bonds with available CDS contracts. In October, bonds with heavy basis trading yield higher returns, suggesting the possible return of arbitrageurs to the bond market.

The overall results suggest that the severe negative basis was due to the exits from excessive arbitrage trading. Although we cannot pinpoint exactly who these arbitrageurs were, it is likely that they were mostly hedge funds. In the bond market, dealers, including proprietary trading desks, on aggregate did not seek liquidity, nor did mutual funds and insurance companies. In the CDS market, hedge funds were the typical counterparties of dealers and they also significantly unwound their long CDS positions. Moreover, declines in bond prices were concentrated in bonds with CDS and supposedly high arbitrage activities.

6 Conclusion

In this paper we examine liquidity provision by dealers in the corporate bond and CDS markets during the 2007-2009 financial crisis. We use unique corporate bond and CDS transactions data sets to construct the positions of dealers in both markets over time as well as the positions of hedge funds in the CDS market. We find that, contrary to common perception, dealers were engaged in liquidity provision in the corporate bond market throughout the financial crisis. Also, we find evidence that declines in bond prices are concentrated in bonds with available CDS contracts and 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.

Our results have an important implication for the Volcker rule. Once the proposed rule is implemented, market-makers' capacity to provide liquidity will be reduced. Given that market-making is a profitable business, other institutional investors, who are typically arbitrageurs, will potentially fill the void. We doubt whether this is a desirable outcome, because our evidence points out that the unwinding of arbitrage positions by these institutional investors can be detrimental to the cash market, and thus to the funding costs of corporations.

Our paper also adds to the literature on the role of CDS contracts in the real economy. Our empirical evidence suggests that the disruption in the cash market was enabled by the presence of derivative contracts. This reveals a new aspect such that the CDS market can affect the underlying market when arbitrageurs exit at the same time.

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A Measuring 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 CDS spread minus bond spread might seem to be a simple difference calculation, making two different instruments comparable is a more intricate task in practice than it may appear. CDS is readily available in a spread form[14] and a full term structure is observable. Bond spreads, on the other hand, are a theoretical measure that needs to be backed out from a unique bond price. In this appendix we review two common spread measures for fixed-rate corporate bonds, Z-spread and par-equivalent CDS spread (PECS), and we then explain why we choose to use the latter as the benchmark specification in this paper.

A.1 Z-Spread Methodology

The Z-spread is the parallel shift, z, to the risk-free curve that gives the market value of the risky corporate bond. The price of a risk-free bond is equal to the present value of the cash flows, including the bond coupons plus the notional amount paid back at maturity. The price of a risky corporate bond is lower than the price of a risk-free bond, since we might not receive all cash flows in the case where the firm does not survive. Hence, to equate the price of a risky corporate bond to the present value of the expected cash flows of the risk-free bond, we need to move the risk-free discount curve by a constant amount z. So, the Z-spread is given as follows:

$$\text{Bond's Dirty Price} \quad = \quad \sum_{n=1}^{N} \frac{\frac{C}{f}}{\left(1+\frac{r(0,t_n)+z}{f}\right)^n} + \frac{1}{\left(1+\frac{r(0,t_N)+z}{f}\right)^N}$$

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

where C is the coupon, and $r(0, t_n)$ is the discretely compounded zero rate, determined from the discount factor to time t_n, $Z(0, t_n)$:

$$Z(0, t_n) = \frac{1}{\left(1 + \frac{r(0, t_n)}{f}\right)^n}.$$

The basis will then be calculated as (CDS Spread $- z$). If the bond's maturity is exactly that of a quoted CDS spread, then it is clear which CDS spread to use for the basis calculation. If not, the choice is either to compare it with the CDS of closest maturity or to interpolate the CDS spread for the bond maturity. While the latter gives a more accurate idea of the spread differential, it has the disadvantage of not being an actual tradable security. Another choice that needs to be made is how to measure the bond spread using the unique price of that bond so it will be comparable with the whole curve of CDS spreads. In the course of converting the bond spread, we also need to decide which risk-free rate to use and which recovery rate to assume.

A.2 Par-Equivalent CDS Spread Methodology

The PECS, 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 PECS. In other words, the PECS is the shift in the term structure of CDS spreads in order to match the price of the bond.

To get the PECS, we start with 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 to 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 resulted 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 able to calculate the basis at any maturity.

