# Liquidity Basis between Credit Default Swaps and Corporate Bonds Markets

May 2014


## ABSTRACT

Liquidity risk has drawn much attention among academic researchers, institutional professionals and financial regulators in various financial markets. This paper empirically investigates the difference and relationship between the liquidities of CDS and corporate bond markets. The liquidity basis which is defined as the bid-ask spread difference between CDS and corporate bond are negative most of the time across different rating categories, implying more illiquid corporate bond market and the fact that CDS market moves quickly in reflecting credit quality changes. There exists significant Granger-causality from CDS liquidity to bond liquidity, and some bidirectional Granger-causality for most investment grade reference entities. The relative bid-ask spread adopted by many researchers turns out to be inappropriate as a measure of liquidity for CDS and corporate bond where the credit spread and liquidity risk are positively correlated.



*JEL classification:* G1; G12; G13

*Keywords*: Credit default swap; Corporate bond; Liquidity risk; bid-ask spread; Credit spread

## I. Introduction

Financial markets have been experiencing periodic turbulences for the past several decades and theses cyclical ups and downs are also going to be repeated in the future. Some of them are associated with stock and fixed income market crashes and others are related to the speculative investments in derivative security markets. Global financial institutions including large investment banks and hedge fund companies experienced big losses and banking panics related to the credit and liquidity problems during these financial shocks. Recent 2007-2009 financial crisis is triggered initially by the burst of the U.S. housing bubbles but mainly by a liquidity shortfall in U.S. banking systems. Worldwide economies slowed down as credit condition is tightened, most financial assets became illiquid, and many large financial institutions and other major players in the market collapsed during this period.

Liquidity in general, or market liquidity, is defined as an ability of asset to be traded quickly in any quantity without causing significant movement in price and within a short period of time, which is also called market liquidity. Funding liquidity refers to an ability of business to possess sufficient liquid asset to meet its obligation to pay its liability. Many empirical studies naturally found that the liquidity effect is an important economic factor, and significant in many asset prices. While the effect of market and credit risk in asset prices have been theoretically and

empirically studied by many financial researchers and industry professionals, the research on liquidity risk has been less developed, and the pricing impact of liquidity risk on financial instrument is relatively difficult to be measured and quantified. In addition, the valuation of the liquidity risk in the credit derivatives markets is a critical issue to be addressed from an investment perspective, since outstanding credit derivative contracts take significant portion in the global financial markets and have been expanding rapidly.

Credit derivative is a financial contract whose value is derived from the credit risk of underlying basic financial asset. Since its introduction in the mid-1990s, it has been growing rapidly and evolving into many complicated products as investors and market participants become more sophisticated. However, the rapid expansion of the credit derivatives market, the lack of comprehension of the complex credit products and loose regulatory supervision have raised some policy concerns about the market stability and the adverse selection problem that can influence the liquidity of credit derivatives. A proper understanding of the liquidity structure and its pricing impact on the credit derivative market is essential for the adequate implementation of risk management and the efficiency and stability of financial markets as evidenced by the recent several financial crises. Among credit derivative securities, credit default swap (CDS) is the most typical and widely traded security.

Past literatures on liquidity theoretically investigate the significance of liquidity risk in asset prices, and empirically find discrepancies of liquidity risk in stocks, bonds and other derivative securities in various markets. In equilibrium asset pricing framework, Acharya and Pedersen (2005) derive the liquidity-adjusted CAPM where the asset's required excess return depends on its expected illiquidity cost and on the covariance of the asset return and asset illiquidity cost with the market return and the market illiquidity cost. Bongaerts, De Jong and Driessen (2011) extend this model incorporating liquidity risk for derivative securities where equity assets are in positive net supply and the hedge assets are in zero net supply. They apply GMM estimation to test the liquidity effects empirically for equity and CDS markets. Both models found that liquidity is a priced factor that significantly affects asset returns and liquidity risk and expected liquidity premiums are economically significant in equity and derivatives markets.

The liquidity effects in equity and bond markets are investigated empirically in many literatures. Chordia, Roll and Subrahmanyam (2000) find the existence of macroeconomic commonality in stock market liquidity without recourse to asset pricing implication. Amihud (2002) shows that using the ratio of monthly average of the daily absolute return to dollar volume, expected market illiquidity positively affects *ex ante* stock excess return, but unexpected illiquidity is negatively

related to contemporaneous stock returns.[1] Chordia, Sarkar and Subrahmanyam (2005) and Goyenko and Ukhov (2009) examine the macroeconomic factors on the liquidities in stock and bond markets and find an interaction and lead-lag relationship between the illiquidities of two markets.

Another stream of literatures investigates the liquidity effects in the prices of the credit derivative instruments whose contractual nature and zero net supply distinguish them from the other traditional securities. Blanco, Brennan and Marsh (2005) among others examine the theoretical equivalence of CDS spread derived from structural model and bond yield spread which is measured from the difference between the bond yield to maturity and risk-free interest rate. They find that the parity relation holds as an equilibrium condition for investment-grade corporate reference entities, and the CDS markets are more liquid than corporate bond markets in the sense that new information is impounded into CDS spread more rapidly than into corporate bond price. Elton, Gruber, Agrawal and Mann (2001) and Delianedis and Geske (2001) also report that only a small percentage of yield spread for investment-grade bonds is attributed to the default risk. In contract, Longstaff, Mithal and Neis (2005) argue that the CDS spreads mainly reflect the credit risk premium due to its contractual nature, and hence use the

[1] The liquidity measure of the ratio of the monthly average of the daily absolute return to dollar volume is first employed by Amihud (2002) and also used by Acharya and Pedersen (2005) and Bongaerts, De Jong and Driessen (2011).

information in CDS to separate the default and nondefault components in corporate bond yield spreads. Applying the reduced-form model, they find that most part of the corporate yield spread is due to default risk which suggests that the market price of credit risk may be larger than implied by some structural models. However this result is mainly due to their assumption that CDS spread reflects only the default component of bond yield spread.

This paper aims to clarify the significance and pricing implication of liquidity risk in the CDS markets and compare directly with those in comparable corporate bond markets. Empirical tests are performed on the credit and liquidity risks implied in the prices of credit default swaps and corporate bonds. To our knowledge, this paper is the first paper to investigate and directly compare the liquidities in CDS and corporate bond markets for each credit rating category in the time series data. We define the liquidity basis as the difference between the liquidities, measured by the bid-ask spreads of CDS and corporate bond, and test the causality relationship between illiquidities in these markets. We also investigate the deviations from the parity relationship between the yield spread of corporate bond and CDS spread, because CDS spread is widely regarded as less prone to liquidity risk and more closely correspond to default risk than the yield spread in corporate bond market. Granger-causality is tested on the interaction between these two markets in terms of the credit and liquidity risks. That is, we examine

whether one market has a dominant price discovery effect on another market, and test the Granger-causality between the CDS liquidity and corporate bond liquidity, as well as between the CDS spread and corporate bond yield spread and among CDS spread or bond yield spread and CDS or bond liquidity.

The remainder of this paper is organized as follows. Section II describes the data for CDS and corporate bond markets and the measures of liquidity risk. Section III presents the empirical results and the summary statistics for the sample period and discusses the Granger-causality relationship between the CDS and corporate bond markets. Section IV summarizes the major findings and makes concluding remarks.

## II. CDS and Corporate Bond Markets

### 1. Credit Default Swap Market

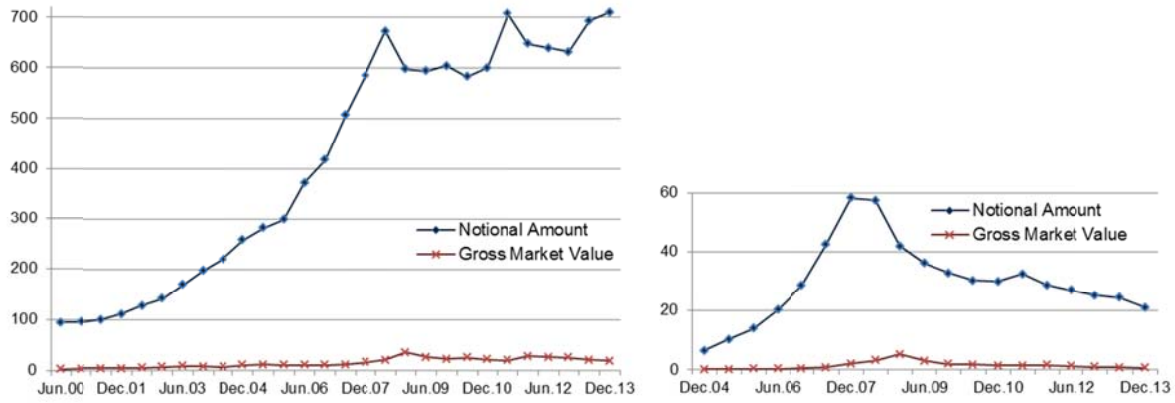
Credit default swap (CDS) introduced in mid-1990s is the most popular credit derivative security whose value is derived from the credit quality of underlying bonds, loans and other financial assets. It facilitates the transfer or isolation of credit risk among various counter-parties, and provides liquidity and efficient links between structurally different financial

markets. This feature is useful for a wide variety of market participants including investment and commercial banks, hedge and pension funds, insurance companies, and other financial intermediaries and institutions.

