科技部補助專題研究計畫成果報告
期末報告

流動性風險探討─以美國公司債/信用違約交換市場為例（第 2 年）

計 畫 類 別 ：個別型計畫
計 畫 編 號 ：NSC 100-2410-H-004-055-MY2
執 行 期 間 ：101 年 08 月 01 日至 103 年 02 月 28 日
執 行 單 位 ：國立政治大學財務管理學系

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中 華 民 國 103 年 05 月 29 日

中 文 摘 要 ： 本研究計劃在探討市場流動性對公司債價格的影響。文獻上已證明流動性會影響股票的報酬率，並建議將市場流動性視做股票市場的風險性因子。而債券市場的流動性較股票市場更差，因此在定價公司債及分析其報酬率時，更應將不流動性的各個面向考慮進去。因此本計劃旨在探討流動性對公司債定價的影響。

中文關鍵詞： 市場流動性 ； 泰德價差； 流動性風險因子； 公司債報酬

英 文 摘 要 ： In this paper, we first study whether liquidity risk is a priced risk factor in the corporate bond market. In contrast to the literature, we find no evidence that liquidity risk is an important risk factor in the bond pricing model during our sample period from July 2002 to Dec. 2011. Then we further study the effect of market liquidity, measured by the TED spread, on the liquidity of corporate bond market. Our empirical results show that when the TED spread increases, the market shares of volume for the most liquid group decrease. The result is contrast to the liquidity pull-back effect of Nyborg and Ö stberg (2014). However, if we divide a particular liquidity group into eight groups according to the ratings of corporate bonds, we find no evidence that better ratings in a liquidity group will trade more frequently compared to those with poor ratings.

英文關鍵詞： market liquidity； TED Spread； liquidity risk factor； corporate bond returns

附件一

行政院國家科學委員會補助專題研究計畫

□期中進度報告
■期末報告

流動性風險探討 – 以美國公司債/信用違約交換市場為例

Liquidity Risk in Corporate Bond / CDS Markets

計畫類別：■個別型計畫　□整合型計畫
計畫編號：NSC100－2410－H－004－055－
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執行機構及系所：國立政治大學財務管理學系

計畫主持人：岳夢蘭
共同主持人：
計畫參與人員：邱信瑜，謝依婷

本計畫除繳交成果報告外，另含下列出國報告，共 _0_ 份：
□移地研究心得報告
□出席國際學術會議心得報告
□國際合作研究計畫國外研究報告

處理方式：除列管計畫及下列情形者外，得立即公開查詢
□涉及專利或其他智慧財產權，□一年□二年後可公開查詢

中　華　民　國 103 年 5 月 28 日

Section 1. Introduction

Liquidity risk has captured the attention of researchers during the financial crisis of 2008. While the crisis causes a dramatic widening in corporate bond spreads, the literature explains part of the spread-widening with the decrease in bond liquidity. Dick-Nielsen, Feldhütter and Lando (2012) examine liquidity components of corporate bond spreads using different illiquidity measures and find the spread contribution from illiquidity increases during the subprime crisis. Lin, Wang and Wu (2011) examine the cross section of corporate bond returns and find positive relation between expected bond returns and liquidity beta. They conclude that liquidity risk is an important determinant of corporate bond returns.

Our study attempts to further investigate the difference in liquidity nature across corporate bonds with different ratings. Since the turnover and trading frequency is low in corporate bond markets, the question that when and which bonds have transaction is important for understanding the trading behavior of bond investors. Nyborg and Östberg (2014) examine the liquidity pull-back effect in stock markets and find tighter interbank markets are associated with relatively more volume in more liquid stocks. They provide a useful empirical methodology to investigate the trading behavior across different liquidity portfolio. We utilize their approach to sort all corporate bonds by Amihud (2002) illiquidity measure of each bond and examine the effect of TED spread and VIX on the market share of volume of each liquidity group. This allows us to shed light on the different trading behavior across different rating and liquidity in corporate bond markets.

We first examine the role of liquidity risk by the factor model. In contrast to the existing literature, we cannot find evidences on supporting that liquidity risk is an important risk factor in time-series regression during our sample period from Jul. 2002 to Dec. 2011. We find that default and term premium have most impact on corporate bond returns. However, the returns of systematic illiquidity measure constructed by Amihud's (2002) individual illiquidity measure cannot explain the variation in time-series corporate bond returns. We also use the Amihud liquidity innovation and Pastor-Stambaugh liquidity innovation constructed by Lin, Wang and Wu (2011) as the measure for systematic liquidity risk. The result shows that the coefficients of these measures in the time-series regression are not significant.

We then focus on exploring the difference in the effect of TED spread and VIX on different liquidity groups and rating groups. We first sort all available corporate bonds in the TRACE database by their Amihud illiquidity measure and form ten liquidity groups in month t. Each liquidity group includes 10% corporate bonds. In month

$t + 1$, we conduct time-series regression tests for each liquidity group. The tests regress the market share of volume of a particular liquidity group on the TED spread and VIX. The TED spread measures the interbank liquidity and increases when interbank liquidity is tight. By examining the effect of TED spread on the market share of volume of each group, we provide a linkage between the interbank market and the corporate bond market. The VIX measures the market-wide uncertainty. The relationship between the VIX and the market share of volume of each group shows how investors balance their portfolio and change their exposure across different liquidity groups.