As it emerges from the calculations described above, the Z-spread accounts for the maturity of the bond and the term structure of interest rates, while the PECS accounts for the assumed recovery rate and the term structure of default probabilities derived from the CDS market. The former measure implicitly assumes a flat term structure of credit spreads and does not take into account the term structure of default probabilities. Taking as given that the price of credit risk is less biased in the CDS market, the fact that the PECS takes advantage of the entire information encapsulated in the CDS curve adds value and is a key reason for why this measure is preferable.

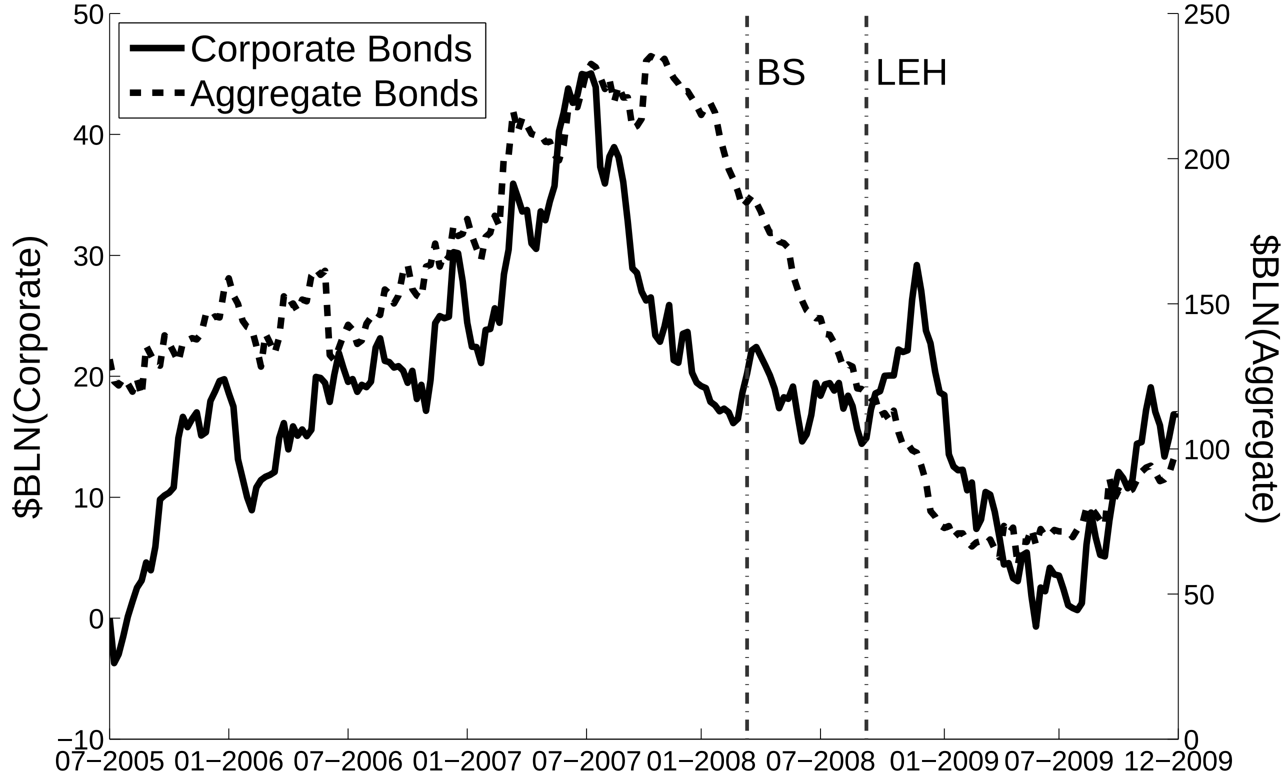

Figure 1: Long-Term Corporate Securities Position of Dealers

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 position 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 MBS. The aggregate position constructed from the TRACE includes only TRACE-eligible corporate bonds.

Figure 2: 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 by J.P. Morgan. Both the CDS and par-equivalent spreads are five-year maturity. We plot the weekly average values in basis points.