Credit default swap provides insurance against the risk of a default by particular reference entity. A simple example of a single-name CDS contract can be illustrated as follows: An investor or a protection buyer who owns a bond issued by a particular company (reference entity) but does not want to bear the risk of the default of reference entity can have an agreement with the third counter-party, or protection seller. If the underlying reference entity defaults before the maturity of a CDS contract, the protection seller pays the protection buyer the face value of the underlying bond or the face value minus recovery value in case of cash settlement. In return for bearing this risk, the protection seller receives from the protection buyer a periodic fixed coupon payment, which is called the CDS premium or CDS spread. If a default does not occur over the life of CDS contract, the periodic payments continue until the contract maturity date. The two sides of the CDS contract are called the premium leg where CDS spreads are paid periodically for default protection, and the protection leg where the protection of underlying bond is paid upon default. Default events for CDS might include bankruptcy, failure to make payment, restructuring of debt, repudiation or moratorium.

In early 2000s, the total outstanding notional amount of CDS contract globally was less than 1 trillion US Dollar, but reached to its highest level of $58 trillion in 2007 with a gross market value of $2 trillion. After the financial crisis of 2007–2009, the size of CDS market declined to almost one-third of its highest level with total notional amount of $21 trillion and gross market value of $0.7 trillion around the end of 2013.[2] The tremendous growth in the credit derivatives market has been driven by the standardization of contract documentation and diversification of market participants and product applications. Figure 1 displays the growth of credit default swaps and total OTC derivatives markets from 2000 to 2013 in terms of outstanding notional amount and gross market value.

**Figure 1. Size of CDS and total OTC derivatives markets**




**(a) Total OTC Derivatives** (in trillions of USD)

**(b) Credit Default Swap** (in trillions of USD)

[2] Bank for International Settlements, Statistical release: OTC derivatives statistics at end-December 2013. The size of total derivatives markets including CDS has been expanding rapidly until the 2007-2009 financial crisis period. During the financial crisis period, the growth of derivatives market was depressed, but the market recovered gradually beyond its pre-crisis level. As of December 2013, the total notional amount of all the OTC derivatives, including foreign exchange, interest rate, equity, commodity and CDS contracts, reached $710.2 trillion with the gross market value of $18.7 trillion.

The total notional amount of CDS market now exceeds that of the underlying bond market, and CDS is often considered to be more liquid than the bond due to its contractual nature. Corporate bonds are often bought and held until their maturity by many investors, and the trade of large amounts of credit risk of corporate bonds in the secondary market is often costly and difficult. On the other hand, price of CDS is often considered to be less significantly affected by liquidity risk than bond price, since CDS contract is a bilateral financial contract between two counter-parties and allows relative ease of transacting large notional amount compared to corporate bonds.

## 2. Spread Data for CDS and Corporate Bond

The price and bid-ask spread data for credit default swaps are collected from Markit data services. Bid-ask spreads are based on the observed quotes sent by market makers to their clients, and produced for each reference entity as a daily end-of-business-day report. Bid and ask CDS spread data for the notional amount of $2 million, $5 million and $10 million and for the maturity from 6-month to 10-year standard ISDA contracts are available in the data set for two-year period from May 2009 to June 2011. We use the quotes for single-name, USD currency, and five-year CDS for the senior unsecured underlying debt with credit ratings ranging from

AAA to CCC in 10 different industry sectors.[3]

For the corporate bonds, the end-of-day bid and ask prices of bond yield data are also collected from Markit data services from the same two-year period. So as to be consistent with CDS data, we select the USD currency, fixed coupon, and senior unsecured corporate bonds with maturity closest to 5 years but within the boundary between 4 and 6 years with credit ratings ranging from AAA to CCC. If there is no bond data available between 4 and 6 years, or no exact matches of the contract specifications, either CDS or corporate bond data is discarded. About two-thirds of matched corporate bonds have maturities within the range of half year from 5 years. Market yield on 5-year U.S.[4] Treasury bond is used to proxy the risk-free interest rate.

Between the CDS spread and bond yield spread, there is a no-arbitrage relationship for the same reference entity with the same maturity. Suppose an investor holds a bond and also buys CDS protection with the same maturity and reference entity to eliminate the default risk associated with the underlying bond. If the reference entity does not default, the investor earns the bond yield to maturity minus the CDS spread which should be risk-free. If the reference entity defaults, then the investor receives the face value from credit protection, which can be

[3] Five-year CDS is the most active and liquid contract among CDS maturities of 6-month, 1-year, 2-year, 3-year, 4-year, 5-year, 7-year and 10-year contracts.

[4] We filter out outliers by eliminating the extreme quote data if the difference between the CDS spread and corporate bond yield spread is more than 500 basis points, or the difference between CDS bid-ask spread and the bond bid-ask spread is more than 200 basis points, which are considered to be an obvious data errors. We also expunge the quote data if CDS bid-ask spread or bond bid-ask spread is more than 50% of respective CDS spread or corporate bond yield.

reinvested at risk-free rate for the remaining period after the default time. Hence, the bond yield to maturity minus CDS spread should be (approximately) equal to the risk-free rate. This no-arbitrage relation between bond yield spread and CDS spread has been investigated by Duffie (1999), Hull and White (2000), Houweling and Vorst (2002), Blanco, Brennan and Marsh (2005), and many other researchers. If a bond is yielding more than CDS spread plus risk-free interest rate, then borrowing at risk-free rate, taking a long position in risky bond and buying a protection in CDS should provide a profitable arbitrage opportunity.[5]

So as to avoid any confusion related to the terminology of the credit spread and bid-ask spread, we will call the bond yield spread for the difference between the yield to maturity of corporate bond and the corresponding risk-free interest rate, and call the CDS spread for the annual percentage rate of CDS premium. In addition, we will strictly refer to the difference between the offer and bid quotes of CDS spread and bond yield as the bid-ask spread of bond and CDS, respectively, which reflects the transaction cost or the illiquidity of the market. Bond yield spread and CDS spread reflect the credit spread of the reference entity, and the bond bid-ask spread and CDS bid-ask spread reflect the illiquidity of the corresponding markets. The credit spread difference between the CDS spread and bond yield spread is called the spread basis, and

[5] For our sample period, if we use five-year swap rates as a proxy for risk-free rate, the bond yield spread often turns to negative especially for higher credit rating of AAA bond for our sample period. Hence we prefer to use Treasury rate instead of swap rate even though swap rate has some advantages as a proxy for risk-free interest rate (Blanco, Brennan and Marsh (2005) and other researchers).

the liquidity difference between the CDS bid-ask spread and bond bid-ask spread is called the liquidity basis. We conjecture that the CDS market is more liquid than corresponding bond market due to its contractual features of CDS, CDS bid-ask spread is smaller than bond bid-ask spread, and CDS spread is smaller than bond yield spread, leading to negative spread basis and negative liquidity basis.

## 3. Liquidity Measures

Liquidity is a degree to which an asset, in any quantity or amount, can be bought or sold in the market within a short period of time and without causing significant movement in its price. A security is considered to be liquid if its bid-ask spread is small, a large amount can be traded without affecting the price much, or if price recovers quickly after a demand or supply shock. Empirical studies have found that the impact of liquidity on asset prices is statistically significant and the liquidity risk is an important risk factor.

The price of any security in the financial market reflects the market risk, credit risk, liquidity risk and other relevant risk factors. Market risk involves the risk related to the fluctuation of prices as well as volatility and correlation of financial assets. Credit risk involves the default or

credit quality changes of counter-party or reference entity. While market and credit risk have been extensively studied and investigated in academia as well as in financial industry for a long period of time with better understanding of the pricing structure of the financial instruments, liquidity risk which is proven to be a significant factor in the recent financial crisis has relatively been less developed in its research and difficult to be measured quantitatively.