Our results show many differences compared with the argument of Nyborg and Östberg (2014). When the TED spread increases, the market shares of volume for the most liquid group decrease. The result is contrast to the liquidity pull-back effect of Nyborg and Östberg (2014). However, if we divide a particular liquidity group into eight groups according to the ratings of corporate bonds, we may find the market share of volume for the most liquidity group in some rating groups increase while the TED spread increase. Corporate bonds differ from individual stocks as corporate bonds have many characteristics, for example, ratings, maturities, issued amounts, or ages. These features may separate corporate bonds into several market segments.

The rest of this study is organized as follows. Section 2 reviews the existing literature. Section 3 describes the methodology for empirical investigations. Section 4 provides our empirical results. Section 5 concludes.

Section 2. Literature

It is well know that liquidity is time-varying and has commonality in individual stocks and stock market. Chordia, Roll and Subrahmanyam (2000) study common determinants of liquidity. They find quoted spreads, quoted depth and effective spreads co-move with market-wide liquidity. The common factors have impacts on individual liquidity measure even after controlling for individual determinants of liquidity, for example, trading volume, volatility and price. Hasbrouck and Seppi (2001) find that common factors constructed by principal components or canonical correlations exist in order flows. The common factors also explain the commonality in stock returns. Chordia, Sarkar and Subrahmanyam (2005) investigate cross-market liquidity dynamics between stock and bond markets. They find liquidity and volatility shocks are correlated across two markets at daily horizons. They conclude that liquidity and volatility shocks are often systematic.

Pastor and Stambaugh (2003) construct a market-wide liquidity measure based on order flow which induces greater return reversals when liquidity is lower. They find that expected stock returns are correlated with the sensitivities of returns to variation in the market-wide liquidity cross-sectionally. They conclude that market-wide liquidity is a state variable for asset pricing. Using another illiquidity measure constructed by the average across stocks of the daily ratio of absolute stock return to dollar volume, Amihud (2002) also find that stock returns are negatively related to unexpected illiquidity. In the cross-section estimation, illiquidity measure has a positive effect on stock returns. In time-series, expected market illiquidity has a positive effect on ex ante stock excess return.

Inspired by these empirical findings, Acharya and Pedersen (2005) provide an equilibrium model with liquidity risk. The liquidity-adjusted capital asset pricing model implies that investors increase the required return of a security in the covariance between its illiquidity and the market illiquidity.

For corporate bond market, Chen, Lesmond and Wei (2007) provide evidences that more illiquid bonds earn higher yield spreads after controlling for bond-specific, firm-specific and macroeconomic variables. This shows that liquidity risk is priced in corporate yield spreads. Default risk alone cannot fully explain the level or the dynamic of yield spreads. Longstaff, Mithal and Neis (2005) find that corporate bond spreads can be mainly explained by default risk by using the information in credit default swaps (CDS) as the direct measures of the size of the default component. However, they also find the nondefault component is related to bond-specific illiquidity measures and bond market-wide liquidity. Friewald, Jankowitsch and Subrahmanyam (2012) employ a wide range of liquidity measures and explore the time-series and cross-sectional effects using panel and Fama-MacBeth regressions. They find that liquidity measures account for 14% of the explained time-series variation of the yield spread changes. Bao, Pan and Wang (2011) and Dick-Nielsen, Feldhütter and Lando (2012) both find that aggregate liquidity is the dominant factor in explaining the time variation in bond spreads.

Instead of using corporate bond yield changes, Lin, Wang and Wu (2011) find that liquidity risk is an important determinant of expected corporate bond returns. They prove empirically liquidity is a state variable in corporate bond pricing model and that liquidity risk is priced in bond returns by using Pastor-Stambaugh (2003) and Amihud (2002) illiquidity innovations. Bongaerts, de Jong and Driessen (2012) also investigate the relation between liquidity risk and expected corporate bond returns by an asset pricing approach. They construct the liquidity measures by a Bayesian approach based on Roll's measure. The effect of equity market liquidity risk on expected corporate bond returns are strong, however, corporate bond liquidity risk cannot explain expected corporate bond returns.

Corporate bond markets have many differences from stock markets. Typically, corporate bonds are less liquid than equity markets. Transactions of corporate bonds are less frequent and turnover is low. Also, the characteristics of corporate bonds, for example, ages, maturities, coupon rates, ratings, may separate corporate bond markets into several segments. The question related to when and which bonds are traded draws our attention. Nyborg and Östberg (2014) examine liquidity pull-back effect in stock market. They attempt to make a connection between the interbank market and the financial markets. They argue that tighter interbank markets induce more volume and more selling pressure in more liquid stocks. Their approach is useful to understand different trading behaviors between different liquidity groups.

In this paper, we first examine whether liquidity risk is priced in corporate bond market by time-series regression of corporate bond returns on market-wide liquidity measure. Then, we follow Nyborg and Östberg (2014) and focus and the market share of volume of each liquidity groups sorted and ranked by individual illiquiidity measures. We test the liquidity pull-back effect in corporate bond market and investigate the role of bond characteristics in determining changes of the market share of volume for each group.