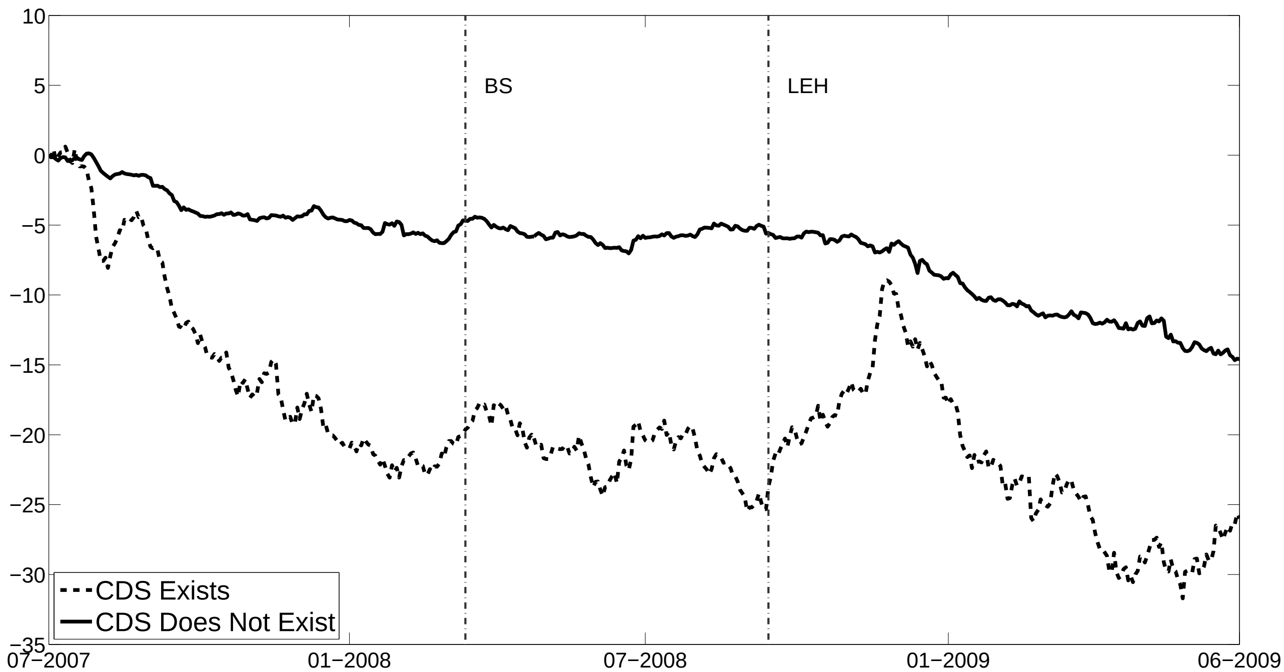

Figure 3: Inventory of Corporate Bonds with Available CDS vs. Corporate Bonds Without Available CDS