Various proxies can be used for liquidity measures to capture various facets of CDS and corporate bond liquidities. They include the bid-ask spread, volatility, trading volume or the number of outstanding contracts, holding period or the turnover rate, the ratio of missing prices, and the price impact or the response of returns to trading volume. Amihud and Mendelson, (1986) and Jegadeesh and Subrahmanyam (1993) among many other researchers assert that the bid-ask spreads are correlated negatively with the price level, volume and the number of market makers, and positively with volatility. In this paper, we apply the absolute and relative measures of bid-ask spread to capture the liquidity of CDS and bond markets, and later compare and examine the validity of these measures. The absolute bid-ask spread of CDS or corporate bond can simply be expressed as the difference between the offer and bid prices:

$$\text{Liq\_CDS or Liq\_Bond} = S_{Ai} - S_{Bi}$$

where $S_{Ai}$ and $S_{Bi}$ are the offer and bid prices, respectively, of CDS spread or bond yield to

maturity. The relative liquidity of CDS or corporate bond as a percentage of the price is:

$$\text{Liq\_CDS\_relative or Liq\_Bond\_relative} = \frac{S_{Ai} - S_{Bi}}{\left(\frac{S_{Ai} + S_{Bi}}{2}\right)}$$

Illiquidity in the market is caused by the difficulty of finding counterparty, the immediacy of demand and supply, exogenous transaction costs, or other inventory risks. Also, it may be partly due to market-wide systematic illiquidity or illiquidity for specific asset class or reference entities. Large financial institutions and intermediaries find difficulty in the valuation and valuation adjustment of their huge portfolios, and have yet to established the standard practice where credit and liquidity risks are involved. Especially, the valuation and adjustment for the assets with counter-parties or reference entities are more complicated and difficult to separate out for credit risk and liquidity risk. New IFRS accounting standard on fair value measurement and the new change under Basel III related to valuation adjustments requires financial institutions to reflect the impact of credit and liquidity risk.[6] Also, as noted by Ericsson and Renault (2006), the components of bond yield spreads attributable to illiquidity increase as default becomes more likely. Bid-ask spreads of CDS and corporate bond as well as credit spreads are often important factors for the valuation adjustment of CDS, corporate bonds, loans and other more complicated financial instruments involving risky reference entities. In the next

[6] Basel Committee on Banking Supervision, 2010

section, we investigate the empirical relationship between CDS and bond market liquidities and also relate to CDS spread and bond yield spread.

## III. Empirical Relation of Liquidities between CDS and Bond Markets

### 1. Credit Spread and Liquidity Risk

We present summary statistics here associated with the credit spreads and liquidities in CDS and corporate bond markets. Table 1 summarizes and compares the CDS spread and the corporate bond yield spread for each rating category from AAA to CCC. There are total of 285,942 valid quotes for CDS spreads with 630 reference entities, and total of 147,095 quotes for bond yield spreads of 572 corporate bonds for two-year period. From these quotes, we find 98,661 valid combined quotes for the matching 402 reference entities in both CDS and corporate bond markets, where about 80% are either in the credit rating of A, BBB or BB category. In general, the prices of credit risk in CDS and corporate bond markets are very close to each other where the lower credit rating category carries higher CDS spread or bond yield spread and higher standard deviation. The average credit spread for CDS is slightly lower than that for corporate bond except for the credit ratings of AAA and CCC, which do not have enough

reference entities quoted in the market. The yield spreads for investment grade bonds are less than 200 basis points on average, and the CDS spreads are in similar scales. The high yield bonds with credit rating of BB or lower exhibit 400 basis points or higher and up to 1000 basis points for CCC rating, and similarly for CDS spreads.

**Table 1. CDS spread and corporate bond yield spread**

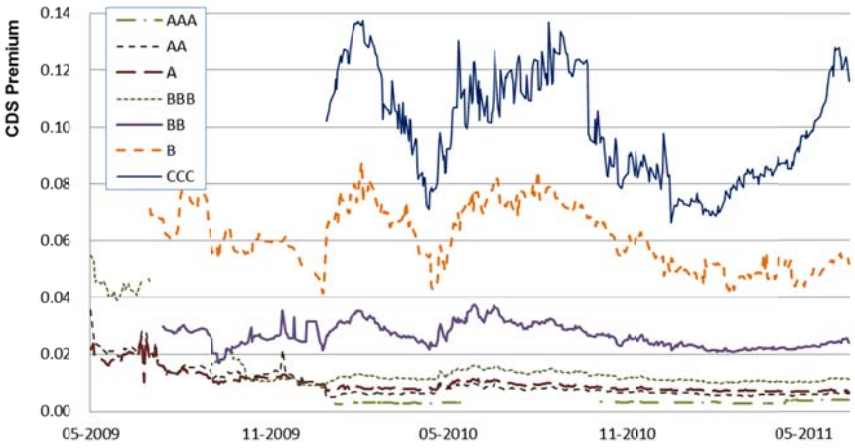
| | | CDS Spread | | | | Bond Yield Spread | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rating | # reference | Average | Std Dev | Max | Min | Average | Std Dev | Max | Min |
| AAA | 2 | 0.0033 | 0.0005 | 0.0043 | 0.0025 | 0.0009 | 0.0017 | 0.0040 | -0.0031 |
| AA | 16 | 0.0076 | 0.0060 | 0.0567 | 0.0018 | 0.0084 | 0.0086 | 0.0395 | -0.0024 |
| A | 94 | 0.0084 | 0.0057 | 0.0610 | 0.0014 | 0.0099 | 0.0076 | 0.1007 | -0.0063 |
| BBB | 169 | 0.0120 | 0.0069 | 0.0775 | 0.0017 | 0.0178 | 0.0093 | 0.0833 | -0.0012 |
| BB | 70 | 0.0264 | 0.0134 | 0.0915 | 0.0044 | 0.0399 | 0.0134 | 0.0906 | 0.0054 |
| B | 39 | 0.0609 | 0.0365 | 0.2553 | 0.0015 | 0.0623 | 0.0311 | 0.2205 | -0.0223 |
| CCC | 12 | 0.0980 | 0.0442 | 0.2643 | 0.0203 | 0.0922 | 0.0358 | 0.2406 | 0.0242 |
| Total | 402 | 0.0199 | 0.0247 | | | 0.0250 | 0.0239 | | |

*Notes*: This table presents descriptive statistics of the CDS spread and corporate bond yield spread for the credit rating categories from AAA to CCC for the daily observation from May 2009 to June 2011. CDS spread represents the annualized credit spread of fixed coupon payment on 5-year CDS contract, and bond yield spread represents the yield to maturity of closest-to-5-year corporate bond over the risk free interest rate.

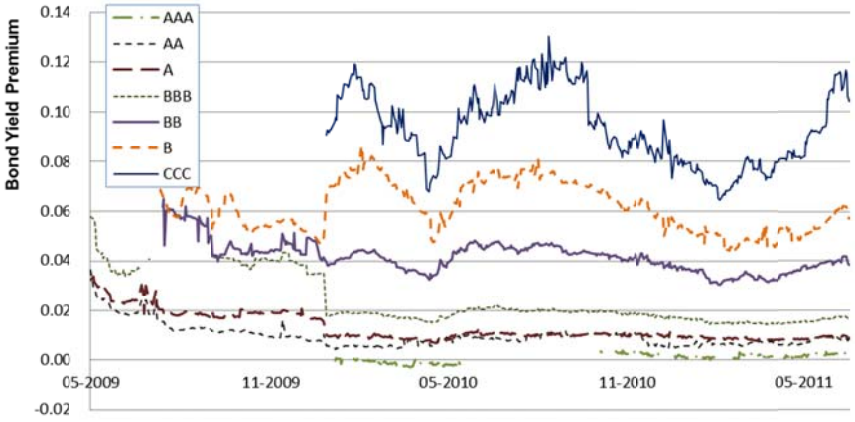
The time series of the daily average quotes of each rating category for CDS spread and bond yield spread are plotted in Figure 2 (a) and (b), respectively. These two graphs display similar magnitudes and trends for CDS spread and bond yield spread for each rating category as noted in the previous table. The credit conditions for most reference entities are gradually recovering from the financial crisis in early 2009 where the credit ratings of CCC and B are still fluctuating quite much over time.

**Figure 2. Time series of CDS spread and corporate bond yield spread**

(a) Time series of the average quoted CDS spread for credit rating categories from AAA to CCC from May 2009 to June 2011




(b) Time series of the average quoted corporate bond yield spread for credit rating categories from AAA to CCC from May 2009 to June 2011




In this study, we measure liquidity risk by the bid-ask spread which also represents the transaction cost in CDS and corporate bond markets. Table 2 below compares the bid-ask spreads of the CDS spread and corporate bond yield for each rating category from AAA to CCC.

Lower credit rating CDS or corporate bond exhibits higher average bid-ask spread with higher standard deviation. CDS and corporate bond markets do not exhibit significant difference for each rating categories, implying similar movement of liquidity risk in both CDS and corporate bond markets.

