Cross-Market Liquidity Shocks: Evidence from the CDS, Corporate Bond, and Equity Markets

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Abstract

Using data from the credit default swap (CDS), corporate bond, and equity markets, we construct several measures of liquidity and examine the spill-over of liquidity shocks across these markets. Based on the principal component analysis of multiple liquidity measures, we show that there is a dominant first principal component in each of the markets. However, the linkage of liquidity shocks varies between different markets. In particular, there is a common component between the equity and both CDS and bond markets, but not between the CDS and bond market. Moreover, the vector autoregression results show that while there is spill-over of liquidity shocks between equity and CDS markets, surprisingly there is no clear spill-over of liquidity shocks between equity and bond markets. There appears to be a time lag of liquidity spill-over from the CDS to both bond and equity markets. Finally, we find no evidence of liquidity spill-over from bond to CDS market.

Key Words: Liquidity shock; Commonality

1 Introduction

Market liquidity has received great attention in recent finance literature and liquidity risk is generally viewed as an important factor of asset prices. Moreover, recent work in this area has focused on the spill-over of liquidity shocks across different markets. The burgeoning research interest by both academics and practitioners is directly motivated by what happened in the market place. For instance, the recent financial crisis was accompanied by a substantial drop in market liquidity and returns across several - otherwise unrelated - markets. In particular, liquidity crunch is widely believed to be the main cause of such dramatic financial market turmoil. A similar phenomenon occurred following the Russian default in August of 1998 and the subsequent collapse of Long Term Capital Management (LTCM) and other financial intermediaries around the world.

Since the Russian crisis several studies have shown that indeed there exists commonality in liquidity *within* the U.S. stock market [Chordia, Roll, and Subrahmanyam (2000), Hasbrouck and Seppi (2001), Huberman and Halka (2001), Acharya and Pedersen (2005)], or other international stock markets.[1] Furthermore, recent studies have shown that the common patterns in returns and liquidity can also be found *across* international markets.[2] Despite the evidence regarding the commonality in returns and liquidity within and across *stock* markets, our knowledge regarding these common patterns in *other* markets, or *across* other markets, is limited thus far. Prior literature has not thoroughly examined this aspect of commonality, with a few exceptions.[3] Furthermore, little is known why we observe these common patterns, again with a few exceptions.

[1]Brockman and Chung (2002) document common patterns of liquidity in the Hong Kong market, Fabre and Frino (2002) and Domowitz, Hansch, and Wang (2005) in the Australian market, Bauer (2004) in the Swiss market, and Mayston and Kempf (2005) in the German market, to name a few.

[2]For example, Qin (2007) shows that commonality in liquidity is more prevalent across emerging markets, rather than developed markets, Brockman, Chung, and Pérignon (2008) investigate the commonality in liquidity using intraday spread and depth data across 47 stock exchanges, and Karolyi, Lee, and Van Dijk (2007) examine the common patterns in returns, liquidity, and trading activity across 40 developed and emerging countries.

[3]Kapadia and Pu (2007) examine the correlation between the credit default swap and equity data for a sample of 153 firms, while Cao and Wei (2008) investigate the commonality in liquidity within the options market using measures such as the bid-ask spread, volume, and price impact.

The aim of this paper is to fill those gaps in the literature. Using multiple data sources from three markets [credit default swap (CDS, hereafter), corporate bond, and equity] that span the period from July 1, 2002 to September 30, 2008, we examine the common patterns in returns and liquidity across these markets. Precisely, we seek to answer the following important questions:

I. Are there common patterns in liquidity *within* the CDS and corporate bond markets?

II. Are there spill-over of liquidity shocks across the three markets at the firm level?

III. Do these cross-market patterns exist at the market-level?

IV. What are the determinants that drive the common patterns?

Investigating the existence of these patterns with different markets and data can provide another perspective as to the source of their existence. This is important since recent studies have shown that risk arising from commonality in liquidity is priced in financial markets [Acharya and Pedersen (2005) in U.S. stock markets, Lee (2006) in international equity markets, Jacoby, Theocharides, and Zheng (2007) in the corporate bond market, and Bongaerts, De Jong, and Driessen (2007) in the CDS market]. Furthermore, other recent studies have shown that liquidity can spill-over from one market to another. For example, Chordia, Sarkar, and Subrhahmanyam (2005) document covariation in liquidity and volatility between the stock and Treasury bond market, while in the same spirit Goyenko (2005) documents a cross-market effect of liquidity affecting returns in both markets. De Jong and Driessen (2005) show that liquidity risk from the equity and Treasury market affects corporate bond returns.

As it was pointed out earlier a few recent papers have come up with arguments as to the existence of common patterns in liquidity, although this is still an open question. For example, Fernando (2003) provides a model where the common patterns of liquidity are caused by covariation in investor heterogeneity, rather than from common (systematic) liquidity shocks. Coughenour and Saad (2004) argue that the co-variation in liquidity of NYSE stocks is affected by the specialist firm. The level of liquidity covariation among stocks depends on the capital constraints of the specialist firm. In Brunnermeier and Pedersen's (2006) model, market makers provide market liquidity given they can get the necessary funding. However, during market downturns the ease of obtaining funding is reduced leading to increases in commonality in liquidity among stocks and a substantial drop of market liquidity.[4] Hameed, Kang, and Viswanathan (2006) confirm the above prediction finding an asymmetric response of both the level of liquidity and commonality to upturns and downturns of the market. Acharya, Schaefer, and Zhang (2007)'s investigation and findings of the General Motors and Ford downgrades in May 2005 are also consistent with the models that predict the inter-linkage between *market* liquidity and *funding* liquidity. They show that during this period of stress, the level of liquidity risk has increased in the corporate bond market, and due to capital constraints of market makers, it resulted in an increased correlation risk in other markets. Kamara, Lou, and Sadka (2007) show that the liquidity commonality in the cross-section of stocks has increased over time and attribute this to patterns of institutional ownership.

Using transaction and quote information from each market, we construct different measures of liquidity. We then examine whether they capture common components of liquidity based on a principal component analysis. We show that there is a dominant first principal component in each of the markets. However, the linkage of liquidity shocks varies between different markets. In particular, there is a common component between the equity and both CDS and bond markets, but not between the CDS and bond market. To study the interactions and spill-over of liquidity shocks across the three different markets, we specify and estimate a vector auto-regression (VAR) model. Using the VAR model, we examine the behavior of liquidity shocks across the three markets. Furthermore, the VAR model allows us to examine the impulse response of market liquidity to temporal shocks. We find that

[4] Gromb and Vayanos (2002) is another model where decreases in the ability of arbitrageurs to fund liquidity and capital constraints might lead to further reductions in market liquidity.

there is spill-over of liquidity shocks between equity and CDS markets. Surprisingly, there is no clear spill-over of liquidity shocks between equity and bond markets. There appears to be a time lag of liquidity spill-over from the CDS to both bond and equity markets. Finally, we find no evidence of liquidity spill-over from bond to CDS market.

The rest of the paper is organized as follows. Section 2.1 provides a brief explanation into the mechanics of the recently formed CDS market, describes the corresponding data and the construction of the various liquidity measures. Section 2.2 presents the data sources utilized for the corporate bond market and the corresponding liquidity measures. Section 2.3 explains the equity data and its liquidity measures, while section 2.4 describes the information collected on market indexes. Section 2.5 presents summary statistics/correlations across all of our liquidity measures. Section 3 documents the empirical analysis - principal component analysis, VAR model and impulse response functions. Section 4 concludes.