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

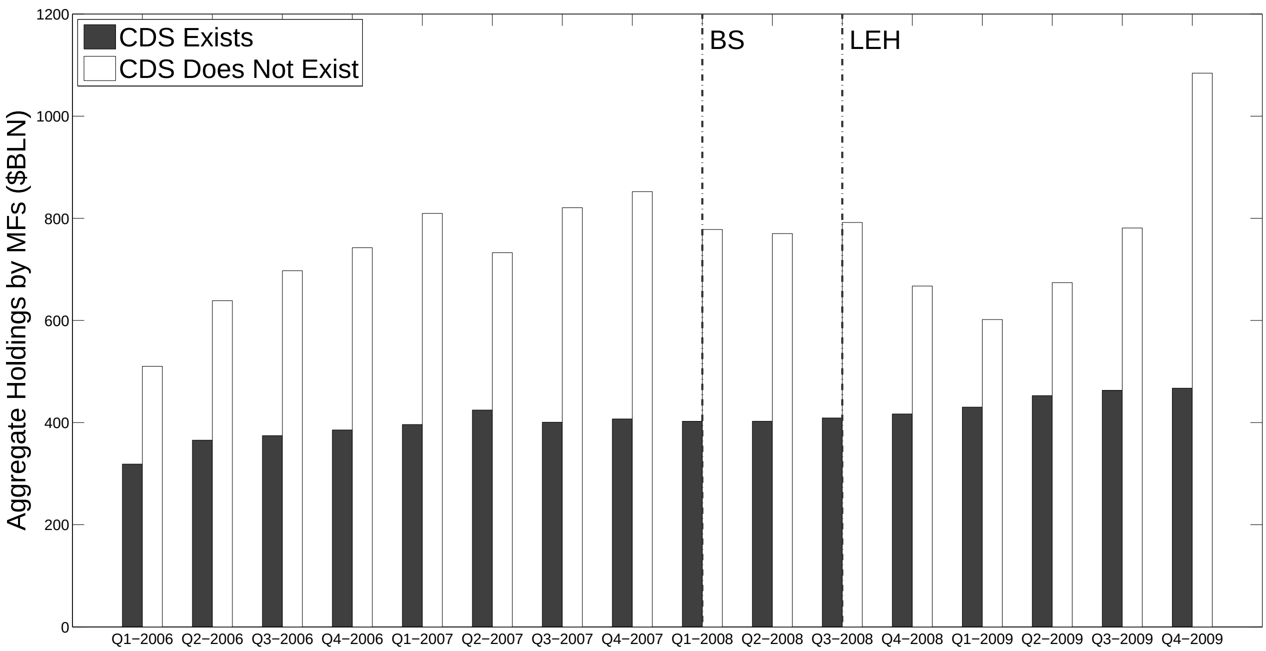

Figure 4: Mutual Funds' Holdings of Corporate Bonds with Available CDS vs. Corporate Bonds Without Available CDS

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 CDS with the inventories of corporate bonds without available CDS. The availability of a CDS is determined by the existence of a quote in Markit for the period from January 2002 to August 2008.

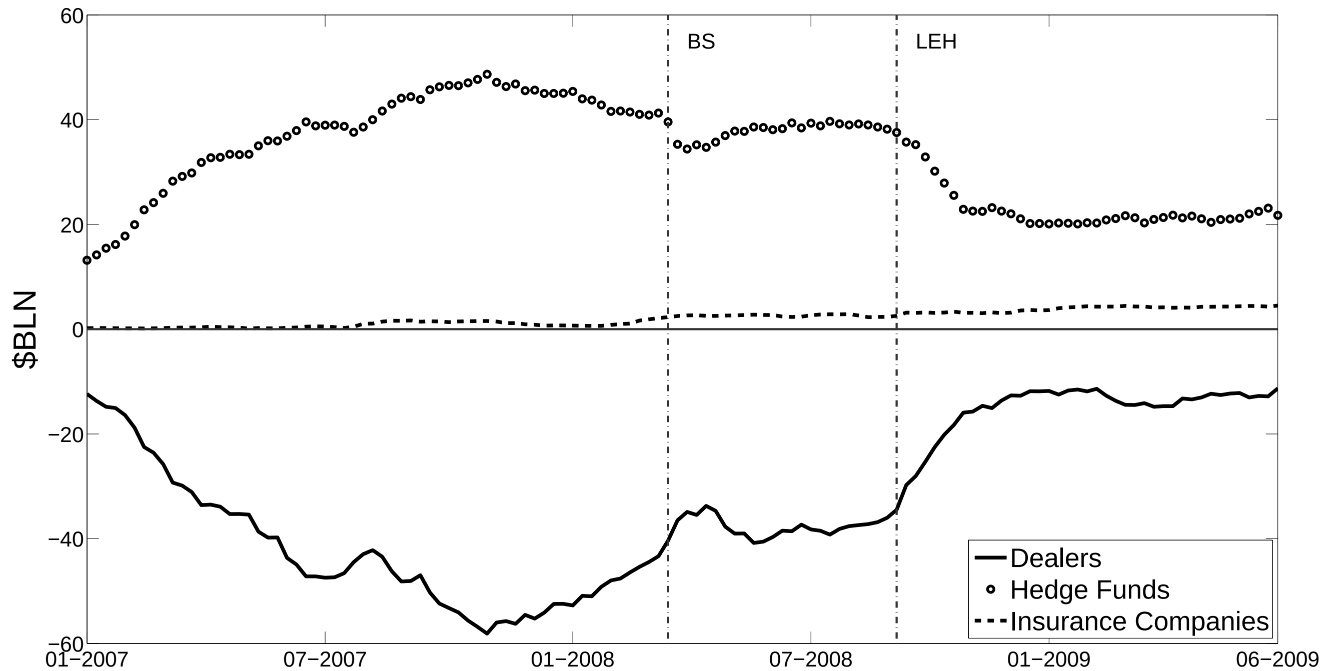

Figure 5: Aggregate CDS Positions by Dealers, Insurance Companies, and Hedge Funds