**Table 2. Bid-ask spread for CDS and corporate bond yield**

| | | CDS Bid-Ask Spread | | | | Bond Yield Bid-Ask Spread | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rating | # reference | Average | Std Dev | Max | Min | Average | Std Dev | Max | Min |
| AAA | 2 | 0.0011 | 0.0003 | 0.0015 | 0.0004 | 0.0009 | 0.0003 | 0.0020 | 0.0005 |
| AA | 16 | 0.0006 | 0.0004 | 0.0050 | 0.0003 | 0.0011 | 0.0005 | 0.0058 | 0.0005 |
| A | 94 | 0.0006 | 0.0003 | 0.0032 | 0.0003 | 0.0011 | 0.0004 | 0.0073 | 0.0005 |
| BBB | 169 | 0.0009 | 0.0005 | 0.0052 | 0.0003 | 0.0014 | 0.0007 | 0.0075 | 0.0005 |
| BB | 70 | 0.0016 | 0.0007 | 0.0115 | 0.0004 | 0.0032 | 0.0021 | 0.0090 | 0.0005 |
| B | 39 | 0.0030 | 0.0020 | 0.0206 | 0.0004 | 0.0046 | 0.0024 | 0.0090 | 0.0007 |
| CCC | 12 | 0.0048 | 0.0029 | 0.0247 | 0.0007 | 0.0047 | 0.0023 | 0.0103 | 0.0009 |
| Total | 402 | 0.0012 | 0.0012 | | | 0.0020 | 0.0018 | | |

*Notes*: This table presents descriptive statistics of the bid-ask spreads for CDS spread and corporate bond yield for the credit rating categories from AAA to CCC for the daily observation from May 2009 to June 2011. CDS bid-ask spread is the difference between the quoted offer and bid prices of CDS, and bond bid-ask spread is the difference between the quoted offer and bid prices of corporate bond. Bid-ask spread represents the transaction cost of a security and hence greater illiquidity for higher bid-ask spread.

Figure 3 illustrates the relationship between the bid-ask spread for 5-year CDS and corresponding corporate bond for credit rating categories from AAA to CCC for two year period. CDS bid-ask spread exhibits high fluctuations and volatility towards the end of 2009 especially for lower credit rating reference entities reflecting illiquid CDS markets during the financial crisis period, and is stabilized gradually for the remaining periods. The bid-ask spread for CDS is less than 200 basis points and that for corporate bond yield is less than 100 basis points for

most of the period, where the average of bid-ask spreads range from 10 basis points to 50 basis points across different rating categories as shown in Table 2 which are typically less than 10% of the credit spreads in Table 1. Some corporate bonds exhibit sticky bid-ask spread over time across all rating categories due to the contractual nature while CDS bid-ask spread fluctuates with market condition changes especially before 2010, reflecting the 'flight to quality' phenomenon during financial crisis period. While high credit quality securities maintain lower bid-ask spreads most of the time and vice versa for low credit categories, still significant portions of low credit quality CDS's and corporate bonds still maintain small bid-ask spreads and hence are relatively liquid.

The spread basis or the average difference between CDS spread and corporate bond yield spread is shown in Table 3 for each credit rating category and industry sector. In general, the spread basis in the table is negative most of the time, implying that bond yield spread is greater than CDS spread on average most of time and reflecting the fact that corporate bond market is less liquid than CDS market if we assume the same credit risk of reference entity and ignoring the contractual difference between CDS and bond. The reference entities with higher credit quality

**Figure 3. CDS liquidity vs. corporate bond liquidity for each credit rating category AAA through CCC**

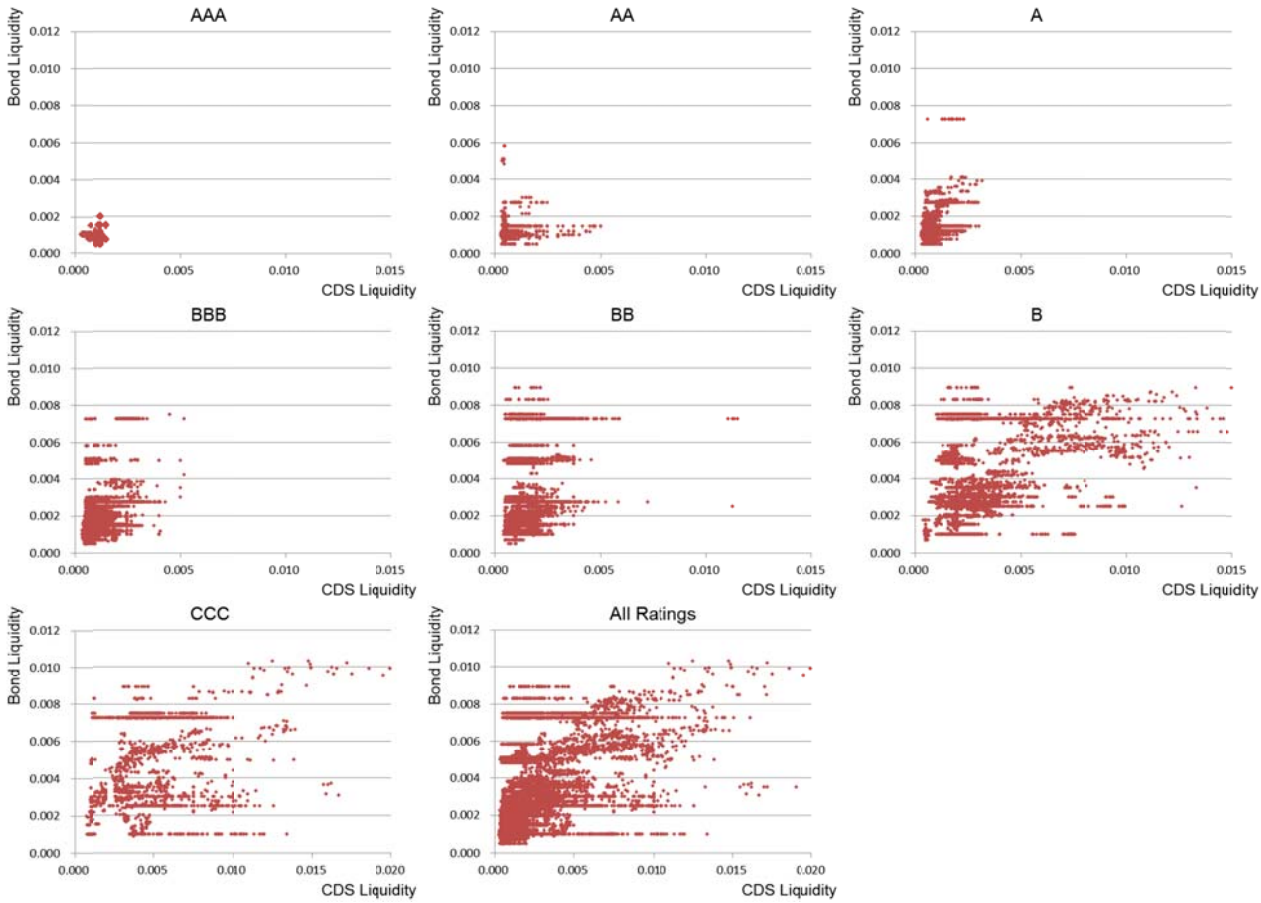



exhibit less significant difference between the CDS spread and bond yield spread.[7] There is not much significant difference among different industry sectors in terms of the average differences, and the financial sector also shows similar basis to that of other industry sectors on average for our sample period.

[7] In addition, the mean absolute errors, which is not presented in this paper for conciseness, for higher credit quality entities between the CDS spread and corporate bond yield spread are also lower, and those for lower quality entities are higher.

**Table 3. Spread basis between CDS and corporate bond**

| Sector | # reference entity | AAA | AA | A | BBB | BB | B | CCC | Total |
|---|---|---|---|---|---|---|---|---|---|
| Basic Materials | 30 | | | -0.0002 | -0.0090 | -0.0172 | 0.0044 | | -0.0093 |
| Consumer Goods | 49 | | 0.0008 | -0.0015 | -0.0046 | -0.0131 | -0.0037 | 0.0189 | -0.0056 |
| Consumer Services | 64 | | 0.0012 | -0.0006 | -0.0047 | -0.0151 | 0.0017 | 0.0065 | -0.0045 |
| Financials | 82 | | -0.0014 | -0.0031 | -0.0071 | -0.0111 | -0.0040 | -0.0049 | -0.0054 |
| Health Care | 28 | 0.0011 | 0.0003 | -0.0017 | -0.0036 | -0.0161 | -0.0059 | | -0.0042 |
| Industrials | 46 | | -0.0099 | -0.0007 | -0.0062 | -0.0187 | -0.0093 | | -0.0053 |
| Oil & Gas | 36 | | 0.0025 | -0.0011 | -0.0032 | -0.0077 | | | -0.0036 |
| Technology | 20 | 0.0025 | | -0.0001 | -0.0065 | -0.0053 | -0.0003 | | -0.0018 |
| Telecommunications | 13 | | | -0.0007 | -0.0113 | -0.0167 | -0.0109 | | -0.0096 |
| Utilities | 34 | | | 0.0006 | -0.0048 | -0.0060 | 0.0082 | 0.0125 | -0.0021 |
| Total | 402 | 0.0023 | -0.0008 | -0.0015 | -0.0057 | -0.0134 | -0.0014 | 0.0058 | -0.0050 |

*Notes*: This table presents the spread basis for the average difference between CDS spread and corporate bond yield spread for the credit rating categories from AAA to CCC and 10 industry sectors for the daily observation from May 2009 to June 2011. CDS spread represents the annualized credit spread of fixed coupon payment on 5-year CDS contract, and bond yield spread represents the yield to maturity of closest-to-5-year corporate bond over the risk free interest rate.