2 Data and Liquidity Measures

2.1 CDS Market and Liquidity Measures

Credit derivatives market is an "Over-the-Counter" (OTC) market that sprang to life about a decade ago, and since then has seen an enormous growth. According to a recent press release by the International Swaps and Derivatives Association (ISDA), there bi-annual market survey indicates that the notional amount outstanding of credit derivatives as of June 30, 2008 was $54.6 trillion.[5] There has been actually a drop of 12 percent in the first half of 2008 (from $62.2 trillion) due to the recent mess in the financial markets, yet compared to mid-year of 2007 the market grew by 22 percent from $45.5 trillion. In this survey, all major derivatives houses have participated (69 of them) while the market includes credit default

[5] ISDA Press Release, September 24, 2008

swaps that reference single-names, indexes, baskets, and portfolios. Comparing the above figures with a notional outstanding volume of $631.497 billion for the first half of 2001, one can see the tremendous growth of this market.[6]

Credit derivatives are essentially instruments that help to transfer credit risk from a lender (protection buyer) to a third party (protection seller). In response, the third party receives compensation in the form of a regular fee (premium). Although this is a global market, London and New York are the dominant locations. The major players are banks, securities' houses, hedge funds, and insurance companies. These participants can be found on both sides of these transactions, either as protection buyers or sellers. Although the market is composed of a number of instruments, it is primarily dominated by CDSs. Furthermore, these instruments are mostly written on corporate assets with an investment-grade rating.[7]

As it was pointed out above, the CDS are the dominant instruments in these markets. In these contracts, two parties enter into an agreement whereby one party (protection buyer) pays a periodic payment fee (either monthly, quarterly, semiannually, or yearly) in return for credit risk protection. Thus the CDS can be considered an insurance instrument on the value of the reference asset. The fee is a fraction of the face value of the reference security. In case of default (bond default, bankruptcy, or debt restructuring) of the reference entity, the contract is terminated and the protection seller needs to make a payment. This payment can be done in two ways - a physical or a cash settlement. In a physical settlement, the buyer provides the seller with the defaulted bonds and thus the seller needs to pay the buyer the face value of those bonds. In a cash settlement, the buyer keeps the asset thus the seller needs to pay the difference between the face and recovery value of the asset. Most contracts use a physical settlement.

Although there exist CDS contracts of different maturities, the most common is the 5-year CDS. Also, CDS can reference a single-name, basket, portfolio, or an index. In the

[6] ISDA Press Release, November 9, 2001

[7] For more information about these markets, see the annual British Bankers Association Credit Derivatives Report (requires a fee), or the Credit Derivatives book by Chacko, Sjӧman, Motohashi, and Dessan (2006).

basket CDS the reference asset is a group of securities and default can be triggered when one of them defaults. Portfolio CDS are similar to the basket CDS, however the difference is that they cover a prespecified amount thus even if a security within the basket defaults, the contract is still alive as long as the prespecified amount is not reached. In the basket CDS the contract is terminated as soon as there is a default.

In terms of the CDS market, our data come from two sources: Markit Group and Bloomberg Financial Services. Markit is the leading industry provider of credit derivatives pricing. It provides CDS composite quotes on over 3,000 individual entities around the globe with data that cover the tier, currency, and documentation clause level.[8] It collects data each day from more than 70 contributing market makers, screens and removes outliers, stale prices, flat curves, or any other inconsistent data. Markit then computes the mean of contributions that passed the data quality tests.

We restrict our sample to the daily 5-year single-name CDS spreads (which constitute the majority of the market) on senior unsecured debt, from U.S. entities, for contracts denominated in U.S. dollars. The spreads are provided as an annual percentage on the face value of the reference security. Following the standards adopted in the U.S., we also restrict our sample to the modified restructuring information. Our sample covers the period from January 2, 2001, to December 31, 2008, and includes 1,227,329 daily quotes from 1,532 contracts.

Based on the list of issuers under the Markit data sources, we then proceed to collect another sample of CDS prices from Bloomberg. Using the ticker symbol for the issuer, we identify the corresponding 5-year ticker for the CDS contract and collect the relevant data. Bloomberg provides the following information: bid/ask/mid, open/last, low/high prices.[9] The prices reported correspond to the spread found in the Markit database. Our sample from Bloomberg contains 438 contracts for a total of 331,088 daily observations. After merging

[8]Kapadia and Xu (2007), and Acharya, Schaefer, and Zhang (2007) are some recent papers that have used this source.

[9]Das and Hanouna (2008), and Nashikkar, Subrahmanyam, and Mahanti (2007) are some recent papers that have utilized Bloomberg for CDS information.

with the data from Markit, the combined sample includes 273,440 observations from 424 contracts. We also compared the differences in the CDS premiums between the two sources to make sure that the information is consistent (using the last price from Bloomberg); the mean (median) absolute difference in spread is 8.8 (1.4) basis points, which corresponds to approximately 6% (2%) of the mean (median) spread provided by Markit. Furthermore, for around 53% of the observations the Bloomberg spread is higher.

The availability of different data sources provides us the capability of constructing multiple measures of liquidity. This is imperative as liquidity is not an observable variable. Furthermore, it has multiple dimensions. These dimensions relate to *tightness*, *depth*, *resiliency*, and *immediacy*.

For the CDS market, we are able to construct the following monthly measures: bid-ask spreads that capture trading costs (quoted and relative), the number of contributors that proxies for the depth in the contract, the percentage of non-trading days, the Bao, Pan, and Wang (2008) *gamma* measure that is similar in spirit to the Roll (1984) measure and captures the magnitude of transitory price movements, as well as the run length measure by Das and Hanouna (2008). Below we explain briefly the construction of these measures for the CDS market:

- *Quoted Bid-Ask Spread*: For each daily observation provided by Bloomberg, we calculate the quoted spread (ask price - bid price). This constitutes the trading costs for a round-trip, i.e. the customer buys at the ask price, and sells at the bid price. We then proceed and remove outliers, i.e. spreads that fall outside the 1th-99th percentile range, and compute the mean of spreads for each contract per month.

- *Relative Bid-Ask Spread*: From our cleaned sample of spreads, we also calculate the relative spread, i.e. the quoted spread divided by the midpoint of the bid and ask price, averaging for each contract per month.

- *No. of Contributors*: Markit provides the daily number of contributors for each contract, an indication of the depth of the market. Thus we utilize this information as a measure of liquidity and provide the average depth for each contract per month.

- *Percentage of Non-Trading Days*: To compute this measure, we first calculate the number of trading days per month using the S&P 500 data as a proxy. This is used as the denominator in the calculation of the above variable.[10] The numerator for this variable is the difference between the total number of trading days and the number of days with a last price from Bloomberg.

- *Bao, Pan, and Wang (2008) Gamma Measure*: Bao, Pan, and Wang (2008) propose a new measure of illiquidity that is in the spirit of Roll (1984) measure and is based on the magnitude of transitory price movements. Specifically, transitory price movements induce negative serial correlation in price changes which is captured by the gamma, i.e.:

$$\gamma = -Cov(\triangle P_t, \triangle P_{t+1}) \tag{1}$$

where $\triangle P_t = P_t - P_{t-1}$ and $\triangle P_{t+1} = P_{t+1} - P_t$.

Using our sample of daily Bloomberg observations, we proceed to measure gamma. To this end, we follow suggestions by Bao, Pan, and Wang (2008) to clean the sample. First, a CDS contract must trade on at least 50% business days (where the business days are again proxied by the S&P 500 trading days) during its existence in our sample.[11] Second, a contract must be in existence in our sample for at least one full year (365 calendar days). Third, there should be at least 10 observations during the month of the paired price changes,$(\triangle P_t, \triangle P_{t+1})$, to compute γ. Finally, once we compute a gamma for each contract in our sample per month, we proceed and remove outliers, i.e. measures of γ that fall outside the 5th-95th percentile range.

- *Run Length Measure*: Das and Hanouna (2008) propose another measure of liquidity based on the average run length of a security. This measure is negatively related to measures

[10]We acknowledge that the trading days of the equity market are not exactly the same as that of the fixed-income markets. However, since we are working with cross-sectional tests in this project, we believe that this discrepancy will not affect our results.

[11]Bao, Pan, and Wang (2008) put a restriction of at least 75% business days. We believe however that a 50% restriction is sufficient enough and furthermore it allows us to work with a larger sample.

such as trading volume, but positively related to illiquidity measures such as price impact of trades. We use Bloomberg's last price to compute daily returns. Similar to Das and Hanouna, when there is no price change (i.e., zero daily return) it is assumed that the run continues. The run length measure is based on the average length of positive and negative runs over each month.

2.2 Corporate Bond Market and Liquidity Measures

In terms of corporate bond information, our data comes again from two sources: the Trade Reporting And Compliance Engine (TRACE) system and Bloomberg Financial Services. TRACE is a central reporting system for secondary corporate bond market transactions provided by the Financial Industry Regulatory Authority (FINRA), formerly known as the National Association of Securities Dealers (NASD). NASD requires all of its members to report in a relatively short-period of time all transactions on bonds that are eligible under the TRACE system. The current reporting time is 15 minutes. TRACE was initiated in phases, the first phase starting on July 1, 2002. Phase II was implemented in May-April 2003 and included the introduction of more bonds, with lower ratings and smaller issue sizes. The final phase began in October 1, 2004 and was fully implemented by February 7, 2005 with the dissemination of approximately 99 percent of all public transactions. This includes the universe of corporate bonds which constitutes a market of more than 30,000 bonds. According to the Corporate Bond Market Panel report published on September 30, 2004, 65% of all corporate bond market transactions are in quantities of $100k or less, a size representing individual-investor activity.