Section 3. Methodology

We first discuss our data for empirical investigation. We obtain price and transaction data of corporate bonds from the TRACE transaction database. Since dealers are required by the NASD to report their transactions on the TRACE system after July 1, 2002. Our sample includes corporate bond transaction records from July 2002 to December 2011. There are 62,759,376 bond transactions during the sample period. The total number of corporate bonds reported on the TRACE system is 67,233. We also obtain ratings and characteristic information including issue date, issuer, issued amount, coupon rate, coupon type and maturity date of corporate bonds from the Bloomberg database. We thus acquire 66,561 bonds, which represents the total number of different Committee on Uniform Security Identification Procedures (CUSIP) numbers. We then merge two databases by the CUSIP number of each corporate bond.

We exclude the corporate bonds which have missing issuance data, missing ratings, and the feature of callable, putable, sinkable and convertible. Bonds with the coupon type of floating rates are also eliminated. This yields 20,110 bonds which have transaction data in TRACE and issuance information in Bloomberg at the same time. The total number of transactions is 31,181,773.

To calculate monthly corporate bond returns, we follow Lin, Wang and Wu (2011). The monthly bond return in month t is calculated as

$$r_t = \frac{(P_t + AI_t) + C_t - (P_{t-1} + AI_{t-1})}{P_{t-1} + AI_{t-1}}$$

where P_t is the transaction price, AI_t is accrued interest and C_t is the coupon payment. The transaction price at the end of each month is calculated by interpolating the last price of the month and the first price of the following month.

We also follow Bongaerts, de Jong and Driessen (2012) and Bessembinder, Kahle, Maxwell and Xu (2009) to remove bond trades that are with dealer commission, canceled or reversed. The TRACE database has the commission indicator to indicate if the reported price is inclusive of dealer commission. Furthermore, the TRACE database has a trade status indicator to denote the canceled or corrected trades, and an as/of indicator to indicate if the transaction is an as/of trade, reversal from a prior business day, or a delayed disseminated trade. We also remove the reported prices with negative yield.

Then, we remove duplicate records by consecutively sorting on bond CUSIP, date and volume and removing identical consecutive records. We also remove consecutive trades with yield changes of more than 1000 basis points. After applying the above filters, we provide a summary for transactions with these features as table 1. Note that now we have 12,673 bonds and 17,685,019 transactions.

Table 1: Summary of available transaction data and filters

All trades	No. of transactions	No. of CUSIP
during Jul. 2002-Dec. 2011 in TRACE	62,759,376	67,233
corporate bonds which have issuance information in Bloomberg	31,181,773	20,110

Filters	No. of trades removed	No. of trades removed/Total trades with issuance information in Bloomberg	Remaining trades	No. of CUSIP

Transaction price includes commission	603,074	1.9341%	30,578,699	
Trades cancellation	381,661	1.2240%	30,800,112	
Trades correction	321,678	1.0316%	30,860,095	
As/of trades	562,628	1.8043%	30,619,145	
Reversal	314,627	1.0090%	30,867,146	
Delayed dissemination	14,030	0.0450%	31,167,743	
Delayed reversal	380	0.0012%	31,181,393	
Negative yield sign	93,858	0.3010%	31,087,915	
Transactions after maturity date	4,110	0.0132%	31,177,663	
Transactions before issue date	402659	1.2913%	30,779,114	
Above filters	2,544,031	8.1587%	28,637,742	
unrealistically high yield changes	815,101			
Duplicated trades	10,436,852			
All filters	13,496,754		17,685,019	12,673

To investigate the relationship between bond returns and liquidity risk, we first follow Elton, Gruber, Agrawal and Mann (2001) and conduct a regression test using a linear factor model which includes the traditional risk factors. The factor model is as follows:

$$excess\ return_{it} = \alpha_i + \beta_{MKT\_RF,i} MKT\_RF_t + \beta_{SMB,i} SMB_t + \beta_{HML,i} HML_t + \beta_{TERM,i} TERM_t + \beta_{DEF,i} DEF_t + \varepsilon_{it} \quad (1)$$

where $excess\ return_{it}$ is the calculated monthly bond excess returns, MKT_RF_t is the stock market excess returns, SMB_t is the size factor, HML_t is the book-to-market factor. For MKT_RF_t, SMB_t and HML_t, we collect from Ken French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/. DEF_t is the default premium and calculated as the difference between the monthly returns of long-term government bonds and investment grade bonds with more than ten years to maturity. $TERM_t$ denotes the term premium and is calculated as the difference between the monthly returns of long-term government bond and one-month Treasury bill. Fama and French (1993) investigate common factors of corporate bond returns and provide evidences that term and default premium explain most of the variation. Also Elton, Gruber, Agrawal and Mann (2001) find that the Fama-French three factors

(MKT_RF, SMB and HML), term and default premium can explain corporate bond returns.

To test the effect of liquidity risk on bond returns, we include a systematic liquidity factor into the original factor model. We first calculate the monthly Amihud (2002) illiquidity measure for each bond. The measure is defined below:

$$Amihud\_illq_{it} = \frac{1}{days_{it}} \sum_{j=1}^{days_{it}} \frac{|r_{ijt}|}{Volume_{ijt}} \quad (2)$$

where $days_{it}$ is the number of days for which transaction data are available in the TRACE database for bond i in month t. $Volume_{ijt}$ is the dollar volume for bond i on day j in month t. r_{ijt} is the return for bond i on day j in month t. The daily return r_{ijt} is calculated using the first transaction price and the last one for bond i on day j.