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

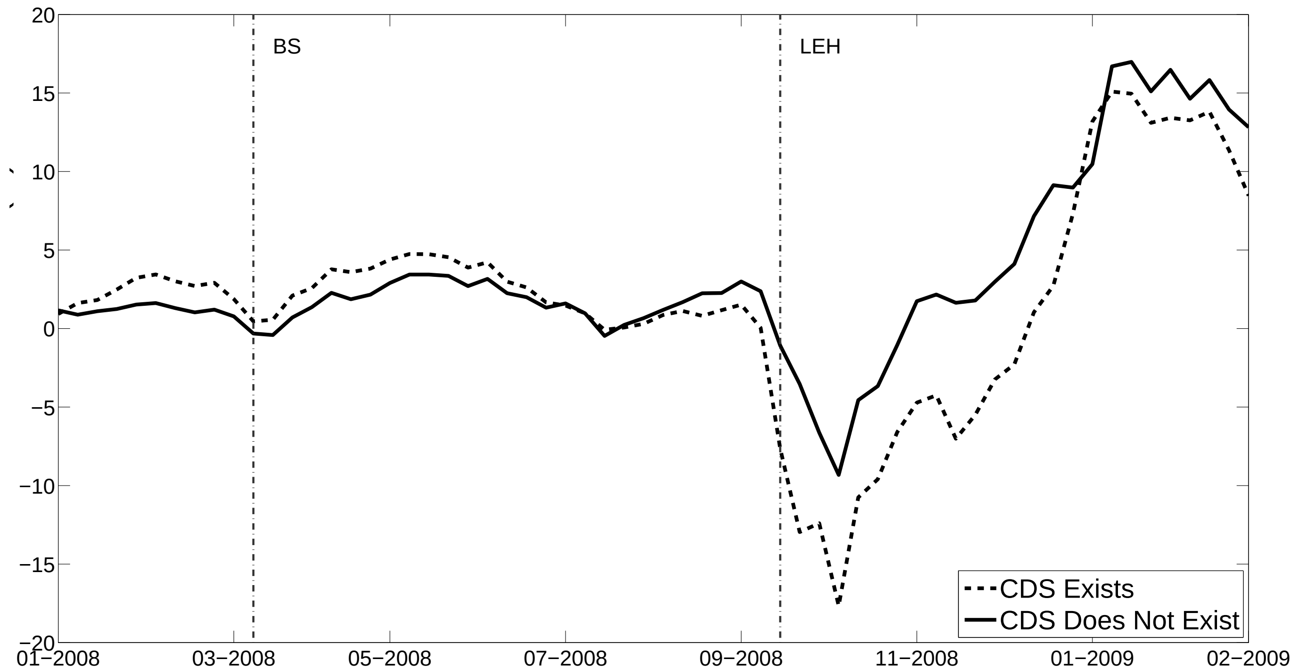

Figure 6: Cumulative Returns for Corporate Bonds with CDS Available vs. Unavailable

This figure plots cumulative weekly corporate bond returns available from the TRACE. Weekly bond returns are constructed using last available daily prices and accrued interest in consecutive weeks. We plot two return series based on the availability of CDS quotes in Markit. The solid line plots returns on bonds that have available CDS contracts and the dashed 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.

Table 1
Summary Statistics

This table provides summary statistics for the following three periods: *Crisis 1* from July 2007 through September 14, 2008, *Crisis 2* from September 15, 2008 through February 28, 2009, and *Crisis 3* from March 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. $q(\text{CDS}, \text{buy})$ and $q(\text{CDS}, \text{sell})$ are daily gross quantities (in millions of dollars) bought and sold by dealers in the CDS market, respectively. $q(\text{Bond}, \text{buy})$ and $q(\text{Bond}, \text{sell})$ are daily gross quantities (in millions of dollars) bought and sold by dealers in the corporate bond market, respectively.