The information provided by TRACE includes (among others) transaction dates and times, clean prices, and par quantities traded. However, the par value is truncated: $5 million for high-yield bonds, and $1 million for investment-grade bonds. In terms of company/bond specific information, TRACE provides the CUSIP of the issue which can be used to merge with other databases. Furthermore, since November 2008 it began providing a buy/sell/inter-dealer indicator.[12] The bond data set is then merged with the Fixed Investment Securities Database (FISD) to obtain issue- and issuer-specific variables, using the bond CUSIP. FISD is provided by Mergent, Inc. (available through Wharton Research Data Services (WRDS)), and includes issue details on more than 140,000 bond issues (either corporate, corporate MTN (medium term note), supranational, U.S. Agency, or U.S. Treasury). Our sample of FISD information ends in June 2008.

After placing a number of restrictions on the type of bonds to be included, our final sample from TRACE covers the period from July 1, 2002 to September 30, 2008 and includes 7,666,129 intra-day transactions from 6,620 (1,868) unique issues (issuers). Appendix A details our screening procedure. Note that we keep redeemable bonds since they constitute 52% of our sample (3,463 issues).[13]

Armed with the list of debt issues from TRACE, we proceed to collect a sample of corporate bond prices from Bloomberg Financial Services. Bloomberg provides the following information: bid/ask/mid, open/last, low/high prices. The data collected covers the period from July 1, 2002 to December 31, 2008 for a total of 2,275,979 observations from 6,074 (1,770) issues (issuers). After merging the two databases, the combined sample contains 5,477 bond issues from 1,642 issuers. We have also compared the two samples, by averaging first the prices per day for every issue in TRACE and examining its difference to the last price reported by Bloomberg. For approximately 36% of the observations the TRACE price is higher, while the mean (median) absolute difference is 41 (15) bp.

In terms of the corporate bond market, we utilize our two databases to construct the following monthly liquidity measures: bid-ask spreads (quoted and relative), the percentage of non-trading days, the Amihud (2002) illiquidity measure that captures the price impact of

[12]Information reported to TRACE but not yet publicly disseminated includes whether the broker-dealer reporting the transaction is acting as agent or principal; and the identification of the dealer and the counterparty.

[13]FISD includes credit ratings by four agencies (S&P, Moody's, Fitch, and Duff and Phelps). We use the S&P ratings.

trades, the Bao, Pan, and Wang (2008) *gamma* measure, as well as the run length measure. Below we explain briefly the construction of these measures for the corporate bond market:

- *Quoted Bid-Ask Spread*: For each daily observation provided by Bloomberg, we calculate the quoted spread (ask price - bid price). This constitutes the trading costs for a round-trip, i.e. the customer buys at the ask price, and sells at the bid price. We then proceed and remove outliers, i.e. spreads that fall outside the 1th-99th percentile range, and compute the mean of spreads for each bond (issue) per month.

- *Relative Bid-Ask Spread*: From our cleaned sample of spreads, we also calculate the relative spread, i.e. the quoted spread divided by the midpoint of the bid and ask price, averaging for each bond per month.

- *Percentage of Non-Trading Days*: Similar to the procedure used for the CDS market, we first calculate the number of trading days per month by using the S&P 500 data as a proxy. This is used as the denominator in the calculation of the above variable. The numerator (the difference between the total number of trading days and the number of days with at least one transaction) is computed in two ways : using TRACE as well as Bloomberg.

- *Amihud ILLIQ Measure*: Amihud (2002) is a popular measure of illiquidity that captures the price impact of trades. It has been applied to both equity and fixed-income markets. This measure tells us how an asset price is affected by a small change in volume. The larger the impact, the greater the illiquidity of the asset. The monthly measure of issue i in month t is calculated as follows:

$$ILLIQ_t^i = \frac{1}{Days_t^i} \sum_{d=1}^{Days_t^i} \frac{|R_{td}^i|}{V_{td}^i} \tag{2}$$

where R_{td}^i captures the return on day d in month t for bond i, V_{td}^i is the dollar volume on that day, and $Days_t^i$ gives the number of trading day observations for bond i during month t. The return each day is computed in two ways: in our first approach we use the Bloomberg prices (using the midpoint of the bid and ask) to compute the return for each day, while in the second approach we use the trading price provided by TRACE. The volume per bond i during day d is computed by summing up the volume for each trade provided by TRACE. Note also that we multiply this measure by 10^8 for presentational purposes. We also require at least 10 observations per month for each bond to compute the measure. Finally, we remove outliers, i.e. measures of monthly *ILLIQ* that fall outside the 1th-99th percentile range.

- *Bao, Pan, and Wang (2008) Gamma Measure*: Similar to the CDS market, we compute the gamma measure using our TRACE sample. Following the suggestions by Bao, Pan, and Wang, we put the following restrictions to our sample:

1. We drop the Phase I period of TRACE which was a period with a limited number of bonds. Thus our sample runs from April 14, 2003, until September 30, 2008.

2. We remove any bonds that have only traded after Feb. 7, 2005 (the beginning of the full implementation of TRACE) to have a more balanced sample.

3. A bond must be trade on at least 50% of business days (where the business days are again proxied by the S&P 500 trading days) during its existence in our sample.

4. A bond must be in existence in our sample for at least one full year (365 calendar days).

5. There should be at least 10 observations during the month of the paired price changes,$(\triangle P_t, \triangle P_{t+1})$, to compute γ.

6. Once the monthly gamma is computed for each bond, we proceed and remove outliers, i.e. measures of γ that fall outside the 1th-99th percentile range.

Similar to Bao, Pan, and Wang, the measure is computed using two approaches: using trade-by-trade data, and end-of-the-day data (last transaction of the day).

- *Run Length Measure*: We use a similar procedure to the CDS market to construct this measure [based on Das and Hanouna (2008)]. Returns are computed by utilizing Bloomberg's last price.

2.3 Equity Market and Liquidity Measures

The equity data comes from the CRSP daily database. Our stock sample is restricted to those stocks that have observations either in the CDS or bond market. Based on daily data, we construct the following six monthly illiquidity measures: quoted bid-ask spread, relative bid-ask spread, the percentage of non-trading days, the Amihud (2002) illiquidity measure that captures the price impact of trades, the Bao, Pan, and Wang (2008) *gamma* measure, as well as the run length measure. Below we explain briefly the construction of these measures:

- *Quoted Bid-Ask Spread*: We calculate the average of daily quoted spread for each stock over each month during our sample period based on the close ask price and bid price from the CRSP daily database.

- *Relative Bid-Ask Spread*: Relative spread is equal to the quoted spread divided by the midpoint of the bid and ask price, and then averaged for each stock over each month.

- *Percentage of Non-Trading Days*: It is defined as the ratio of the number of non-trading days divided by the number of trading days for the month. A day is considered as non-trading if the trading volume is zero or missing.

- *Amihud ILLIQ Measure*: As defined earlier, the Amihud (2002) illiquidity measure is the absolute daily return divided by the dollar trading volume for all trading days, and then averaged over each month. We require a stock to have at least five trading days (or one week) to have a valid measure.

- *Gamma Measure*: The Gamma measure is calculated using daily close stock price based on the formula in Bao, Pan, and Wang (2008). We require a stock to have at least ten (two weeks) daily price observations on prices to have a valid measure.

- *Run Length Measure*: Daily close prices from CRSP are used to construct this measure (as explained above).

2.4 Market Indexes

We are also utilizing corporate and CDS indices gathered from different sources. In terms of CDS indices we have the following:

- The Dow Jones CDX.NA.IG on-the-run (5yr) Swap JPMorgan CDS spread mid quote, beginning on April 4, 2003, until July 20, 2007. From July 21, 2007, until December 31, 2008, we extrapolate the above data using a series provided through Datastream: CMA DJ CDX.NA.IG Series 5 on senior debt (5yr) - mid quote.[14]

- The Dow Jones CDX.NA.HY on-the-run (5yr) Swap JPMorgan CDS spread mid quote, beginning on July 1, 2002, until July 20, 2007.[15] From July 21, 2007, until December 31, 2008, we again extrapolate the above data using a series provided through Datastream: CMA DJ CDX.NA.HY Series 7 on senior debt (5yr) - mid quote.[16]

In terms of the corporate bond market, we have gathered the following indices: Moody's indices based on rating (AAA, AA, A, BAA) as well as for the complete market from July 1, 2002, until December 31, 2008.