Then we calculate the market-wide illiquidity measure by summing the monthly individual illiquidity measure as:

$$Amihud\_illq_{Market,t} = \frac{1}{N_t} \sum_{i=1}^{N_t} Amihud\_illq_{it} \quad (3)$$

where N_t is the number of corporate bonds for which the monthly individual illiquidity measure is available in month t. The new factor model with liquidity risk is as follows:

$$excess\ return_{it} = \alpha_i + \beta_{MKT\_RF,i} MKT\_RF_t + \beta_{SMB,i} SMB_t + \beta_{HML,i} HML_t + \beta_{TERM,i} TERM_t + \beta_{DEF,i} DEF_t + \beta_{Amihud\_return,i} Amihud\_illq_{Market,t} + \varepsilon_{it} \quad (4)$$

where $Amihud\_illq_{Market,t}$ is the return of the market-wide Amihud illiquidity measure in month t from month $t-1$. We standardize the time-series of market-wide Amihud returns with the mean of 0 and the standard deviation of 1. We also follow Lin, Wang and Wu (2011) to calculate the Pastor and Stambaugh's (2003) illiquidity innovations and the Amihud illiquidity innovations.

Since the average turnover of corporate bonds is low, an interesting question for corporate bond market is that when and which bonds with what features are traded. To investigate the topic empirically, we use the individual Amihud illiquidity measure to sort all corporate bonds into ten liquidity groups on a monthly basis. We calculate the market share of trading volume for each group based on the liquidity ranking in last month and investigate the time series of changes in market share of volume on a daily basis.

In particular, we first calculate $Amihud\_illq_{i,t}$ for each bond in month t. We rank all corporate bonds by their Amihud illiquidity measure and denote the 10% most liquid bonds as group1 and the 10% most illiquid bonds as group10. In month t, the Amihud illiquidity measures increase as we go from group1 to group10. Then in month $t+1$, for each group based on the liquidity ranking in month t, we calculate the market share of trading volume on a daily basis as follows:

$$MS_{group\ i,k} = \frac{Total\ trading\ volume\ of\ group\ i\ on\ day\ k}{Total\ trading\ volume\ of\ all\ groups\ on\ day\ k} \quad (5)$$

Note that for entire month $t+1$, the liquidity groups are sorted using the liquidity ranking in month t. We follow Nyborg and Östberg (2014) and mean-adjust the market share of volume for each group by its average for all sample period. This enables us to conduct comparison across liquidity groups. The mean-adjusted market share of volume for group i on day k is calculated as:

$$MS_{adjusted,i,k} = \frac{MS_{group\ i,k}}{average(MS_{group\ i})} \quad (6)$$

Nyborg and Östberg (2014) investigate the liquidity pull-back effect on stock market and argue that the market share of volume for each liquidity group is affected by the TED spreads which is the three-month Libor less the three-month Treasury bill rate. The regression for estimating the liquidity pull-back effect is as follows:

$$MS_{adjusted,i,k} = \alpha + \beta_{lag\_MS,i} MS_{adjusted,i,k-1} + \beta_{TED,i} TED_k + \epsilon_k \quad (7)$$

They also control for the VIX which represents the market-wide uncertainty. We follow their approach and first regress the VIX on the TED spreads on a daily basis:

$$VIX_k = \alpha + \beta TED_k + \varepsilon_k \quad (8)$$

To examine the effect of TED spreads and VIX on the market share of volume for each group, we run the following regression:

$$MS_{adjusted,i,k} = \alpha + \beta_{lag\_MS,i} MS_{adjusted,i,k-1} + \beta_{TED,i} TED_k + \beta_{VIX\_Resid,i} VIX_{Resid,k} + \epsilon_k \quad (9)$$

where $VIX_{Resid,k}$ is the residual on day k from the regression of the VIX on the TED spread.

For the robustness test, we examine the effect of TED spread while controlling for several variables which may affect the market share of volume for each liquidity group. We include average issued amount, average rating, average age, average remaining maturity, and average return for the liquidity group i on day k. We also include a crisis dummy which takes value of 1 when the market share of volume of group i is measured after Sep. 2008. The regression is as follows:

$$MS_{adjusted,i,k} = \alpha + \beta_{lag\_MS,i} MS_{adjusted,i,k-1} + \beta_{TED,i} TED_k + \beta_{VIX\_Resid,i} VIX_{Resid,k} + \beta_{AMT,i} AMT_k + \beta_{rating,i} Rating_k + \beta_{Age,i} Age_k + \beta_{remaining,i} Remaining_k + \beta_{return,i} return_k + \beta_{crisis,i} Dummy_{crisis} + \epsilon_k \quad (10)$$

The rating is measured on a nominal scale. We assign a value of 0 to the corporate bonds rated Aaa, 1 to Aa1, 2 to Aa2… , and 21 to C. Furthermore, we also form the rating groups within each liquidity group. In a particular liquidity group, we divide the corporate bonds into eight rating groups. We include all bonds rated Aaa in the liquidity group as rating group1, those rated Aa1-Aa3 as rating group2, those rated A1-A3 as rating group3, those rated Baa1-Baa3 as group4…, and those rated Ca and C as group8. This yields 80 double-sorted groups. We then calculate the market shares of volume and mean-adjust these measures for each double-sorted group. We run the time-series regression model (10) for each group.