Panel A: AAA									
	Crisis 1			Crisis2			Crisis3		
	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N
basis	0.29	0.40	7,362	1.47	1.28	3,023	2.28	1.50	4,160
$p(\text{CDS})$	0.90	0.49	7,362	4.12	1.38	3,023	4.56	2.36	4,160
$p(\text{Bond})$	0.62	0.46	7,362	2.64	1.45	3,023	2.20	2.47	4,160
$q(\text{CDS}, \text{buy})$	47.04	55.09	6,418	100.21	130.46	2,585	43.52	62.01	3,733
$q(\text{CDS}, \text{sell})$	27.43	33.92	6,332	72.83	95.39	2,450	41.62	63.74	3,567
$q(\text{Bond}, \text{buy})$	3.35	10.17	7,362	5.85	17.51	3,023	8.12	22.75	4,160
$q(\text{Bond}, \text{sell})$	3.66	10.39	7,362	5.86	16.02	3,023	8.21	19.14	4,160
Panel B: Investment Grade excluding AAA									
	Crisis 1			Crisis2			Crisis3		
	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N
basis	-0.32	1.45	50,188	-3.31	5.76	15,572	-2.09	4.09	19,321
$p(\text{CDS})$	1.47	1.66	50,188	3.63	4.25	15,572	3.83	3.90	19,321
$p(\text{Bond})$	1.79	2.41	50,188	6.99	9.33	15,572	5.84	6.59	19,321
$q(\text{CDS}, \text{buy})$	53.63	82.59	39,156	53.97	103.25	12,808	32.09	61.21	15,960
$q(\text{CDS}, \text{sell})$	59.80	86.28	34,268	61.13	93.85	10,578	38.07	67.91	13,908
$q(\text{Bond}, \text{buy})$	3.02	8.94	50,188	3.84	11.02	15,572	3.27	8.29	19,321
$q(\text{Bond}, \text{sell})$	3.16	8.69	50,188	3.75	10.49	15,572	3.42	9.78	19,321
Panel C: High Yield									
	Crisis 1			Crisis2			Crisis3		
	Mean	Stdev	N	Mean	Stdev	N	Mean	Stdev	N
basis	-0.41	2.81	6,460	-11.13	7.21	1,926	-7.99	6.63	2,809
$p(\text{CDS})$	7.48	4.39	6,460	28.02	23.79	1,926	21.68	28.00	2,809
$p(\text{Bond})$	7.98	6.64	6,460	38.20	22.63	1,926	26.62	19.92	2,809
$q(\text{CDS}, \text{buy})$	42.18	63.38	3,059	35.09	41.35	799	14.69	28.13	1,400
$q(\text{CDS}, \text{sell})$	40.34	56.56	2,987	34.39	33.85	794	19.29	31.99	1,058
$q(\text{Bond}, \text{buy})$	3.74	8.40	6,460	5.14	16.48	1,926	3.45	7.18	2,809
$q(\text{Bond}, \text{sell})$	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% both at the top and bottom. The control variables *ctrls* include: the lagged basis, $\text{basis}(t-1)$; lagged changes in basis, $\Delta\text{basis}(t-1)$; 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: *Crisis 1* from July 2007 through September 14, 2008, *Crisis 2* from September 15, 2008 through February 2009, and *Crisis 3* from March 2009 through June 2009. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. The numbers in parentheses are t-statistics using standard errors clustered at the issuing firm level.

	Crisis 1				Crisis 2				Crisis 3			
	Bond	Bond	CDS	CDS	Bond	Bond	CDS	CDS	Bond	Bond	CDS	CDS
$\Delta\text{basis}(t)$	-0.15***		-0.03		-0.05***		-0.00		-0.07***		0.00	
	(-5.27)		(-0.94)		(-4.22)		(-0.20)		(-6.13)		(0.51)	
$\Delta p(\text{CDS}, t)$		-0.19***		0.15		-0.05*		-0.18		-0.02		-0.13**
		(-4.06)		(1.40)		(-1.82)		(-1.42)		(-1.19)		(-2.27)
$-\Delta p(\text{Bond}, t)$		-0.15***		-0.03		-0.05***		-0.01		-0.07***		0.01
		(-5.33)		(-0.96)		(-4.00)		(-0.46)		(-6.00)		(0.82)
$\text{basis}(t-1)$	0.00	0.00	0.05*	0.05**	0.00	0.00	0.02**	0.02**	-0.00	0.00	0.01**	0.01**
	(0.92)	(0.84)	(1.91)	(1.97)	(0.30)	(0.26)	(2.11)	(2.07)	(-0.27)	(0.01)	(2.27)	(2.23)
$\Delta\text{basis}(t-1)$	-0.03*	-0.03*	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.00	-0.00	-0.01	-0.01
	(-1.89)	(-1.93)	(-1.08)	(-1.31)	(-0.97)	(-1.01)	(-0.92)	(-0.67)	(-0.13)	(-0.41)	(-1.59)	(-1.22)
Δvix_t	-0.00	-0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01*	0.01*	-0.06***	-0.05***
	(-1.38)	(-1.48)	(0.41)	(0.54)	(1.40)	(1.58)	(0.62)	(0.02)	(1.82)	(1.69)	(-4.51)	(-4.41)
Δois_t	0.21***	0.21***	-0.11	-0.08	0.15*	0.15**	1.22***	1.12***	0.48	0.54	-1.24	-1.45
	(3.25)	(3.16)	(-0.31)	(-0.22)	(1.96)	(2.04)	(6.05)	(5.20)	(1.36)	(1.46)	(-1.36)	(-1.54)
$ret_{dealer,t}$	-0.46***	-0.41**	1.26***	1.00*	0.00	0.01	-0.00	0.00	0.11	0.02	-0.58	-0.29
	(-2.95)	(-2.55)	(2.59)	(1.89)	(0.10)	(0.19)	(-0.02)	(0.01)	(0.62)	(0.13)	(-1.05)	(-0.58)
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:

$$q(\text{Bond},t) = c_1 + \beta_1 \Delta\text{basis}(t)\cdot Inc + \beta_2 \Delta\text{basis}(t)\cdot Dec + \text{ctrls} + \varepsilon_{1t}$$
$$q(\text{CDS},t) = c_3 + \beta_3 \Delta\text{basis}(t)\cdot Inc + \beta_4 \Delta\text{basis}(t)\cdot Dec + \text{ctrls} + \varepsilon_{3t}$$

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 $ret_{dealer,t}$. The sample sub-periods are: *Crisis 1* from July 2007 through September 14, 2008, *Crisis 2* from September 15, 2008 through February 2009, and *Crisis 3* from March 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. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. 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	
	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS
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 When Basis Is Large

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:

$$q(\text{Bond}, t) = c_1 + (\beta_1 + \beta_2 \cdot |\text{basis}(t-1)|)\, \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{1t}$$
$$q(\text{CDS}, t) = c_3 + (\beta_3 + \beta_4 \cdot |\text{basis}(t-1)|)\, \Delta\text{basis}(t) + \text{ctrls} + \varepsilon_{3t}$$

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 ($p(\text{CDS}, t) - p(\text{Bond}, t)$). 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: *Crisis 1* from July 2007 through September 14, 2008, *Crisis 2* from September 15, 2008 through February 2009, and *Crisis 3* from March 2009 through June 2009. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. 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$(t-1) < 0$	
	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS
Δbasis(t)	-0.36***	-0.16**	-0.17***	0.01	-0.17***	-0.18*	-0.09***	0.01	-0.23***	-0.04*	-0.13***	0.03**
	(-7.10)	(-2.09)	(-4.81)	(0.33)	(-4.51)	(-1.93)	(-6.15)	(0.45)	(-7.49)	(-1.76)	(-9.05)	(2.44)
Δbasis(t)|basis$(t-1)$|	0.31***	0.21**	0.03***	0.00	0.15***	0.12	0.01***	-0.00	0.20***	-0.02	0.01***	-0.00*
	(3.77)	(2.10)	(2.92)	(0.00)	(2.73)	(1.43)	(3.92)	(-0.11)	(6.10)	(-0.67)	(6.32)	(-1.92)
basis$(t-1)$	0.01	0.10**	0.00	-0.00	0.01	0.03	0.00	0.01*	0.01	0.01	0.00	0.01
	(0.78)	(2.19)	(0.63)	(-0.73)	(0.18)	(0.81)	(0.43)	(1.66)	(0.82)	(0.74)	(0.73)	(1.44)
Δbasis$(t-1)$	-0.09***	-0.07*	-0.02	-0.01	-0.14	-0.05	-0.01	-0.00	-0.02	-0.03***	-0.00	-0.00
	(-3.94)	(-1.72)	(-0.91)	(-0.44)	(-1.04)	(-1.25)	(-0.96)	(-0.18)	(-1.27)	(-2.89)	(-0.05)	(-0.51)
Δvix_t	-0.01***	-0.01	0.00	0.02*	0.01**	-0.02***	0.00	0.01	0.02**	-0.04***	0.00	-0.06***
	(-2.67)	(-0.47)	(0.68)	(1.95)	(2.03)	(-4.74)	(0.82)	(0.97)	(2.14)	(-3.52)	(0.94)	(-3.95)
Δois_t	0.37***	-0.14	0.12	-0.09	0.29	0.88***	0.12	1.17***	0.25	-0.53	0.66*	-1.79
	(3.33)	(-0.25)	(1.34)	(-0.23)	(1.63)	(5.07)	(1.41)	(4.80)	(0.33)	(-0.71)	(1.71)	(-1.48)
$ret_{dealer,t}$	-0.45*	-0.26	-0.37	2.06***	0.08	0.49***	-0.01	-0.09	0.18	0.35	-0.03	-0.61
	(-1.85)	(-0.29)	(-1.46)	(3.72)	(0.97)	(4.55)	(-0.25)	(-0.70)	(0.61)	(0.93)	(-0.12)	(-1.03)
R^2	1.4%	0.6%	0.6%	0.2%	1.2%	2.9%	0.8%	1.8%	1.0%	2.4%	1.5%	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 5
Liquidity Demand by Insurance Companies