2.5 Summary Statistics on Liquidity Measures

Table I provides descriptive statistics on the liquidity measures constructed. Panels A, B, and C present the findings on the CDS market, corporate bond market, and equity market, respectively. Panel A shows that despite the fact that the CDS market is considered a liquid market, transaction costs (quoted and relative bid-ask spreads) can be quite substantial. This is also documented by Chen et al. (2008) where they compute relative bid-ask spreads using a sample of CDS quotes from Creditex for the period 2000-2003. However, measures such as the percentage of non-trading days, or the gamma, point to a liquid market. Specifically,

[14] The correlation between the two series using a joint sample of 829 observations is 0.89.

[15] We thank the Bond Market Association for providing us the above two series.

[16] The correlation between the two series using a joint sample of 199 observations is -0.89.

the mean cross-sectional value for the monthly percentage of non-trading days is 18%, while the median is only 9%. Furthermore, the gamma measure which is based on the negative autocovariances induced in price changes turns out to be negative for the cross-sectional mean, although it's still positive for the median.

Panel B captures the liquidity of the corporate bond market in multiple dimensions. The first proxy measures the transaction costs using the quoted and relative bid-ask spreads. The monthly average cross-sectional spread (round-trip cost) per bond is 8.5 cents to a $100 par. There are no negative spreads, although there is a large number of zero spreads (72% of the sample) thus the median is at 0. These spreads are substantially smaller than the estimates during the pre-TRACE period (prior to July 2002) and are consistent with the substantial reduction brought about by TRACE documented by Bessembinder et al. (2006) and Goldstein et al. (2007).[17] In terms of trading activity, the % of non-trading days during the month, computed either through TRACE or Bloomberg, is much higher than the CDS market, with a mean of 58% and 48%, respectively. Note also that both the percentage of non-trading days and the Amihud ILLIQ are computed using the Bloomberg and TRACE prices and results are approximately equal. Finally, the gamma measure computed using trade-by-trade data as well as daily data indicates a level of illiquidity that compares to the results documented by Bao, Pan, and Wang. Note that the measure computed using the trade-by-trade data is lower than the measure using the daily data, consistent with the Bao et al. paper. In unreported results, we also compute the gamma measure using the full sample rather than on a monthly basis to have a more direct comparison to the Bao et al.'s paper. The magnitude of gamma from the full sample using trade-by-tade is 0.7401 and 0.4751 for the cross-sectional mean and median, respectively. This is slighty higher than what reported by Bao et al.; .5814 and 0.3598 for the mean and median, respectively. One plausible reason is the fact that one of our restrictions in constructing the measure is that a bond must trade on at least 50% business days during its existence in our sample, whereas

[17] See Hong and Warga (2000) and Chakravarty and Sarka (2003) for related papers on size of transaction costs in the pre-TRACE era.

their cutoff point is 75%. In terms of the measures from the full sample using daily data, our results are again slightly higher; 0.9931 and 0.6207 for the mean and median, respectively, compared to 0.9080 and 0.5533 reported by Bao et al. Finally, one puzzling result is that the run length measure is actually smaller (either median or mean) for the corporate bond market rather than the CDS market.

Panel C presents the statistics regarding the liquidity of the equity market. In terms of bid-ask spreads,the distribution is skewed since the mean is 19 cents while the median is only 3.6 cents. As expected, the mean percentage of non-trading days is very close to zero (the median is zero) since unlike the corporate bond market, one expects most stocks to be traded everyday. The gamma measure is also extremely small suggesting the higher liquidity of the equity market compared to the corporate bond market.

In panels D, E, and F of Table I we report the correlation matrix between our various liquidity measures, constructed for each market. With respect to the CDS market, five of the measures used are *illiquidity* measures while the number of contributors is a *liquidity* measure. A puzzling result in panel D is that the quoted and relative spreads are negatively correlated. A plausible reason could be the fact that during the recent financial crisis there was an explosion in the spreads (prices) of the CDS market, while transaction costs remained relatively constant. Thus relative spreads would naturally diminish compared to quoted spreads. Overall, the highest correlations are between the number of contributors and the rest of the measures. With respect to the corporate bond market, the highest correlation turns out to be between quoted and relative spreads. Finally, with respect to the equity market the highest correlation is reported between Amihud's ILLIQ and the percentage of non-trading days.

3 Empirical Analysis

3.1 Principal Component Analysis of Liquidity Measures

We first examine the behavior of liquidity shocks at the market level. Market liquidity is calculated as an equal weighted average of the firm level liquidity measure over each month. With multiple measures of liquidity, the obvious question is what to use in our analysis. Existing literature has documented that different measures may capture different aspects of liquidity. For example, bid-ask spreads are used to capture the *tightness* of the security or market [Amihud and Mendelson (1986, 1989), Chordia, Roll, and Subrahmanyam (2000), and Hasbrouck and Seppi (2001) are some representative papers]. Measures such as trading volume/frequency or turnover can capture the *depth* of the security or market [see Brennan and Subrahmanyam (1996) and Elton and Green (1998)]. Finally, measures such as price impact of trades or the popular Amihud (2002) measure can capture *resiliency*.

In our empirical analysis, we perform a principal component analysis of all measures and then use the first principal component of each market to perform the cross-market analysis. Table II presents the results from the principal component analysis. Panels A and B show that remarkably the first two principal factors can explain around 97% of the variation in monthly changes of our liquidity measures for the CDS and corporate bond markets. The first factor explains 84% and 87% of the variation in the CDS and corporate bond market, respectively. The percentage explained is even higher in the equity market, with the first factor explaining almost 98% of the variation. Panel D presents the results from the interaction between the CDS and corporate bond market. In this case, the first factor can explain a much smaller percentage (only 50%). Panels E and F present the results between the corporate bond-equity and CDS-equity markets, while panel G reports the results for all three markets together. In all cases, two factors explain between 80-90% of total variation.

3.2 Cross-Market Liquidity Shocks

With the first principal component from each market, we specify and estimate the following VAR model to examine liquidity shocks across markets:

$$\mathrm{LIQ}_t^{cds} = \alpha^{cds} + \sum_{i=1}^{p} \beta_i^{cds}\mathrm{LIQ}_{t-i}^{cds} + \sum_{i=1}^{p} \beta_i^{bond}\mathrm{LIQ}_{t-i}^{bond} + \sum_{i=1}^{p} \beta_i^{eq}\mathrm{LIQ}_{t-i}^{eq} + \epsilon_t^{cds} \quad (3)$$

$$\mathrm{LIQ}_t^{bond} = \alpha^{bond} + \sum_{i=1}^{p} \beta_i^{cds}\mathrm{LIQ}_{t-i}^{cds} + \sum_{i=1}^{p} \beta_i^{bond}\mathrm{LIQ}_{t-i}^{bond} + \sum_{i=1}^{p} \beta_i^{eq}\mathrm{LIQ}_{t-i}^{eq} + \epsilon_t^{bond} \quad (4)$$

$$\mathrm{LIQ}_t^{eq} = \alpha^{eq} + \sum_{i=1}^{p} \beta_i^{cds}\mathrm{LIQ}_{t-i}^{cds} + \sum_{i=1}^{p} \beta_i^{bond}\mathrm{LIQ}_{t-i}^{bond} + \sum_{i=1}^{p} \beta_i^{eq}\mathrm{LIQ}_{t-i}^{eq} + \epsilon_t^{eq} \quad (5)$$

where LIQ_t^{cds}, LIQ_t^{bond}, and LIQ_t^{eq} denote, respectively, the first principal component of the CDS, corporate bond, and equity market liquidity shocks in month t, and p denotes the number of lags in the VAR model. The value of p is determined by the BIC criterion, and is equal to six in our empirical analysis.

Table III reports estimation results of the above model. The results show that for the CDS market liquidity regression, the coefficient of the first lagged CDS market liquidity shock is negative and significant at the 1% significance level. The negative serial correlation suggests a mean-reverting behavior of the liquidity in the CDS market. In addition, the coefficients of the fifth- and sixth-order lagged CDS market liquidity shock are also negative. On the other hand, none of the coefficients of the first four lagged bond market liquidity shock are significant in the CDS market liquidity regression. Moreover, the magnitude of these coefficients is generally small. This indicates that there is no immediate spill-over of liquidity shocks from the bond market to CDS market. The coefficients of the higher order (fifth and sixth) lagged bond market liquidity shock are significant at the 10% and 5% significance level, respectively. Nevertheless, both coefficients are negative. The coefficient of the first lagged equity market liquidity shock is positive, indicating certain level of spill-over of liquidity shocks from the equity market to CDS market. However, it is statistically insignificant. The coefficient of the second lagged equity market liquidity shock is negative and highly significant, indicating certain degree of reverse effect between the first and second lagged equity market liquidity shock on the CDS market liquidity.