Finally, we form the double-sorted groups in another way. In month t, we first divide all corporate bonds into eight rating groups. Then we sort all bonds in a particular rating group by their Amihud illiquidity measure calculated in month $t-1$ and divide these bonds into ten liquidity groups. This also yields 80 double-sorted groups. We also run the time-series regression model (10) for each group.

These two different methods for forming double-sorted groups enable us to investigate the effect of TED spread on different bonds with different features. Dividing the corporate bonds in a particular liquidity group can be used to examine the effect across different ratings while controlling the liquidity nature of corporate bonds. On the other hand, sorting by illiquidity measure within a particular rating group allow us to examine the effect across different liquidity nature while controlling the credit risk of corporate bonds.

Section 4. Empirical results

We first show the summary statistics of risk factors for all sample period in table 2. During the sample period, the average of excess returns for all traded corporate bonds is 61.43bps. The average monthly return is reasonable compared to the results of Bessembinder, Kahle, Maxwell and Xu (2009). The average of monthly bond returns of Bessembinder, Kahle, Maxwell and Xu (2009) is 70bps, which is calculated from the Lehman Brothers Bond Database for the period from 1987 to 2004. Also, the average daily return from their empirical investigation is 2.7bps for the period from 2002 to 2006. The average excess return for our sample period is 42.65bps monthly. The average market-wide Amihud illiquidity return is 83.47bps.

Note that the average of Amihud and Pastor-Stambaugh (PS) liquidity innovation is negative whereas the average market-wide Amihud illiquidity return is positive. This is because that the innovation measures of Lin, Wang and Wu (2011) increase when the market liquidity improves. However, the market-wide Amihud illiquidity measure decreases when the market liquidity improves.

During Jul. 2002-Dec. 2011, the monthly average stock market return is 77.81bps and its volatility is 4.6755%. The average monthly returns of SMB and HML are 57.25bps and 35.62bps respectively. The average default premium is -1.45bps and the average term premium is 40.75bps. The Amihud and PS liquidity innovation of Lin, Wang and Wu (2011) have means close to zero.

The summary of time series regression estimates is shown in table 3. We run the time series regression for each corporate bond and average their estimated coefficients, t-statistics and R^2. Panel A presents the estimated coefficients of the traditional factor model. The most significant variable is the term premium which has the mean t-statistics of 2.7393. The mean coefficient for the term premium is 0.5568. The mean t-statistics of the default premium is 1.8149 and the coefficient is 0.5211. Similar to Lin, Wang and Wu (2011), the term and default premium are significant whereas the coefficients of other risk factors are not significant. The R^2 of the traditional factor model is averaged at 41.10%.

Table 2: Summary statistics of risk factors for the regression tests

Summary statistics of factors (%)

Variable	Mean	Standard deviation	Maximum	Minimum	Median
return	0.6143	2.7395	14.2106	-12.0009	0.4752
Excess return	0.4265	2.7592	13.9699	-12.0157	0.2477
MKT_RF	0.7781	4.6755	11.0400	-18.5500	1.5000
SMB	0.5725	2.3795	5.8800	-4.2700	0.1800
HML	0.3562	2.3279	7.5700	-6.7300	0.2700
DEF	-0.0145	2.8095	11.5100	-10.7450	-0.0320
TERM	0.4075	3.2931	12.8550	-8.8190	0.4930
Amihud innovation	-0.1563	1.0667	1.7978	-4.7313	0.0006
PS innovation	-0.0185	0.2447	0.3645	-1.3336	0.0235
Market-wide Amihud illiquidity returns	0.8347	10.6261	27.5003	-23.2688	-0.3386

In panel B, C and D, we include different measure for liquidity risk into the traditional factor model. Contrary to the results of Lin, Wang and Wu (2011), the coefficients of these liquidity risk factors are not significant during our sample period. Panel B presents the estimated coefficients when the market-wide Amihud illiquidity return is included. The average β_{Amihud_return} is -0.0002 and the mean t-statistics is only -0.0579. The average $\beta_{Amihud\_returns}$ in panel C and $\beta_{PS\_innovation}$ in panel D are 0.0564 and 0.1743 respectively. The mean t-statistics are not significant for these two liquidity risk factors.

Next, to further understand the nature of bond transactions, we divide all corporate bonds into ten groups sorted by their illiquidity measure on a monthly basis. Our attempt is to investigate when and what kind of bonds are traded from time to time. Note that the constitution of a particular liquidity group in month t may differ from that in month $t-1$. That is, we construct the liquidity groups every month by the illiquidity measure of each bond last month.