Table 4 exhibits the liquidity basis which represents the average difference between bid-ask spread of CDS spread and that of corporate bond yield for each credit rating category and industry sector. The bid-ask spread for bond yield is greater than that for CDS spread in general, leading to negative liquidity basis and implying the illiquid corporate bond market compared with CDS market. The higher credit quality reference entities exhibit less significant difference between the bid-ask spreads of CDS and bond yield to maturity.[8] Here again, the liquidity basis between CDS and corporate bonds in financial industry show similar magnitudes and patterns as that in other industry sectors, and not much noticeable difference among different industry sectors during the sample period.

[8] Reference entities with higher credit quality also show less significant mean absolute errors between CDS bid-ask spread and corporate bond yield bid-ask spread, which is not reported in this paper for conciseness.

**Table 4. Liquidity basis between CDS and corporate bond**

| Sector | # reference entity | AAA | AA | A | BBB | BB | B | CCC | Total |
|---|---|---|---|---|---|---|---|---|---|
| Basic Materials | 30 | | | -0.0004 | -0.0007 | -0.0013 | -0.0007 | | -0.0009 |
| Consumer Goods | 49 | | 0.0000 | -0.0004 | -0.0006 | -0.0018 | -0.0028 | 0.0012 | -0.0011 |
| Consumer Services | 64 | | -0.0004 | -0.0005 | -0.0006 | -0.0019 | -0.0016 | 0.0005 | -0.0009 |
| Financials | 82 | | -0.0006 | -0.0006 | -0.0004 | -0.0017 | -0.0007 | -0.0006 | -0.0006 |
| Health Care | 28 | -0.0006 | -0.0004 | -0.0004 | -0.0002 | -0.0016 | -0.0028 | | -0.0008 |
| Industrials | 46 | | -0.0009 | -0.0004 | -0.0007 | -0.0013 | -0.0011 | | -0.0007 |
| Oil & Gas | 36 | | -0.0003 | -0.0004 | -0.0003 | -0.0010 | | | -0.0005 |
| Technology | 20 | 0.0003 | | -0.0004 | -0.0006 | -0.0015 | -0.0024 | | -0.0010 |
| Telecommunications | 13 | | | -0.0005 | -0.0009 | -0.0026 | -0.0006 | | -0.0013 |
| Utilities | 34 | | | -0.0002 | -0.0004 | -0.0013 | 0.0005 | -0.0002 | -0.0004 |
| Total | 402 | 0.0002 | -0.0004 | -0.0005 | -0.0005 | -0.0016 | -0.0016 | 0.0001 | -0.0008 |

*Notes*: This table presents the average liquidity basis between CDS spread and corporate bond yield to maturity for the credit rating categories from AAA to CCC and 10 industry sectors for the daily observation from May 2009 to June 2011. CDS bid-ask spread is the difference between the quoted offer and bid prices of CDS spread, and bond bid-ask spread is the difference between the quoted offer and bid prices of corporate bond yield. Bid-ask spread represents the transaction cost of the security and hence greater illiquidity for higher bid-ask spread.

## 2. Granger Causality between CDS and Corporate Bond Liquidities

To analyze the influence of CDS liquidity on corporate bond liquidity or vice versa, we employ the Granger causality test which is a simple way to test whether one variable has a dominant effect on another. Given the time series of a pair of variables, one variable is said to Granger-cause another variable if past values of one variable contain useful information to explain the current value of another variable. This relationship is investigated here through the simple regressions of CDS liquidity and bond liquidity separately against the past values of them:

$$\text{Liq\_Bond}_t = \lambda_1 + \sum_{i=1}^{n} \delta_{1,i} \cdot \text{Liq\_CDS}_{t-i} + \sum_{i=1}^{n} \gamma_{1,i} \cdot \text{Liq\_Bond}_{t-i} + \varepsilon_t \qquad (1)$$

$$\text{Liq\_CDS}_t = \lambda_2 + \sum_{i=1}^{n} \delta_{2,i} \cdot \text{Liq\_CDS}_{t-i} + \sum_{i=1}^{n} \gamma_{2,i} \cdot \text{Liq\_Bond}_{t-i} + \varepsilon_t \qquad (2)$$

where $n$ is the number of lags, $\lambda$ is a constant, Liq_CDS and Liq_Bond are the liquidities of CDS and corporate bond markets, respectively. For the liquidity measures, we take the logarithm of the daily quotation of bid-ask spreads of CDS or corporate bond. The first null hypothesis for equation (1) is that:

The coefficients of the lagged variables of CDS liquidity equal zero and therefore do not Granger-cause the dependent variable of bond liquidity.

The second null hypothesis for the regression (2) is that:

The coefficients of the lagged variables of bond liquidity equal zero, and therefore do not Granger-cause the dependent variable of CDS liquidity.

Table 5 reports the two-way Granger causality test for these measures of liquidities: the CDS liquidity Granger-causes bond liquidity in regression equation (1), and bond liquidity Granger-causes CDS liquidity in equation (2) for every pairwise combination with the lag of 1 and 4 business days. The *F* statistics and p-values are presented for the restriction that the coefficients of the lagged variables for explaining the liquidity of either CDS or bond equal zero.

**Table 5. Granger causality for the liquidities of CDS & corporate bond**

$$\text{Liq\_Bond}_t = \lambda_1 + \sum_{i=1}^{n} \delta_{1,i} \cdot \text{Liq\_CDS}_{t-i} + \sum_{i=1}^{n} \gamma_{1,i} \cdot \text{Liq\_Bond}_{t-i} + \varepsilon_t$$

$$\text{Liq\_CDS}_t = \lambda_2 + \sum_{i=1}^{n} \delta_{2,i} \cdot \text{Liq\_CDS}_{t-i} + \sum_{i=1}^{n} \gamma_{2,i} \cdot \text{Liq\_bond}_{t-i} + \varepsilon_t$$

| | | | CDS Liquidity | | | Bond Liquidity | | | Bond Liquidity | | | CDS Liquidity | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rating | No Ref Entity | No Lags | Adj R-sq | F stat | | p-value | Adj R-sq | F stat | | p-value | | | |
| AAA | 2 | 1 | 0.83 | 0.0 | | (0.868) | 0.89 | 0.3 | | (0.606) | | | |
| | | 4 | 0.80 | 0.3 | | (0.894) | 0.92 | 0.9 | | (0.466) | | | |
| AA | 16 | 1 | 0.89 | 1.8 | | (0.178) | 0.95 | 1.3 | | (0.255) | | | |
| | | 4 | 0.88 | 1.3 | | (0.273) | 0.95 | 0.8 | | (0.556) | | | |
| A | 94 | 1 | 0.89 | 57.7 | ** | (0.000) | 0.94 | 29.0 | ** | (0.000) | | | |
| | | 4 | 0.89 | 5.7 | ** | (0.000) | 0.94 | 3.6 | ** | (0.006) | | | |
| BBB | 169 | 1 | 0.91 | 269.8 | ** | (0.000) | 0.97 | 63.6 | ** | (0.000) | | | |
| | | 4 | 0.91 | 25.6 | ** | (0.000) | 0.97 | 4.5 | ** | (0.001) | | | |
| BB | 70 | 1 | 0.92 | 54.2 | ** | (0.000) | 0.94 | 18.7 | ** | (0.000) | | | |
| | | 4 | 0.92 | 10.4 | ** | (0.000) | 0.95 | 1.3 | | (0.274) | | | |
| B | 39 | 1 | 0.93 | 35.4 | ** | (0.000) | 0.97 | 7.6 | ** | (0.005) | | | |
| | | 4 | 0.93 | 7.3 | ** | (0.000) | 0.97 | 1.4 | | (0.234) | | | |
| CCC | 12 | 1 | 0.93 | 2.6 | | (0.108) | 0.96 | 1.0 | | (0.322) | | | |
| | | 4 | 0.93 | 0.6 | | (0.664) | 0.97 | 0.8 | | (0.511) | | | |

*Notes*: This table presents *F* statistics and *p*-values of pair-wise Granger causality test between CDS liquidity and corporate bond liquidity for the credit rating categories from AAA to CCC for the daily observation from May 2009 to June 2011. Null hypothesis is that either CDS or bond liquidity does not Granger cause another variable, or vice versa. CDS liquidity is represented by the difference between the quoted offer and bid prices of 5-year CDS contract, and corporate bond liquidity is represented by the difference between quoted offer and bid prices of comparable closet-to-5-year corporate bond. * denotes significance at the 5% level and ** denotes significance at the 1% level.