For the bond market liquidity regression, we observe a similar mean-reverting pattern. In particular, the coefficients of both the first and second order lagged bond market liquidity shock are negative and significant at the 5% significance level. The coefficients of the lagged CDS market liquidity shock are generally positive, indicating certain level of spill-over of liquidity shocks from the CDS market to bond market. However, only the coefficient of the third order lagged CDS market liquidity shock is statistically significant. This suggests that there appears to be a time lag of liquidity spill-over from the CDS market to bond market. Surprisingly, none of the coefficients of the lagged equity market liquidity shock is statistically significant. As a matter of fact, the coefficient of the first-order lagged equity market liquidity shock is negative. This shows that at monthly frequency, there is no clear evidence of liquidity spill-over from the equity market to the bond market.

Finally, for the equity market liquidity regression, there is a similar mean-reverting pattern. The coefficients of the first order lagged equity market liquidity shock is negative and significant at the 1% significance level. Again, all the coefficients of the lagged bond market liquidity shock are small in magnitude and largely insignificant. Only the sixth order lagged bond market liquidity shock is positive and weakly significant at the 10% significance level. In other words, there is no clear liquidity spill-over from the bond market to equity market either. The lagged CDS market liquidity shock seems to be more related to equity market. The coefficient of the first order lagged CDS market liquidity shock is negative and significant, suggesting a reversal effect of CDS market liquidity shock on equity market liquidity. In addition, the coefficient of the third order lagged CDS market liquidity shock is positive and significant at the 5% significance level. This suggests that there appears to be a time lag of liquidity spill-over from the CDS market to equity market as well.

Figure 1 plots the impulse response function of CDS market liquidity, bond market liquidity, and equity market liquidity to temporal liquidity shocks. The plots show that there is a clear fluctuating pattern for liquidity shocks within each market. The effect dies off gradually. In general, cross-market responses are weak except that there appears to be a strong but delayed effect of equity market shock on the CDS market. On the other hand, there is also a delayed effect of CDS market liquidity shock on the equity market. Consistent with the VAR estimation results, bond market liquidity shocks have no clear effect on the CDS or equity market.

4 Conclusions

Using data from the credit default swap (CDS), corporate bond, and equity markets, we construct several measures of liquidity and examine the spill-over of liquidity shocks across these markets. Liquidity has multiple dimensions (tightness, depth, resiliency, immediacy) thus it is essential to construct a number of measures. Based on the principal component analysis of multiple liquidity measures, we show that there is a dominant first principal component in each of the markets. However, the linkage of liquidity shocks varies between different markets. In particular, there is a common component between the equity and both the CDS and bond markets, but not between the CDS and bond market. Moreover, the vector autoregression results show that while there is spill-over of liquidity shocks between equity and CDS markets, surprisingly there is no clear spill-over of liquidity shocks between equity and bond markets. There appears to be a time lag of liquidity spill-over from the CDS to both bond and equity markets. Finally, we find no evidence of liquidity spill-over from bond to CDS market.

Appendix A: Screens applied for eliminating undesirable observations from the TRACE database

We impose the following restrictions on the type of bonds: (1) we include corporate debentures, corporate issues backed by letter-of-credit, corporate medium-term notes, corporate medium-term note zeros, corporate zeros, and corporate insured debentures; (2) we include only fixed-rate bonds, with a credit rating, from U.S. issuers, with semi-annual coupons, and a 30/360 day-count convention; (2) the industry groups include the industrial, financial, and utility sectors; (3) we exclude bonds that are putable, convertible, perpetual, exchangeable, and have announced calls; and (4) we exclude asset-backed issues, credit enhancements, yankees, canadian, issues denominated in foreign-currency, as well as issues offered globally. We then clean the data by removing cancelled, corrected, or commission trades, and calculate yields to maturity for every transaction using the standard convention for corporate bonds of 30/360 days(taking into account accrued interest), removing any obvious erroneous prices/yields.

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Table I

Summary Statistics on Liquidity Measures

We report summary statistics on all our firm-specific liquidity measures. These are based on monthly observations. Panels A, B , and C present the results for the CDS, corporate bond, and equity markets, respectively.

Panel A: CDS Market

	No. of Obs.	No. of Contracts	Mean	Median	Minimum	Maximum
Quoted Bid-Ask Spr.	18,453	429	9.4	6.1	2.1	74.2
Relative Bid-Ask Spr.	18,453	429	0.13	0.11	0.00	0.81
% of Non-Trading Days	18,928	438	0.18	0.09	0.00	0.96
Gamma Measure (daily data)	11,508	252	-0.7855	0.0270	-35.0419	10.6259
Run Length Measure	16,887	429	3.19	2.5	1	24
No. of Contributors	63,267	1,532	6.8	5.0	2.0	31.5

Panel B: Corporate Bond Market

	No. of Obs.	No. of Bonds	Mean	Median	Minimum	Maximum
Quoted Bid-Ask Spr.	177,788	5,607	8.5	0.0	0.0	0.9
Relative Bid-Ask Spr.	177,788	5,607	0.001	0.000	0.000	0.476
% of Non-Trading Days (TRACE)	191,730	6,620	0.58	0.67	0.00	0.96
% of Non-Trading Days (Bloomberg)	200,481	6,044	0.48	0.52	0.00	0.96
Amihud (ILLIQ) (Bloomberg prices)	40,199	2,421	16.81	4.64	0.05	233.98
Amihud (ILLIQ) (TRACE prices)	44,539	2,725	18.79	7.24	0.07	238.21
Gamma Measure (trade-by-trade data)	49,166	1,109	0.7338	0.3598	-0.0029	6.2023
Gamma Measure (daily data)	24,352	1,092	1.0730	0.4401	-0.1269	10.8553
Run Length Measure	181,724	5,953	1.94	1.75	1	24

Panel C: Equity Market

	No. of Obs.	No. of Stocks	Mean	Median	Minimum	Maximum
Quoted Bid-Ask Spr.	50,750	965	19.2	3.6	0.4	99100.0
Relative Bid-Ask Spr.	50,750	965	0.0029	0.0011	0.0001	2.5199
% of Non-Trading Days	51,199	965	0.0012	0	0	0.9091
Amihud (ILLIQ) Measure	51,199	965	0.00177	0.00003	0	3.08003
Gamma Measure (daily data)	51,199	965	0.0671	0.0081	-15	15
Run Length Measure	51,181	965	2.068	2	1	13

Table I…contd.

Correlation of Liquidity Measures

We report the correlation between our firm-specific monthly CDS, bond, and equity liquidity measures. The correlation matrix is constructed by first taking a cross-sectional average for every month, and then a time-series average for all months. *p*-values are in parentheses.

Panel D: CDS Market

	Quoted Spr.	Relative Spr.	% of Non-Trad. Days	Gamma	Run Length	No. of Contr.
Quoted Spr.	1					
Relative Spr.	-0.176	1				
	(<.0001)					
% of Non-Trad. Days	0.125	0.012	1			
	(<.0001)	(0.6288)				
Gamma	-0.234	0.225	0.009	1		
	(<.0001)	(<.0001)	(0.6946)			
Run Length	0.036	-0.011	0.183	-0.112	1	
	(0.1286)	(0.6665)	(<.0001)	(<.0001)		
No. of Contr.	-0.102	-0.253	-0.212	-0.154	-0.124	1
	(0.0004)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	

Panel E: Corporate Bond Market

	Quoted Spr.	Relative Spr.	% of Non-Trad. Days (TRACE)	% of Non-Trad. Days (Bloomberg)	ILLIQ (Bloomberg)	ILLIQ (TRACE)	Gamma (trade-by-trade)	Gamma (daily)	Run Length
Quoted Spr.	1								
Relative Spr.	0.985	1							
	(<.0001)								
% of Non-Trad. Days (using TRACE)	0.076	0.063	1						
	(<.0001)	(<.0001)							
% of Non-Trad. Days (using Bloomberg)	-0.245	-0.234	0.684	1					
	(<.0001)	(<.0001)	(<.0001)						
Amihud ILLIQ (using Bloomberg prices)	-0.217	-0.210	0.153	0.287	1				
	(<.0001)	(0.6665)	(<.0001)	(<.0001)					
Amihud ILLIQ (using TRACE prices)	-0.033	-0.031	0.212	0.221	0.823	1			
	(<.0001)	(0.0001)	(<.0001)	(<.0001)	(<.0001)				
Gamma Measure (trade-by-trade data)	-0.153	-0.146	-0.044	0.1	0.465	0.373	1		
	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)			
Gamma Measure (daily data)	-0.110	-0.101	-0.016	0.098	0.430	0.347	0.656	1	
	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)		
Run Length Measure	0.207	0.208	0.055	-0.06	-0.106	-0.033	-0.075	-0.137	1
	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	(<.0001)	