Table 3: Time series regression results

Summary of time series regression estimates

Variable	Mean	Standard deviation	Maximum	Minimum	Median	Mean t	Median t
	Panel A: Factor model						
Intercept	0.1687	0.4390	4.9423	-2.8005	0.1213	0.4059	0.3924
β_{MKT_RF}	0.0280	0.2116	1.6917	-1.7101	0.0293	0.3063	0.2959
β_{SMB}	0.0432	0.2448	1.8539	-2.4348	0.0186	0.1656	0.1368
β_{HML}	0.0364	0.2787	3.3667	-2.7917	0.0094	0.0855	0.0719
β_{TERM}	0.5568	0.4795	4.3971	-4.1532	0.4892	2.7393	2.3728
β_{DEF}	0.5211	0.5840	5.1390	-3.2716	0.4588	1.8149	1.6139
R^2	0.4110	0.1842	0.9979	0.0070	0.4050		
	Panel B: Factor model with market-wide Amihud illiquidity returns						
Variable	Mean	Standard deviation	Maximum	Minimum	Median	Mean t	Median t
Intercept	0.1657	0.4505	5.5347	-4.7057	0.1194	0.3939	0.3907
β_{MKT_RF}	0.0292	0.2305	1.7573	-1.9635	0.0299	0.2765	0.2783
β_{SMB}	0.0447	0.2555	3.7439	-1.7348	0.0169	0.1713	0.1254
β_{HML}	0.0364	0.2903	3.4181	-2.8184	0.0080	0.0692	0.0634
β_{TERM}	0.5615	0.4961	4.5369	-4.5334	0.4980	2.6858	2.2729
β_{DEF}	0.5261	0.6037	5.4483	-5.0834	0.4708	1.7847	1.6021
$\beta_{Amihud\_returns}$	-0.0002	0.0642	0.5657	-0.5212	-0.0010	-0.0579	-0.0287
R^2	0.4430	0.1856	0.9999	0.0191	0.4365		
	Panel C: Factor model with changes of Lin, Wang and Wu's (2011) Amihud liquidity innovation						
Variable	Mean	Standard deviation	Maximum	Minimum	Median	Mean t	Median t
Intercept	0.0873	0.5894	7.2082	-5.3077	0.0701	0.2132	0.2299
β_{MKT_RF}	0.0225	0.2665	2.6844	-2.9559	0.0170	0.1759	0.1433
β_{SMB}	0.0314	0.3321	3.5542	-2.6669	0.0119	0.0870	0.0796
β_{HML}	0.0451	0.3178	4.3704	-2.8260	0.0192	0.1341	0.1384
β_{TERM}	0.5618	0.6037	4.3818	-3.2083	0.4438	2.3431	1.9522
β_{DEF}	0.5104	0.7861	6.7749	-4.0342	0.4124	1.3839	1.1683
$\beta_{Amihud\_innovation}$	0.0564	0.8701	8.7308	-7.2368	0.0580	0.1103	0.1527
R^2	0.4716	0.1984	0.9983	0.0293	0.4690		
	Panel D: Factor model with changes of Lin, Wang and Wu's (2011) Pastor-Stambaugh liquidity innovation						
Variable	Mean	Standard deviation	Maximum	Minimum	Median	Mean t	Median t
Intercept	0.0895	0.5992	10.1013	-5.3801	0.0627	0.1785	2.3967
β_{MKT_RF}	0.0218	0.2841	2.5081	-3.4619	0.0168	0.1691	3.7320
β_{SMB}	0.0372	0.3272	3.6882	-2.5625	0.0150	0.1188	3.2090
β_{HML}	0.0575	0.3389	2.9096	-3.9947	0.0257	0.2060	3.3776
β_{TERM}	0.5711	0.5336	4.5956	-4.5804	0.4746	2.6612	9.8024
β_{DEF}	0.5360	0.6939	8.8445	-4.0072	0.4573	1.6547	6.7051
$\beta_{PS\_innovation}$	0.1743	3.7937	26.9421	-61.1295	0.1211	0.0542	3.3679
R^2	0.4765	0.2012	0.9996	0.0088	0.4717		

In table 4, we show the summary statistics of bond characteristics for each liquidity group during all sample period. The market share of volume is largest for the liquidity group1. This is because while the trading volume of a particular bond increases, its illiquidity measure decrease which implies that its liquidity improves. The bonds in most liquid group have large trading volume on average. We can find that the average age of corporate bonds increases with liquidity rankings while the average issued amount decreases. This shows that the older bonds and the bonds with smaller issue size are more illiquid. The average rating and the average remaining maturity are not monotonic with the liquidity rankings. The rating of the most liquid group has a mean of 7.8922, which is higher than the liquidity group2. The remaining maturity of the liquidity group1 has a mean of 8.1615 which is also higher than group2.

Table 4: Summary statistics of bond characteristics for each liquidity group

Liquidity group	Bond characteristics						
	Market share of volume	Average rating	Average remaining maturity	Average age	Average daily return	Average issued amount	Average Amihud illquidity
1	0.3059	7.8922	8.1615	32.6020	0.0004	1,817,163,837	2.9949
2	0.2112	7.7974	7.1102	36.1907	0.0002	1,335,269,481	3.4167
3	0.1432	7.8811	6.9789	39.7967	0.0003	1,043,732,560	5.3774
4	0.1014	8.0372	7.2575	44.4442	0.0003	851,725,419	7.8850
5	0.0735	8.2796	7.7328	49.2066	0.0005	716,161,990	11.3666
6	0.0539	8.5196	8.0974	54.5886	0.0007	607,953,271	15.2126
7	0.0406	8.8169	8.5647	59.6136	0.0009	530,840,716	19.9504
8	0.0309	8.9832	9.1066	63.8304	0.0011	457,257,530	24.9826
9	0.0236	9.0548	10.0174	71.2646	0.0015	398,701,981	31.8236
10	0.0181	8.9532	11.8213	77.0509	0.0022	350,005,289	45.0598

To investigate the effect of TED spread and VIX on corporate bond trading, we run the regression model (9) and present the results in table 5. For liquidity group1-4, the coefficients of TED are all significant, however the signs are different. The estimated coefficient of TED spreads for the liquidity group1 is -0.0002 and the t-statistic is -3.4656. This implies that while the TED spread increases, the market share of volume for the most liquid group decreases. On the other hand, while the TED spread increases, the market shares of volume for the liquidity group2-4 increase. For the liquidity group5-10, the estimated coefficients of the TED spread are not significant.