*F* statistics in Table 5 with one- and two-asterisks represent 5% and 1% significance level, respectively. Small *p*-value exhibits that the coefficients of the lagged variables are not zero and the null hypothesis of no Granger causality is rejected if it is less than the significance level. The results of the Granger-causality test in the table indicate the evidence of bidirectional relationship between CDS liquidity and bond liquidity. In particular, for credit rating categories A and BBB, the coefficient of the lagged variable is significantly different from zero in both

direction of the regression. Hence, CDS liquidity and bond liquidity show strong Granger causality in both directions, but no liquidity in one market is leading in another market. However, for credit rating BB and B, the results of the test indicate some evidence that the CDS liquidity Granger-causes and leads the corporate bond liquidity, but bond liquidity does not Granger-cause CDS liquidity, especially for the lag length of 4 business days. For credit rating categories AAA, AA and CCC, the coefficient of the lagged variable is not significantly different from zero in the regression, and hence there is not much Granger causality between CDS liquidity and bond liquidity. Apart from the exception of AAA, AA and CCC rating groups where the sample size is not large enough, CDS liquidity and bond liquidity seems to show some evidence of a bidirectional relationship for higher credit rating categories of A and BBB, and significant Granger causality of CDS liquidity leading bond liquidity for lower credit rating groups of BB and B. Significant Granger-causality implies that the liquidity basis is going to be weakened rapidly due to its lead-lag effects after strengthened basis from outside shocks.

## 3. Vector Autoregression Analysis

Here, we analyze the joint behavior among liquidities in CDS and bond markets, and credit spreads in CDS and corporate bond, employing a vector autoregressive (VAR) system of

equations. In VAR methodology, we treat the variables for CDS liquidity and bond liquidity, CDS spread and bond yield spread as endogenous, and also include the stock market return (S&P500 index) and volatility (VIX) as exogenous control variables. This VAR specification consists of a system of four equations, where all variables are function of constant, its own lagged values and lagged values of all the other endogenous variables as well as exogenous variables:

$$\mathbf{X}_t = \mathbf{c} + \sum_{i=1}^{I} \boldsymbol{\alpha}_i \cdot \mathbf{X}_{t-i} + \boldsymbol{\beta} \cdot \mathbf{Y}_t + \boldsymbol{\varepsilon}_t \qquad (3)$$

where

$$\mathbf{X}_t = \begin{pmatrix} \text{Liq\_CDS}_t \\ \text{Liq\_Bond}_t \\ \text{Spd\_CDS}_t \\ \text{Spd\_Bond}_t \end{pmatrix}, \quad \mathbf{Y}_t = \begin{pmatrix} \text{SP500}_t \\ \text{VIX}_t \end{pmatrix},$$

$$\mathbf{c} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{pmatrix}, \quad \boldsymbol{\alpha}_i = \begin{pmatrix} \alpha_{i,11} & \alpha_{i,12} & \alpha_{i,13} & \alpha_{i,14} \\ \alpha_{i,21} & \alpha_{i,22} & \alpha_{i,23} & \alpha_{i,24} \\ \alpha_{i,31} & \alpha_{i,32} & \alpha_{i,33} & \alpha_{i,34} \\ \alpha_{i,41} & \alpha_{i,42} & \alpha_{i,43} & \alpha_{i,44} \end{pmatrix}, \quad \boldsymbol{\beta} = \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \\ \beta_{31} & \beta_{32} \\ \beta_{41} & \beta_{42} \end{pmatrix}, \quad \text{and } \boldsymbol{\varepsilon}_t = \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \end{pmatrix},$$

In the above equation, $\mathbf{X}_t$ represents a column vector of the endogenous variables for liquidities and credit spreads of CDS and bond market for each credit rating category from AAA to CCC. $\mathbf{Y}_t$ represents a column vector of the exogenous variables, where SP500 is the daily rate of return on S&P 500 index and VIX is the implied volatility index of 30-day option on S&P 500. $\boldsymbol{c}$ is a

column vector of intercepts, and $\boldsymbol{\alpha}_i$ is a 4×4 matrix representing the coefficients of the endogenous variables with lag length $i$, where the number of lags, $I$, is chosen on the basis of Schwarz Bayesian Information Criterion. Typically, the sensitivity of the information criterion with respect to the length of lag is not very significant for larger lag lengths. $\boldsymbol{\beta}$ represents the coefficients of the exogenous variables of 4×2 matrix, and $\boldsymbol{\varepsilon}_t$ is a column vector of residuals.

So as to interpret the estimated VAR specifications for CDS and corporate bond markets, we report pairwise Granger-causality test for two liquidity variables and two credit spread variables of CDS and corporate bond for each credit rating category. Table 6 reports the $\chi^2$ statistics and $p$-values (in the parentheses) for testing the null hypothesis that the coefficient of the lagged endogenous variable equals zero in the estimated VAR equation. That is, the numbers in $i$th row and $j$th column represents the $\chi^2$ statistic and $p$-value for the null hypothesis that $i$th variable does not Granger-cause the dependent $j$th variable of interest. These tests from VAR indicate similar results for liquidity measures to those from the Granger-causality tests in the previous section, and more significant evidence that the CDS liquidity Granger-cause bond liquidity, especially for credit rating B at 1% significance level. For rating categories of A, BBB, BB, there is bi-directional Granger causality between the CDS liquidity and bond liquidity, where the coefficients of the lagged variables are significantly different from zero with higher $\chi^2$ statistics

in both directions of VAR equations. For investment grade ratings AAA and AA, CDS and bond liquidities are not significantly Granger-caused by each other.

**Table 6. Granger causality tests of absolute liquidity measures using Vector Autoregression**

| Rating | | CDS Liq | Bond Liq | CDS Spd | Bond Spd |
|---|---|---|---|---|---|
| AAA | CDS Liq | | 0.2 | 0.7 | 0.1 |
| | | | (0.700) | (0.388) | (0.761) |
| | Bond Liq | 1.0 | | 1.1 | 0.9 |
| | | (0.328) | | (0.304) | (0.335) |
| | CDS Spd | 5.0 * | 0.0 | | 1.1 |
| | | (0.024) | (0.997) | | (0.299) |
| | Bond Spd | 0.5 | 1.5 | 1.9 | |
| | | (0.474) | (0.228) | (0.170) | |
| AA | CDS Liq | | 1.6 | 2.6 | 11.4 ** |
| | | | (0.657) | (0.456) | (0.009) |
| | Bond Liq | 1.4 | | 0.2 | 4.2 |
| | | (0.701) | | (0.980) | (0.238) |
| | CDS Spd | 76.6 ** | 5.9 | | 8.5 * |
| | | (0.000) | (0.115) | | (0.036) |
| | Bond Spd | 36.4 ** | 38.9 ** | 2.4 | |
| | | (0.000) | (0.000) | (0.491) | |
| A | CDS Liq | | 37.6 ** | 20.6 ** | 27.9 ** |
| | | | (0.000) | (0.001) | (0.000) |
| | Bond Liq | 30.2 ** | | 7.7 | 12.5 * |
| | | (0.000) | | (0.170) | (0.028) |
| | CDS Spd | 383.4 ** | 172.3 ** | | 240.0 ** |
| | | (0.000) | (0.000) | | (0.000) |
| | Bond Spd | 89.9 ** | 172.9 ** | 15.4 ** | |
| | | (0.000) | (0.000) | (0.008) | |
| BBB | CDS Liq | | 142.6 ** | 41.6 ** | 83.9 ** |
| | | | (0.000) | (0.000) | (0.000) |
| | Bond Liq | 28.9 ** | | 27.3 ** | 39.1 ** |
| | | (0.000) | | (0.000) | (0.000) |
| | CDS Spd | 588.7 ** | 222.7 ** | | 304.4 ** |
| | | (0.000) | (0.000) | | (0.000) |
| | Bond Spd | 107.7 ** | 362.8 ** | 10.5 | |
| | | (0.000) | (0.000) | (0.062) | |
| BB | CDS Liq | | 60.5 ** | 7.3 | 26.7 ** |
| | | | (0.000) | (0.062) | (0.000) |
| | Bond Liq | 14.1 ** | | 9.3 * | 9.1 * |
| | | (0.002) | | (0.025) | (0.028) |
| | CDS Spd | 235.3 ** | 95.5 ** | | 109.1 ** |
| | | (0.000) | (0.000) | | (0.000) |
| | Bond Spd | 69.5 ** | 91.4 ** | 0.5 | |
| | | (0.000) | (0.000) | (0.915) | |
| B | CDS Liq | | 33.8 ** | 15.2 ** | 40.6 ** |
| | | | (0.000) | (0.001) | (0.000) |
| | Bond Liq | 4.6 | | 4.2 | 8.9 * |
| | | (0.205) | | (0.238) | (0.031) |
| | CDS Spd | 239.6 ** | 23.5 ** | | 122.7 ** |
| | | (0.000) | (0.000) | | (0.000) |
| | Bond Spd | 120.5 ** | 17.8 ** | 8.1 * | |
| | | (0.000) | (0.001) | (0.044) | |
| CCC | CDS Liq | | 1.9 | 0.1 | 6.5 * |
| | | | (0.387) | (0.935) | (0.039) |
| | Bond Liq | 1.0 | | 2.2 | 0.9 |

| | | | | |
|---|---|---|---|---|
| | (0.610) | | (0.331) | (0.638) |
| CDS Spd | 48.1** | 1.5 | | 28.3** |
| | (0.000) | (0.484) | | (0.000) |
| Bond Spd | 21.9** | 0.6 | 0.4 | |
| | (0.000) | (0.726) | (0.801) | |

*Notes*: This table presents $\chi^2$ statistics and *p*-values (in the parentheses) of pair-wise Granger causality test from the VAR equations among CDS liquidity and spread and corporate bond liquidity and yield spread for the credit rating categories from AAA to CCC for the daily observation from May 2009 to June 2011. Null hypothesis is that row variable does not Granger-cause column variable. CDS liquidity is represented by the logarithm of the difference between the quoted offer and bid prices of 5-year CDS contract, and corporate bond liquidity is represented by the logarithm of the difference between the quoted offer and bid prices of comparable closet-to-5-year corporate bond. * denotes significance at the 5% level and ** denotes significance at the 1% level.