Table I…contd.
Correlation of Liquidity Measures

Panel F: Equity Market

	Quoted Spr.	Relative Spr.	% of Non-Trad. Days	ILLIQ	Gamma	Run Length
Quoted Spr.	1					
Relative Spr.	0.248	1				
	(<.0001)					
% of Non-Trad. Days	0.256	0.476	1			
	(<.0001)	(0.6288)				
ILLIQ	0.142	0.623	0.703	1		
	(<.0001)	(<.0001)	(<.0001)			
Gamma	0.075	-0.023	0.003	0.0003	1	
	(0.0990)	(0.0080)	(0.2045)	(0.9349)		
Run Length	0.001	0.073	0.030	0.045	-0.157	1
	(0.8262)	(<.0001)	(0.0005)	(<.0001)	(<.0001)	

Table II

Principal Components of Monthly Changes in Liquidity Measures

We report the principal components of monthly changes in our liquidity measures. The rows represent the principal components while the rows under the "factor loadings" represent the loadings of principal components on each liquidity measure. The last column represents the percentage of total variation of changes in these measures explained by each of the individual principal components.

Panel A: CDS Market

Factor	Factor Loadings						Variation (%)
	Quoted Spr.	Relative Spr.	% of Non-Trading Days	Gamma	Run Length	No. of Contr.	
1	4.401	-0.005	0.005	-35.117	3.330	-0.214	0.837
2	13.873	0.038	0.158	1.606	-1.375	0.329	0.131
3	-0.508	0.013	-0.029	-0.610	-5.724	0.497	0.022
4	0.056	0.006	-0.019	-0.001	-0.328	-3.720	0.009
5	-0.010	0.038	0.900	-0.002	-0.004	-0.004	0.001
6	0.000	-0.119	0.005	0.000	0.000	0.000	0.000

Panel B: Corporate Bond Market

Factor	Factor Loadings									Variation (%)
	Quoted Spread	Relative Spread	% of Non-Trading Days (TRACE)	% of Non-Trading Days (Bloomberg)	ILLIQ (Bloomberg)	ILLIQ (TRACE)	Gamma (by-trade)	Gamma (daily)	Run Length	
1	0.008	0.000	-0.055	-0.024	-27.952	-23.382	-0.457	-0.932	0.128	0.872
2	-0.003	0.000	-0.033	0.048	8.831	-10.554	-0.055	-0.054	-0.072	0.124
3	0.006	0.000	0.007	-0.029	0.038	0.043	-0.793	-1.801	0.175	0.003
4	0.007	0.000	-0.001	0.110	-0.006	0.005	0.004	-0.124	-1.244	0.001
5	-0.003	0.000	-0.048	0.017	0.000	-0.001	0.490	-0.214	0.024	0.000
6	-0.024	0.000	-0.166	-0.125	0.000	0.000	-0.010	0.004	-0.012	0.000
7	0.055	0.000	0.074	-0.108	0.000	0.000	0.010	-0.003	-0.009	0.000
8	0.079	0.001	-0.027	0.021	0.000	0.000	-0.003	0.001	0.002	0.000
9	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table II…contd.

Principal Components of Monthly Changes in Liquidity Measures

Panel C: Equity Market

Factor	Factor Loadings						Variation (%)
	Quoted Spread	Relative Spread	% of Non-Trading Days	ILLIQ	Gamma	Run Length	
1	-0.230	-0.159	0.003	-19.687	-0.122	0.257	0.975
2	0.798	1.265	0.053	-0.036	1.156	-0.733	0.010
3	0.343	1.211	-0.087	0.004	-0.975	0.921	0.009
4	0.991	-0.484	-0.020	-0.004	0.044	0.311	0.003
5	-0.255	0.014	-0.088	0.009	0.634	0.740	0.003
6	0.004	-0.004	0.503	-0.001	-0.008	-0.052	0.001

Table II…contd.
Principal Components of Monthly Changes in Liquidity Measures

Panel D: CDS-Corporate Bond Markets

Factor	Factor Loadings															Variation (%)
	Quoted Spr. (CDS)	Rel. Spr. (CDS)	% of Non-Trad. Days (CDS)	Gamma (CDS)	Run Length (CDS)	No. of Contr. (CDS)	Quoted Spr. (bond)	Relative Spr. (bond)	% of Non-Trad. Days (bond - TRACE)	% of Non-Trad. Days (bond - Bl.)	ILLIQ (bond - Bl.)	ILLIQ (bond - TRACE)	Gamma (bond - by trade)	Gamma (bond - daily)	Run Length (bond)	
1	2.907	-0.006	0.126	-9.761	1.365	0.277	-0.007	0.000	0.054	0.026	27.075	22.717	0.541	0.994	-0.119	0.506
2	1.775	-0.003	-0.010	-31.166	2.947	-0.324	0.003	0.000	-0.009	0.004	-6.994	-5.467	0.266	0.110	0.053	0.396
3	-0.710	0.000	0.082	0.074	-0.035	-0.469	0.003	0.000	0.033	-0.048	-8.777	10.589	0.041	0.038	0.072	0.071
4	-5.710	0.019	-0.030	-0.500	-0.634	0.048	-0.005	0.000	0.005	-0.015	0.476	0.019	-0.316	-0.570	-0.060	0.013
5	0.516	0.004	0.012	-0.386	-4.289	0.712	0.010	0.000	-0.003	0.044	-0.021	0.040	0.018	0.005	-0.355	0.007
6	0.029	0.006	-0.056	-0.028	-0.576	-3.419	0.002	0.000	-0.001	-0.027	0.103	-0.067	0.023	0.145	0.154	0.005
7	-0.202	0.002	-0.019	0.011	0.011	0.060	-0.009	0.000	-0.006	0.027	-0.021	-0.035	0.647	1.664	-0.259	0.001
8	0.019	0.018	0.069	-0.008	-0.086	0.074	-0.006	0.000	0.000	-0.098	0.004	-0.004	0.000	0.179	1.164	0.001
9	-0.003	0.019	0.632	0.000	0.002	-0.012	0.004	0.000	0.000	0.051	0.001	-0.004	-0.009	0.005	-0.033	0.000
10	-0.008	-0.013	0.009	0.003	-0.002	-0.003	-0.006	0.000	-0.059	0.010	0.001	-0.001	0.444	-0.169	0.027	0.000
11	-0.001	-0.001	-0.009	0.000	0.000	-0.001	0.023	0.000	0.166	0.117	0.000	0.000	0.017	-0.006	0.011	0.000
12	0.000	0.015	-0.008	0.000	0.000	0.000	-0.060	0.000	-0.064	0.104	0.000	0.001	-0.010	0.003	0.008	0.000
13	0.000	0.092	0.002	0.000	0.000	0.000	-0.010	0.000	-0.003	0.006	0.000	0.000	-0.003	0.001	0.001	0.000
14	0.000	0.006	0.002	0.000	0.000	0.000	0.074	0.001	'-0.028	0.025	0.000	0.000	-0.003	0.001	0.003	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table II…contd.
Principal Components of Monthly Changes in Liquidity Measures