Despite the different signs of the coefficients, the TED spread has greater impact on more liquid groups (group1-4) than illiquid ones. According to the argument of Nyborg and Östberg (2014), we may conclude that the liquidity pull-back effect exist in the liquidity group2-4.

Table 5: Regression result of each liquidity group

Liquidity group	Estimated coefficients and t-statistics				R^2
	$Intercept$	β_{TED}	β_{lag_MS}	β_{VIX_Resid}	
1	0.2622	-0.0002	0.7498	0.0007	58.27%
	(17.2332)	(-3.4656)	(54.4319)	(1.6604)	
2	0.5239	0.0004	0.4554	-0.0035	26.80%
	(27.8333)	(5.0134)	(24.5472)	(-6.6684)	
3	0.5504	0.0003	0.4336	-0.0040	23.92%
	(28.3362)	(3.4638)	(23.0919)	(-6.9166)	
4	0.7153	0.0003	0.2679	-0.0035	10.07%
	(34.0634)	(3.2944)	(13.2936)	(-5.4959)	
5	0.5192	0.0001	0.4766	0.0002	22.79%
	(26.0540)	(0.7455)	(25.9606)	(0.3264)	
6	0.4884	0.0001	0.5094	0.0045	28.72%
	(23.8514)	(0.3772)	(28.3336)	(5.2885)	
7	0.6256	0.0003	0.3599	0.0057	15.34%
	(27.2521)	(1.7475)	(18.4664)	(5.1590)	
8	0.5246	-0.0003	0.4912	0.0104	27.81%
	(19.0450)	(-1.0969)	(26.9340)	(5.9341)	
9	0.3864	-0.0001	0.6184	0.0090	42.82%
	(16.7214)	(-0.4010)	(37.6860)	(6.3702)	
10	0.3217	-0.0003	0.6949	0.0078	51.64%
	(13.4134)	(-1.3177)	(46.2013)	(4.9731)	

Table 6 also shows that the TED spread have effects on the market share of volume after considering the impacts of the VIX. The regression model is shown in formula (10). The results are similar for the liquidity group1-3, however, the coefficient of the TED spread for the liquidity group4 becomes insignificant after including control variables.

Table 6: Regression result of each liquidity group (control for bond characteristics)

Liquidity group	Estimated coefficients and t-statistics										R^2
	Intercept	β_{TED}	β_{lag_MS}	β_{VIX_Resid}	β_{crisis}	β_{rating}	$\beta_{remaining}$	β_{Age}	β_{return}	β_{AMT}	
1	-0.5102	-0.0003	0.6749	-0.0032	0.1163	0.0562	0.0081	0.0025	-0.5145	0.0000	60.99%
	(-5.5415)	(-3.7778)	(45.9073)	(-5.6026)	(8.5692)	(5.8435)	(3.1390)	(-3.1170)	(-0.3487)	(8.7164)	
2	0.3162	0.0005	0.4067	-0.0041	0.0267	0.0164	0.0350	0.0001	7.1425	0.0000	32.22%
	(3.2660)	(4.8838)	(21.4955)	(-5.1298)	(1.7255)	(1.4243)	(8.8491)	(0.0492)	(4.0844)	(-4.8365)	
3	-0.2907	0.0002	0.3452	-0.0005	-0.0454	0.0677	-0.0185	0.0115	0.9440	0.0000	29.26%
	(-2.9396)	(3.1071)	(17.5606)	(-0.5335)	(-2.9198)	(6.2560)	(-3.8187)	(11.0081)	(0.5136)	(3.8011)	
4	0.8531	0.0002	0.2521	-0.0039	-0.0395	-0.0724	0.0104	0.0063	0.9531	0.0000	12.38%
	(8.5422)	(1.8383)	(12.5236)	(-3.9100)	(-2.2657)	(-6.1517)	(1.7006)	(5.8697)	(0.4072)	(4.7634)	
5	0.1683	0.0002	0.3552	-0.0044	-0.0229	-0.0042	0.0331	0.0002	0.4303	0.0000	29.19%
	(1.7484)	(1.6342)	(18.1637)	(-4.1524)	(-1.2454)	(-0.4545)	(5.5020)	(0.1536)	(0.2045)	(9.3753)	
6	0.0017	0.0001	0.3650	-0.0022	-0.0432	-0.0070	0.0511	0.0003	10.8171	0.0000	37.28%
	(0.0143)	(0.9000)	(18.7621)	(-1.6779)	(-1.9352)	(-0.8283)	(8.1987)	(0.2365)	(4.9367)	(9.0987)	
7	0.1860	0.0003	0.2243	-0.0017	-0.1071	-0.0362	0.0462	0.0033	0.0398	0.0000	26.19%
	(1.3574)	(1.9218)	(11.2954)	(-1.0228)	(-3.6887)	(-3.8873)	(6.6772)	(2.8534)	(0.0139)	(11.5412)	
8	-0.5514	-0.0005	0.4156	0.0042	-0.0589	0.0268	0.0275	0.0056	-6.6494	0.0000	31.64%
	(-2.4466)	(-1.6745)	(21.7246)	(1.5188)	(-1.2714)	(1.9309)	(2.4790)	(2.9521)	(-1.5529)	(7.9175)	
9	-0.2306	-0.0004	0.3337	-0.0026	-0.0317	0.0168	0.0474	-0.0029	2.7988	0.0000	54.22%
	(-1.4219)	(-1.7847)	(17.5413)	(-1.3055)	(-0.9141)	(1.6388)	(6.4062)	(-2.4000)	(1.0028)	(16.7041)	
10	0.2365	-0.0002	0.3778	-0.0073	0.0289	-0.0011	0.0094	-0.0027	-5.3458	0.0000	61.18%
	(1.3469)	(-0.6442)	(19.7910)	(-3.3422)	(0.7768)	(-0.0840)	(1.4024)	(-2.2725)	(-2.4998)	(15.8371)	