In addition, CDS spread exhibits significant Granger causality towards CDS liquidity for all rating categories, and significant Granger causality towards bond liquidity for credit ratings of A, BBB, BB, and B. Bond yield spread also exhibits significant Granger causality towards CDS liquidity for all rating categories except rating AAA, and significant Granger causality towards bond liquidity for rating categories from AA to B. The interaction between CDS spread and bond yield spread is evidenced by significant Granger causality of CDS spread on bond yield spread for all rating categories except for rating AAA and except for bi-directional causality for rating category A.[9] Overall, the results in Table 6 indicate the evidence that the CDS liquidity is more dominant than bond liquidity in terms of leading price discovery process for most rating categories. CDS spread or bond yield spread Granger causes CDS or bond liquidity, and CDS spread is more dominant than bond yield spread in affecting the other prices for most credit rating categories.

[9] This result for the relationship between the liquidity and credit spread is consistent with Blanco, Brennan and Marsh (2005), except that here we analyze the relationship in more detail with respect to each credit rating category.

## 4. Relative Bid-Ask Spread as Liquidity Measure

We also compare the relative bid-ask spread with the absolute bid-ask spread as a measure of liquidity in CDS and corporate bond markets, and examine its validity. The relative or percentage bid-ask spread employed in many other researches including Goyenko and Ukhov (2009), Tang and Yan (2007) and Jegadeesh and Subrahmanyam (1993) is expressed as the ratio of the difference between quoted ask and bid prices to the mid-price. Table 7 reports the average of relative bid-ask spreads for CDS and corporate bond for each credit rating category. Usually, quotes are observed most frequently around the rating categories of A, BBB and BB, representing more CDS and corporate bond trades with greater average number of observations per each business-day due to larger number of reference entities in these credit categories. However, for each observation of bid-ask spread, there are more contributing dealer quotes for lower credit quality securities with greater average number of quotes. For example of A-rated CDS, there are 118 reference entities are quoted on average per one day for the sample period, and 58 contributing dealer quotes on average for one reference entity on a given day. However, for B-rated CDS, the 96 references are quoted on average on a given day, but 230 bid-ask spreads are quoted on average from contributing dealers for one reference entity on a given day.

On the other hand, the higher credit quality security exhibits the greater average relative bid-ask spread for CDS, and similarly for corporate bond. This is due to the fact that the absolute bid-ask spread is low for high credit quality CDS or bond when CDS spread or bond yield spread is also very low, resulting in large relative bid-ask spread. This is more obvious by comparing Table 7 with Table 1 and Table 2 where the effect of increasing absolute bid-ask spread with deteriorating credit quality is obscured by also increasing CDS spread or bond yield. Hence it is dubious whether this relative bid-ask spread can represent the true illiquidity of the CDS and bond markets and underlying reference entity, especially for the securities of varying credit qualities. For example, the averages of relative bid-ask spread of CDS for credit rating A and B are 0.0913 and 0.0578, respectively, which are not likely to reflect the actual transaction costs of each credit quality. The relative bid-ask spread for corporate bond doesn't seem to show any consistent pattern of liquidity risk either.

**Table 7. Relative bid-ask spread for CDS and corporate bond yield**

| | CDS | | | | Corporate Bond | | | |
|---|---|---|---|---|---|---|---|---|
| Rating | Avg No. of Quotes | Avg # obs per day | rel. B-A Spread | Std Dev | Avg No. of Quotes | Avg # obs per day | rel. B-A Spread | Std Dev |
| AAA | 40 | 3 | 0.3532 | 0.1129 | 935 | 2 | 0.0442 | 0.0146 |
| AA | 97 | 18 | 0.1037 | 0.0499 | 1161 | 13 | 0.0391 | 0.0125 |
| A | 58 | 118 | 0.0913 | 0.0407 | 829 | 62 | 0.0377 | 0.0113 |
| BBB | 43 | 226 | 0.0825 | 0.0356 | 746 | 99 | 0.0378 | 0.0113 |
| BB | 98 | 57 | 0.0688 | 0.0379 | 1660 | 42 | 0.0528 | 0.0282 |
| B | 230 | 96 | 0.0578 | 0.0418 | 1495 | 16 | 0.0681 | 0.2607 |
| CCC | 341 | 17 | 0.0493 | 0.0185 | 1837 | 13 | 0.0440 | 0.0207 |
| Total | 88 | 535 | 0.0809 | 0.0428 | 1007 | 275 | 0.0433 | 0.0816 |

*Notes*: This table presents descriptive statistics of the relative bid-ask spreads for CDS and corporate bond yield spread for the credit rating categories from AAA to CCC for the daily observation from May 2009 to June 2011. CDS

relative bid-ask spread is the ratio of the difference between ask and bid prices to mid-price of CDS spread, and bond relative bid-ask spread is the ratio of the difference between quoted ask and bid prices to mid-price of corporate bond yield to maturity. The Avg No. of Quotes represents the average number of quotes from contributing dealers for one reference entity on a given day, and the Avg # obs per day is the average number of reference entities quoted per each business day.

The correlation coefficients of the absolute and relative bid-ask spreads of CDS and corporate bond are compared in Table 8. Panel (a) reports the correlations among CDS and corporate bond liquidity measures using the absolute bid-ask spread, CDS spread and bond yield spread, the level of VIX and the rate of return on S&P 500 index. Most reported correlation coefficients are statistically significant and positive except for the correlations with S&P 500 index, which are close to zero most of the time. However, the correlations with CDS and bond liquidity measures using the relative bid-ask spreads in panel (b) are negative or insignificant most of the time, which also implies the fact that relative liquidity is not very appropriate for the measure of liquidity in CDS and corporate bond markets.

**Table 8. Correlations of the absolute and relative liquidities in CDS and corporate bond markets**

| | CDS Liq | Bond Liq | CDS Spd | Bond Spd | VIX | SP500 |
|---|---|---|---|---|---|---|
| (a) Correlation with absolute liquidities of CDS and corporate bond | | | | | | |
| CDS Liq | 1.000 | | | | | |
| Bond Liq | 0.697 | 1.000 | | | | |
| CDS Spd | 0.800 | 0.658 | 1.000 | | | |
| Bond Spd | 0.817 | 0.749 | 0.927 | 1.000 | | |
| VIX | 0.145 | 0.121 | 0.078 | 0.068 | 1.000 | |
| SP500 | 0.002 | 0.000 | 0.001 | 0.005 | -0.243 | 1.000 |
| | | | | | | |
| (b) Correlation with relative liquidities of CDS and corporate bond | | | | | | |
| CDS Liq | 1.000 | | | | | |
| Bond Liq | -0.015 | 1.000 | | | | |
| CDS Spd | -0.370 | 0.056 | 1.000 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Bond Spd | -0.363 | 0.044 | 0.927 | 1.000 | | |
| VIX | -0.006 | 0.025 | 0.078 | 0.068 | 1.000 | |
| SP500 | 0.006 | 0.000 | 0.001 | 0.005 | -0.243 | 1.000 |

*Notes*: The table reports the correlation matrix for the time series of CDS and corporate bond liquidities, CDS spread and bond yield spread, the level of VIX and the rate of return on S&P 500 index for the daily observation from May 2009 to June 2011. Panel (a) presents the correlation matrix for the absolute liquidity measure represented by the difference between the quoted offer and bid prices of CDS or corporate bond, and panel (b) presents the correlation matrix for the relative liquidity measure represented by the ratio of the quoted bid-ask spread to the mid-price of CDS or corporate bond.

In addition, the results of Granger causality test from the VAR model similar to Table 6 are repeated in Table 9 between the relative liquidity measures of CDS and corporate bond.[10] It indicates that the effect of CDS relative liquidity on bond relative liquidity in one direction or bi-direction is much less significant for most rating categories. The Granger causality between the relative liquidity of CDS or corporate bond and CDS spread or bond yield spread also shows much weaker dominance in either direction. Overall, the results in the table indicate little evidence of one market leading another market liquidity in terms of relative liquidity measures.