Panel E: Corporate Bond-Equity Markets

Factor	Factor Loadings															Variation (%)
	Quoted Spr. (bond)	Relative Spr. (bond)	% of Non-Trad. Days (bond - TRACE)	% of Non-Trad. Days (bond - Bl.)	ILLIQ (bond - Bl.)	ILLIQ (bond - TRACE)	Gamma (bond - by trade)	Gamma (bond - daily)	Run Length (bond)	Quoted Spr. (equity)	Relative Spr. (equity)	% of Non-Trad. Days (equity)	ILLIQ (equity)	Gamma (equity)	Run Length (equity)	
1	0.008	0.000	-0.055	-0.024	-27.951	-23.382	-0.459	-0.935	0.128	-0.178	-0.177	-0.011	-1.013	-0.501	0.128	0.842
2	-0.003	0.000	-0.033	0.048	8.832	-10.552	-0.056	-0.056	-0.073	0.058	0.096	-0.032	-0.147	0.068	-0.145	0.120
3	-0.009	0.000	-0.011	-0.028	-0.120	-0.200	0.263	0.538	0.126	0.214	0.175	-0.023	7.154	0.221	-0.082	0.033
4	0.001	0.000	0.005	0.035	-0.047	-0.039	0.745	1.671	-0.136	0.149	0.140	-0.038	-0.188	0.860	-0.117	0.003
5	0.001	0.000	-0.012	0.102	-0.004	0.001	0.076	0.096	-1.209	-0.075	-0.072	-0.005	0.028	-0.421	-0.022	0.001
6	-0.021	0.000	-0.032	-0.029	0.009	-0.008	0.056	0.363	0.239	0.261	-0.086	-0.071	-0.012	-0.665	0.626	0.001
7	-0.010	0.000	-0.022	-0.043	0.004	-0.003	-0.119	0.207	0.106	-0.654	-0.039	0.086	0.012	-0.162	-0.048	0.000
8	-0.006	0.000	0.013	-0.022	0.001	-0.001	-0.250	-0.003	-0.115	-0.065	0.069	0.030	0.008	0.259	0.382	0.000
9	-0.011	0.000	-0.069	-0.009	0.002	-0.002	0.392	-0.179	-0.004	-0.162	0.001	-0.055	0.004	0.060	0.191	0.000
10	0.024	0.000	0.014	0.018	-0.001	0.001	-0.056	0.013	0.000	-0.042	0.029	-0.403	0.000	0.005	-0.019	0.000
11	0.004	0.000	-0.013	-0.061	0.002	-0.001	-0.011	0.004	-0.006	0.007	-0.259	-0.020	0.005	0.046	0.006	0.000
12	0.014	0.000	0.158	0.101	0.000	-0.001	0.016	-0.005	0.009	-0.014	-0.032	0.007	0.002	0.002	0.015	0.000
13	-0.055	0.000	-0.065	0.103	0.000	0.000	-0.011	0.002	0.008	0.000	-0.020	0.000	0.001	0.007	0.001	0.000
14	0.073	0.001	-0.023	0.024	0.000	0.000	-0.002	0.001	0.002	-0.001	-0.003	0.005	0.000	0.001	0.002	0.000
15	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table II…contd.

Principal Components of Monthly Changes in Liquidity Measures

Panel F: CDS-Equity Markets

Factor	Factor Loadings												Variation (%)
	Quoted Spr. (CDS)	Rel. Spr. (CDS)	% of Non-Trad. Days (CDS)	Gamma (CDS)	Run Length (CDS)	No. of Contr. (CDS)	Quoted Spr. (equity)	Rel. Spr. (equity)	% of Non-Trad. Days (equity)	ILLIQ (equity)	Gamma (equity)	Run Length (equity)	
1	-2.578	0.004	-0.029	32.659	-3.216	0.220	-0.152	-0.027	-0.048	0.515	-0.412	0.175	0.896
2	3.273	-0.014	0.053	0.418	2.606	-0.413	0.238	0.216	-0.017	6.776	0.380	-0.15	0.053
3	5.245	-0.013	0.047	0.312	-1.346	0.646	-0.136	0.057	0.024	-2.011	-0.27	-0.125	0.028
4	-0.126	0.006	-0.015	-0.314	-3.019	-1.614	-0.109	0.057	-0.038	1.142	0.066	0.004	0.011
5	-0.369	-0.002	0.057	-0.187	-1.274	3.061	-0.006	-0.002	-0.010	0.860	0.098	-0.031	0.010
6	0.082	-0.011	-0.063	-0.014	-0.021	0.026	-0.086	-0.216	0.002	0.054	-1.149	0.378	0.001
7	0.008	0.017	0.355	0.000	-0.021	-0.007	0.607	0.051	-0.147	-0.016	0.07	0.442	0.001
8	-0.005	0.020	0.455	0.000	-0.001	-0.009	0.007	-0.05	-0.094	-0.001	-0.142	-0.379	0.000
9	0.004	0.006	-0.283	0.000	-0.018	0.002	0.384	0.034	-0.010	-0.007	-0.115	-0.291	0.000
10	-0.002	0.006	-0.071	0.000	0.006	0.002	-0.057	0.012	-0.384	0.000	0.007	0.006	0.000
11	0.003	0.006	-0.017	0.000	-0.002	-0.003	0.025	-0.268	-0.008	0.004	0.049	-0.001	0.000
12	-0.000	-0.094	0.002	0.000	-0.000	0.000	0.002	-0.002	-0.002	0.000	0.000	-0.002	0.000

Table II…contd.
Principal Components of Monthly Changes in Liquidity Measures

Panel G: CDS-Corporate Bond-Equity Markets

Factor	Factor Loadings									
	Quoted Spr. (CDS)	Rel. Spr. (CDS)	% of Non-Trad. Days (CDS)	Gamma (CDS)	Run Length (CDS)	No. of Contr. (CDS)	Quoted Spr. (bond)	Rel. Spr. (bond)	% of Non-Trad. Days (bond - TRACE)	% of Non-Trad. Days (bond - Bl.)
1	-2.911	0.006	-0.126	9.707	-1.371	-0.275	0.007	0.000	-0.054	-0.025
2	1.773	-0.003	-0.010	-31.184	2.937	-0.321	0.003	0.000	-0.009	0.004
3	0.704	-0.000	-0.082	-0.070	0.024	0.472	-0.003	0.000	-0.033	0.049
4	2.453	-0.013	0.022	0.338	2.649	-0.580	-0.007	0.000	-0.010	-0.026
5	5.165	-0.014	0.025	0.297	-1.238	0.345	0.011	0.000	-0.002	0.035
6	0.365	-0.007	0.006	0.346	3.175	1.004	-0.003	0.000	0.010	-0.010
7	-0.228	-0.004	0.059	-0.120	-0.716	3.277	-0.002	0.000	-0.004	0.033
8	0.174	-0.006	0.007	-0.039	-0.166	-0.014	0.004	0.000	-0.007	-0.022
9	-0.011	0.018	0.086	-0.007	-0.095	0.068	0.000	0.000	0.010	-0.095
10	-0.018	-0.003	-0.059	0.008	0.030	-0.024	0.020	0.000	0.035	0.026
11	0.011	0.019	0.443	0.003	-0.011	-0.018	0.014	0.000	0.019	0.062
12	-0.009	0.012	0.432	-0.001	0.013	-0.004	-0.001	0.000	-0.008	0.017
13	0.005	-0.017	0.039	0.000	0.014	-0.007	-0.013	0.000	-0.020	-0.025
14	-0.010	-0.012	0.034	0.003	0.009	-0.003	-0.004	0.000	-0.065	0.005
15	0.001	0.010	-0.086	-0.001	0.004	0.003	0.022	0.000	0.030	-0.005
16	0.002	0.006	-0.008	0.000	-0.001	-0.004	0.007	0.000	-0.016	-0.067
17	0.000	0.010	0.003	0.000	0.000	0.001	-0.016	0.000	-0.158	-0.092
18	0.000	-0.022	0.010	0.000	0.000	0.001	0.059	0.000	0.052	-0.095
19	0.000	-0.086	0.000	0.000	0.000	0.000	0.006	0.000	-0.014	0.014
20	0.000	0.013	-0.002	0.000	0.000	0.000	0.068	0.001	-0.022	0.026
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000

Table II…contd.

Principal Components of Monthly Changes in Liquidity Measures

Panel G: CDS-Corporate Bond-Equity Markets…contd.