Next, to further investigate the different effect of TED spread on corporate bonds, we double-sort all corporate bonds by their liquidity rankings and ratings. First, we divide each liquidity group into eight rating groups. Table 7 shows the regression results of the double-sorted groups. For simplicity, we only show the t-statistics for the coefficients of the TED spread.

Table 7: t-statistics of regression for each liquidity-rating double-sorted group

Rating group	Liquidity group									
	1	2	3	4	5	6	7	8	9	10
1	-1.4643	1.1220	2.2713	1.6468	1.8597	-0.4897	3.6680	-1.8028	0.8266	1.6043
2	6.4266	-3.1312	-4.7031	-0.9315	-3.0896	-4.7812	-2.7957	-3.5408	-3.9539	-1.8326
3	2.9195	8.4307	8.2751	7.1198	4.0242	3.7182	0.5473	-1.3807	-0.1875	-2.4011
4	-7.9941	1.2853	-0.1906	0.8659	-0.5820	-0.5662	0.0167	-0.0043	0.2725	0.4409
5	-2.6914	-3.4541	-3.6920	-4.6882	-2.1366	-0.9212	-1.1099	1.1736	-0.0802	-0.3032
6	-3.1729	-2.0294	-0.8743	-1.8311	-2.4570	-2.1389	-2.1827	-2.5851	-2.4904	-2.8080
7	-3.7800	-2.9637	-1.0630	-1.9584	-1.0078	-1.2558	0.0965	-1.1177	0.0085	-1.3813
8	-1.0637	-2.1169	-1.4105	-0.2501	-1.6003	-1.6407	-0.5235	0.6869	-0.5071	1.0059

Section 5. Conclusion

In this paper, we first study whether liquidity risk is a priced risk factor in the corporate bond market. In contrast to the literature, we find no evidence that liquidity risk is an important risk factor in the bond pricing model during our sample period from July 2002 to Dec. 2011. Then we further study the effect of market liquidity, measured by the TED spread, on the liquidity of corporate bond market. Our empirical results show that when the TED spread increases, the market shares of volume for the most liquid group decrease. The result is contrast to the liquidity pull-back effect of Nyborg and Östberg (2014). However, if we divide a particular liquidity group into eight groups according to the ratings of corporate bonds, we find no evidence that better ratings in a liquidity group will trade more frequently compared to those with poor ratings.

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本計劃探討公司債的流動性風險，試圖分析總體市場的流動性由市場上的衡量對個別公司債流動性的影響。並進一步分析公司債的特性例如債券的信用評等對債券流動性的影響。實證結果顯示在市場出現危機時，流動性高的債券，其市場交易量的比重會減少。這項結論對市場出現危機時的資本市場的債券交易是否有或的現象，提出了實證的解釋。 ，不同

科技部補助計畫衍生研發成果推廣資料表

日期:2014/05/27

科技部補助計畫	計畫名稱: 流動性風險探討—以美國公司債/信用違約交換市場為例
	計畫主持人: 岳夢蘭
	計畫編號: 100-2410-H-004-055-MY2　　學門領域: 財務

無研發成果推廣資料

100 年度專題研究計畫研究成果彙整表

計畫主持人：岳夢蘭	計畫編號：100-2410-H-004-055-MY2
計畫名稱：流動性風險探討—以美國公司債/信用違約交換市場為例	

成果項目			量化：實際已達成數（被接受或已發表）	量化：預期總達成數(含實際已達成數)	量化：本計畫實際貢獻百分比	單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	1	1	100%		
		研討會論文	0	1	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	1	1	100%	人次	
		博士生	2	2	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	「無」。

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

科技部補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

　　□實驗失敗

　　□因故實驗中斷

　　□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

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專利：□已獲得 □申請中 ■無

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3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

本計劃探討公司債的流動性風險，試圖分析總體市場的流動性(由市場上的 TED spread 衡量)，對個別公司債流動性的影響。並進一步分析公司債的特性，例如債券的信用評等，對債券流動性的影響。實證結果顯示在市場出現流動性危機時，流動性高的債券，其市場交易量的比重會減少。這項結論對市場出現危機時的資本市場的債券交易是否有 flight to quality 或 flight to quantity 的現象，提出了實證的解釋。