**Table 9. Granger causality tests of relative liquidity measures using Vector Autoregression**

| Rating | | CDS Liq | Bond Liq | CDS Spd | Bond Spd |
|---|---|---|---|---|---|
| AAA | CDS Liq | | 0.7 | 0.4 | 0.4 |
| | | | (0.412) | (0.512) | (0.527) |
| | Bond Liq | 0.6 | | 1.0 | 3.5 |
| | | (0.460) | | (0.326) | (0.060) |
| AA | CDS Liq | | 9.0 * | 0.8 | 10.0 * |
| | | | (0.029) | (0.860) | (0.019) |
| | Bond Liq | 2.7 | | 0.8 | 3.6 |
| | | (0.434) | | (0.848) | (0.313) |
| A | CDS Liq | | 2.4 | 29.5 ** | 24.7 ** |
| | | | (0.882) | (0.000) | (0.000) |
| | Bond Liq | 7.5 | | 2.3 | 32.0 |
| | | (0.273) | | (0.888) | (0.000) ** |
| BBB | CDS Liq | | 2.9 | 12.4 * | 12.2 * |
| | | | (0.576) | (0.014) | (0.016) |
| | Bond Liq | 15.3 ** | | 17.6 ** | 36.4 ** |

[10] For brevity, we report only the relative liquidity variables as dependent variable (row variable) in this table.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | (0.004) | | (0.001) | (0.000) | |
| BB | CDS Liq | | 5.2 | 5.1 | 6.0 | |
| | | | (0.270) | (0.276) | (0.196) | |
| | Bond Liq | 10.3 | * | 5.2 | 20.7 | ** |
| | | (0.035) | | (0.268) | (0.000) | |
| B | CDS Liq | | 9.5 | 15.7 | * 8.1 | |
| | | | (0.219) | (0.028) | (0.324) | |
| | Bond Liq | 3.0 | | 0.2 | 1.0 | |
| | | (0.882) | | (1.000) | (0.995) | |
| CCC | CDS Liq | | 1.3 | 4.2 | 6.3 | * |
| | | | (0.532) | (0.122) | (0.042) | |
| | Bond Liq | 0.3 | | 3.9 | 2.8 | |
| | | (0.856) | | (0.144) | (0.244) | |

*Notes*: This table presents $\chi^2$ statistics and *p*-values (in parentheses) of pair-wise Granger causality test from the VAR equations among relative liquidities and credit spreads of CDS and corporate bond for the credit rating categories from AAA to CCC for the daily observation from May 2009 to June 2011. Null hypothesis is that row variable does not Granger-cause column variable. CDS relative liquidity is represented by the ratio of the quoted bid-ask spread to the mid-price of 5-year CDS, and bond relative liquidity is represented by the ratio of the quoted bid-ask spread to the mid-price of comparable closet-to-5-year corporate bond. * denotes significance at the 5% level and ** denotes significance at the 1% level.

## IV. Conclusion

After global financial markets went through several financial crises for the past several decades, the credit and liquidity risks have received much attention among academia, institutional professionals and financial regulators in various financial markets. The market and credit risks in asset prices have been theoretically and empirically studied extensively, but the research on liquidity risk has yet to be developed more and the pricing impact of liquidity risk is relatively difficult to be measured quantitatively. In this paper, we empirically investigated the difference and relationship between the liquidities of CDS and corporate bond markets. There should be a parity relationship between CDS spread and corporate bond yield spread so as to prevent any arbitrage opportunities. Also, it is conjectured that the liquidity risk in CDS market is less

significant due to its contractual nature that relatively allows trading large amount easily compared to corporate bond market.

For the period covered in this study, liquidities represented by the bid-ask spreads exhibit similar pattern and magnitude in both CDS and bond markets, while the bid-ask spread of corporate bond yield often stays sticky for a period of time whereas CDS bid-ask spread fluctuates according to some market condition changes. However, comparing the difference between the bid-ask spreads of CDS and corporate bond for each reference entity, the liquidity basis tends to exhibit negative numbers, implying more illiquid corporate bond markets and the fact that CDS market moves more quickly in reflecting the changes of credit condition. The results of the Granger-causality test from VAR system indicate similar evidence that the CDS liquidity Granger-causes and leads the corporate bond liquidity for some credit rating categories of reference entities. For some investment grade reference entities, CDS liquidity and bond liquidity show strong Granger causality in both directions, implying that there is no dominant effect in terms of price discovery process in either market. CDS spread and corporate bond yield spread also exhibit significant Granger causality towards CDS and corporate bond liquidities for most rating categories. The interaction between CDS spread and bond yield spread is evidenced by significant Granger causality of CDS spread on bond yield spread for most rating categories.

Correlation matrix among CDS and bond liquidities, CDS spread and bond yield spread exhibit significant positive relations.

The relative bid-ask spread adopted by some researchers for liquidity measure doesn't seem to function well for CDS and corporate bond markets where the credit quality of underlying reference entity has implications for the price and bid-ask spread. The correlation coefficients among the relative bid-ask spreads of CDS and bond, CDS spread and bond yield spread do not show any meaningful relations. The results of Granger causality test employing the relative liquidity measure often indicate insignificant effects of one market on another and little evidence of one market liquidity leading another market liquidity for most credit rating categories of reference entities.

This study contributes to the empirical research on the effect of liquidity in CDS and bond markets. It leaves however several paths open to further research on liquidity and credit risks in derivatives markets. Most obviously, since the credit derivative security markets are still developing, the results in this study are not necessarily representative of the other span of period than our relatively short sample period. Furthermore, the pricing implication of liquidity risk and the separation from the credit premium need to be clarified, and the theoretical and empirical links to macroeconomic variables need to be further investigated.

## References


Acharya, Viral and Lasse Pedersen, 2005, Asset pricing with liquidity risk, *Journal of Financial Economics* 77, 375–410.

Amihud, Yakov, 2002, Illiquidity and Stock Returns: Cross-Section and Time-Series Effects, *Journal of Financial Markets* 5, 31–56.

Amihud, Yakov and Haim Mendelson, 1986, 'Asset Pricing and the Bid-Ask Spread,' *Journal of Financial Economics* 17, 223–249.

Basel Committee on Banking Supervision, Basel III: International Framework for Liquidity Risk Measurement, Standards and Monitoring. December 2010

Blanco, Roberto, Simon Brennan, and Ian W. Marsh, 2005, An empirical analysis of the dynamic relationship between investment grade bonds and credit default swaps, *Journal of Finance* 60, 2255-2281.

Bongaerts, Dion, Frank de Jong, and Joost Driessen, 2011, Derivative Pricing with Liquidity Risk: Theory and Evidence from the Credit Default Swap market, *Journal of Finance* 66, 203-240.

Brunnermeier, Markus, and Lasse Heje Pedersen, 2009, Market liquidity and funding liquidity, *The Review of Financial Studies* 22, 2201-2238.

Chen, Ren-Raw, Frank Fabozzi, and Ronald Sverdlove, 2008, Corporate Credit Default Swap Liquidity and Its Implications for Corporate Bond Spreads, Working paper

Chordia, Tarun, Richard Roll, and Avanihar Subrahmanyam, 2000. Commonality in Liquidity, *Journal of Financial Economics* 56, 3–28.

Chordia, Tarun, Asani Sarkar, and Avanihar Subrahmanyam, 2005, An Empirical Analysis of Stock and Bond Market Liquidity, *The Review of Financial Studies* 18, 85-129

Delianedis, Gordon, and Robert Geske, 2001, The components of corporate credit spreads: Default, recovery, tax, jumps, liquidity, and market factors, Working paper, UCLA.

Duffie, Darrell, and Ken Singleton, 1999, Modeling term structures of defaultable bonds,

*Review of Financial Studies* 12, 687-720.

Elton, Edwin J., Martin J. Gruber, Deepak Agrawal, and Christopher Mann, 2001, Explaining the rate spread on corporate bonds, *Journal of Finance* 56, 247-277.

Ericsson, Jan, and Olivier Renault, 2006, Liquidity and credit risk, *Journal of Finance* 61, 2219-2250.

Goyenko, Ruslan and Andrey Ukhov, 2009, Stock and Bond Market Liquidity: A Long-Run Empirical Analysis, *Journal of Financial and Quantitative Analysis* 44, 189-212

Houweling, Patrick, and Ton Vorst, 2005, Pricing default swaps: Empirical evidence, *Journal of International Money and Finance*, 24, 1200-1225.

Hull, John, Mirela Predescu, and Alan White, 2004, The relationship between credit default swap spreads, bond yields, and credit rating announcements, *Journal of Banking and Finance* 28, 2789-2811.

Hull, John C., and Alan White, 2000, Valuing credit default swaps I: No counterparty default risk, *Journal of Derivatives* 8, 29-40.

Jegadeesh, N., and A. Subrahmanyam. 1993, Liquidity effects of the introduction of the S&P 500 index futures contract on the underlying stocks, *Journal of Business* 66, 171-187.

Longstaff, Francis A., Sanjay Mithal, and Eric Neis, 2005, Corporate yield spreads: Default risk or liquidity? New evidence from credit-default swap market, *Journal of Finance* 60, 2213-2253.

Tang, Dragon Yongjun and Hong Yan, 2007, Liquidity and Credit Default Swap Spreads, Working paper, University of South Carolina.