Factor Loadings											Variation (%)
ILLIQ (bond - Bl.)	ILLIQ (bond - TRACE)	Run Length (bond)	Gamma (bond - by trade)	Gamma (bond - daily)	Quoted Spr. (equity)	Rel. Spr. (equity)	Non-Trad. (equity)	ILLIQ (equity)	Gamma (equity)	Run Length (equity)	
-27.086	-22.726	0.118	-0.542	-0.996	-0.207	-0.176	-0.022	-0.862	-0.580	0.166	0.496
-6.946	-5.430	0.053	0.265	0.109	0.094	-0.029	0.044	-0.818	0.248	-0.130	0.389
8.779	-10.588	-0.073	-0.042	-0.040	0.059	0.097	-0.031	-0.130	0.081	-0.151	0.069
-0.339	-0.222	0.180	0.311	0.595	0.216	0.177	-0.018	6.840	0.267	-0.113	0.022
-0.400	0.040	-0.078	0.210	0.359	-0.171	0.025	-0.028	-1.419	0.181	-0.093	0.011
-0.059	0.039	0.231	-0.159	-0.349	0.081	-0.072	0.042	-1.258	-0.130	0.011	0.005
-0.086	0.053	-0.274	0.068	0.043	-0.008	-0.032	-0.002	0.640	0.053	-0.017	0.004
0.029	0.032	0.096	-0.581	-1.554	-0.179	-0.117	0.044	0.201	-0.706	0.006	0.001
0.003	-0.000	1.141	-0.090	-0.096	0.020	0.073	-0.009	0.009	0.447	0.026	0.001
-0.009	0.007	-0.266	-0.084	-0.270	-0.268	0.093	0.072	-0.003	0.665	-0.609	0.000
-0.004	0.000	-0.124	0.031	-0.165	0.514	0.050	-0.154	-0.011	0.179	0.043	0.000
0.003	-0.003	0.021	-0.115	0.126	-0.290	-0.055	-0.052	0.003	-0.100	-0.086	0.000
0.002	-0.002	-0.108	-0.054	-0.066	-0.172	0.048	0.054	0.006	0.219	0.407	0.000
0.001	-0.001	0.027	0.400	-0.132	-0.128	-0.015	-0.156	-0.003	-0.013	0.007	0.000
-0.001	0.002	-0.013	-0.118	0.026	-0.027	0.023	-0.339	0.001	0.018	0.016	0.000
0.001	-0.001	-0.008	-0.007	-0.001	0.017	-0.247	-0.011	0.004	0.046	0.006	0.000
0.000	0.001	-0.009	-0.019	0.005	0.012	0.036	-0.006	-0.001	-0.003	-0.014	0.000
0.000	0.000	-0.006	0.011	-0.001	-0.000	0.021	0.004	-0.001	-0.008	-0.003	0.000
0.000	0.000	0.002	-0.005	0.002	0.002	-0.004	-0.002	0.000	0.001	-0.002	0.000
0.000	0.000	0.002	-0.002	0.001	-0.001	-0.003	0.004	0.000	0.001	0.003	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table III

Liquidity Dynamics across the CDS, Corporate Bond, and Equity Markets

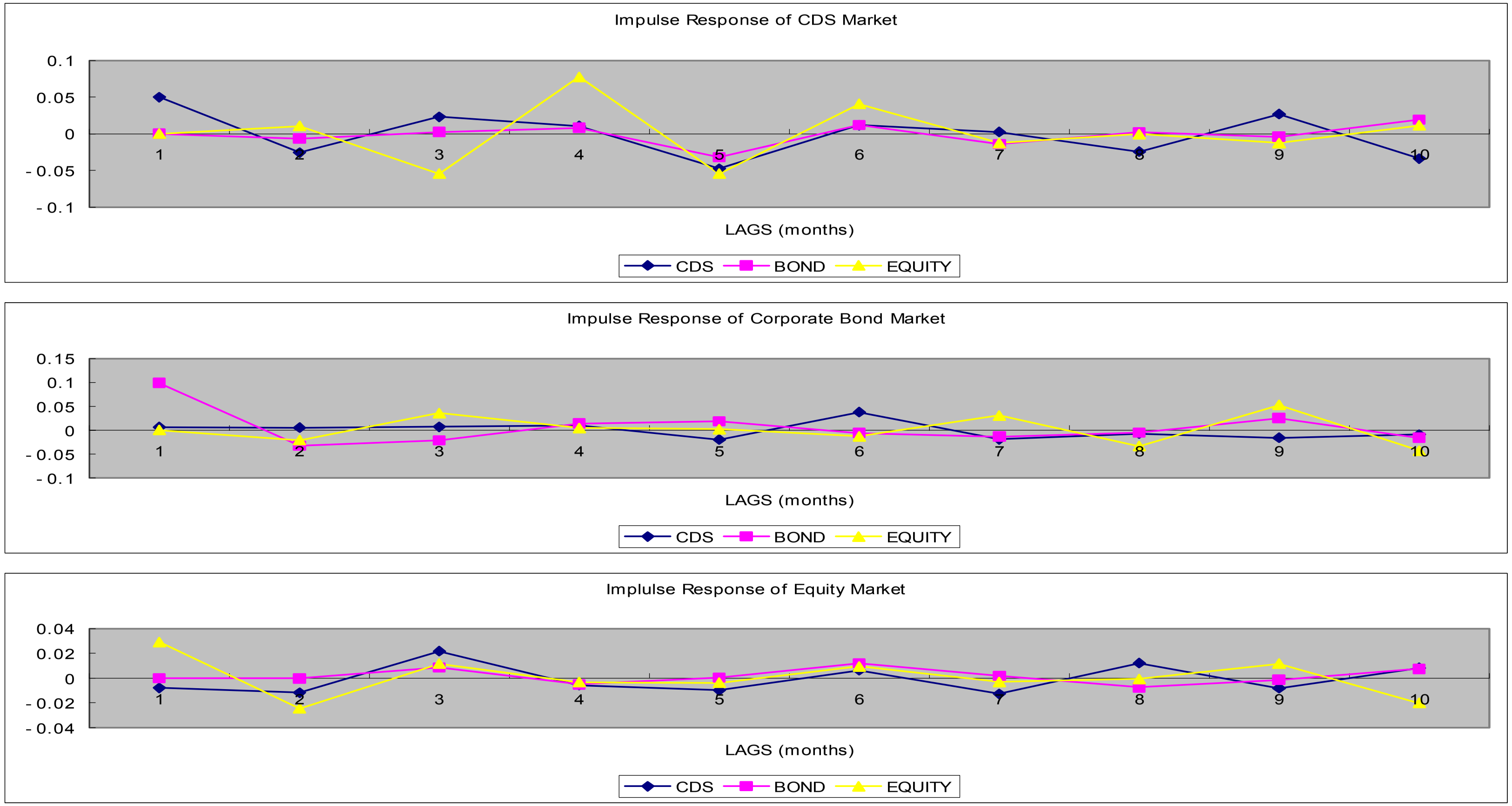
We report the VAR estimation results based on the interaction between the three markets. *t-stats* are in parentheses. The superscripts ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel A: CDS-Corporate Bond-Equity Markets

	CDS	BOND	EQUITY
Constant	0.000	-0.014	-0.001
	(0.02)	(0.94)	(0.22)
CDS_{-1}	-0.453	0.028	-0.367
	(2.86)***	(0.09)	(3.81)***
CDS_{-2}	0.100	0.122	0.015
	(0.49)	(0.30)	(0.12)
CDS_{-3}	0.064	0.878	0.288
	(0.31)	(2.13)**	(2.28)**
CDS_{-4}	0.038	0.201	-0.115
	(0.17)	(0.44)	(0.82)
CDS_{-5}	-0.314	0.277	-0.260
	(1.54)	(0.68)	(2.09)**
CDS_{-6}	-0.236	-0.121	-0.293
	(0.85)	(0.22)	(1.73)*
$BOND_{-1}$	-0.065	-0.335	-0.003
	(0.82)	(2.12)**	(0.06)
$BOND_{-2}$	-0.031	-0.324	0.058
	-0.37	(1.97)**	(1.16)
$BOND_{-3}$	0.043	0.031	0.047
	(0.50)	(0.18)	(0.90)
$BOND_{-4}$	-0.126	0.159	0.052
	(1.43)	(0.91)	(0.98)
$BOND_{-5}$	-0.166	0.048	0.049
	(1.94)*	(0.28)	(0.94)
$BOND_{-6}$	-0.233	-0.017	0.092
	(2.89)***	(0.11)	(1.87)*
$EQUITY_{-1}$	0.357	-0.713	-0.837
	(1.34)	(1.34)	(5.14)***
$EQUITY_{-2}$	-1.444	0.393	-0.173
	(4.48)***	(0.61)	(0.88)
$EQUITY_{-3}$	0.487	0.959	-0.570
	(1.19)	(1.17)	(2.28)**
$EQUITY_{-4}$	0.606	0.943	0.233
	(1.27)	(1.00)	(0.81)
$EQUITY_{-5}$	0.434	1.357	0.442
	(0.82)	(1.29)	(1.37)
$EQUITY_{-6}$	0.294	0.043	-0.037
	(0.70)	(0.05)	(0.14)
Schwarz B.I.C.	-188.93	-188.93	-188.93
N. of Obs.	59	59	59
Adj. R^2	0.832	0.394	0.579

Impulse Response Function

The below figure plots the impulse response of the three markets to liquidity shocks.



Panel A: CDS-Corporate Bond-Equity Markets