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

$$q(\text{Bond}, t) = c_1 + \beta_1 \Delta\text{basis}(t) \cdot Inc + \beta_2 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{1t}$$
$$q(\text{CDS}, t) = c_3 + \beta_3 \Delta\text{basis}(t) \cdot Inc + \beta_4 \Delta\text{basis}(t) \cdot Dec + \text{ctrls} + \varepsilon_{3t}$$

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 February 2009, and *Crisis 3* from March 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. 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$(t-1)<0$	
	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	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$(t-1)<0$	
	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	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$(t-1)<0$	
	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	CDS	Bond	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

Table 6
Returns on Corporate Bonds with Available CDS vs. Unavailable CDS After Lehman Brothers' Collapse

This table provides the regression results for the following model:

$$R_{t+1} \quad = \quad c_1 + \beta_1 \text{CDS}^{\text{YES}} + \beta_2 \text{basis(Aug)Mat5Y(Aug)} + \text{ctrls} + \varepsilon_{t+1}$$

where R_{t+1} is the monthly corporate bond returns constructed from the TRACE using the last available daily price within a week from 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, basis(Aug) is 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. The control variables *ctrls* 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. The numbers in parenthesis are t-statistics clustered at the issuing firm level. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. The sample period is September 2008 to December 2008.

	Bond Return			
CDS^{YES}	-0.02**		-0.02*	-0.04**
	(-2.39)		(-1.69)	(-2.27)
basis(Aug) · Mat5Y(Aug)		1.33**	1.57**	0.23
		(2.27)	(2.17)	(0.25)
TTM_t			0.00	0.00
			(1.26)	(0.30)
VIX_t			0.00***	0.00***
			(10.77)	(8.92)
$ILLIQ1_t$			0.11	0.09
			(0.55)	(0.43)
$ILLIQ2_t$			0.01*	0.00
			(1.73)	(0.67)
LEV_t				-0.00
				(-1.35)
VOL_t				-0.36
				(-1.50)
$LEV_t \cdot VOL_t$				0.02***
				(3.45)
R^2	12.2%	12.0%	12.3%	37.1%
N	1,960	1,933	1,933	1,466
Rating Dummy	Yes	Yes	Yes	Yes

Table 7

Returns on Corporate Bonds with Available CDS vs. Unavailable CDS After Lehman Brothers' Collapse: Month-by-Month Analysis

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

$$R_{t+1} \quad = \quad c_1 + \beta_1 \mathrm{CDS}^{\mathrm{YES}} + \beta_2 \mathrm{basis(Aug)Mat5Y(Aug)} + \varepsilon_{t+1}$$

where R_{t+1} is the monthly corporate bond returns constructed from the TRACE using the last available daily price within a week from 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, basis(Aug) is 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. We include issue-level credit rating dummies from S&P. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. The numbers in parenthesis are t-statistics.

	Bond Return				
	Aug	Sep	Oct	Nov	Dec
$\mathrm{CDS}^{\mathrm{YES}}$	-0.00	-0.07***	-0.01	-0.00	-0.00
	(-0.42)	(-2.89)	(-0.71)	(-0.37)	(-0.16)
basis(Aug) · Mat5Y(Aug)	-0.30**	4.25***	-3.38*	0.51	-0.47
	(-2.21)	(2.87)	(-1.79)	(0.70)	(-0.34)
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