2007

Liquidity, Credit Risk and Pricing of Corporate Bond

Xiaoli SUN
Singapore Management University, xiaoli.sun.2006@mf.smu.edu.sg

LIQUIDITY, CREDIT RISK AND PRICING OF CORPORATE BOND

SUN XIAOLI

A THESIS SUBMITTED
FOR THE DEGREE OF
MASTER OF SCIENCE (BY RESEARCH) IN FINANCE
SINGAPORE MANAGEMENT UNIVERSITY

JULY 2007

Liquidity, Credit Risk and Pricing of Corporate Bonds

Abstract

Employing a comprehensive database on transactions of corporate bonds issued by corporations, agencies and financial institutions, we compare the different liquidity measures—bid-ask spread, zero-return percentage, Amihud illiquidity factor for the corporate bond market. The criteria of judging is based on the explanatory power of different liquidity measures in determining yield spread over the benchmark curve (equivalent-maturity Treasury bond or notes). The conclusion is that liquidity plays a role in determining corporate bond yield spread. There are significant differences in the explanatory power of the different liquidity measures; among the liquidity measures, zero-return percentage works best. Preliminary findings, based on the mean correlation analysis and portfolios approach, give the intuitive results of suggesting that zero-return percentage is a better predictor of yields spread than the other liquidity measures—bid-ask spread and Amihud illiquidity factor. Controlling the effect of credit rating, the zero-return percentage increases R-square dramatically, with incremental R-square of 7%. Model specification test shows that the model with zero-return percentage as liquidity measures gives the smallest BIC whatever form the models are. We also compare the zero-return percentage with trading-based liquidity measure. The results show that zero-return percentage is more powerful in explaining yield spread than other liquidity measures.

Table of Contents

Acknowledgement

First and foremost, I would like to thank my supervisor, Professor Chunchi Wu, for his instruction, encouragement and great help during the whole period of my studies. His dedications to research and vast knowledge have truly inspired me. I would also like to express my heartfelt appreciation to my examiner, Professor Chua Choong Tze, who has given a lot of helpful suggestions for my thesis.

Foremost, I would like to mention Professor Hai Lin, in Xiamen University, who has given me a huge help during my study and accomplishment of this thesis. And I also would like to thank Professor Lim Kian Guan, who has helped me in my learning journey. Both of them are excellent teachers, always willing to share their knowledge and experience with students.

My stay at SMU would not have been so pleasant, if not for the assistance of Ms Rozana Bte Osman, our course administrator. She has been most helpful with all sorts of administrative nitty gritties.

I am also thankful for the classmates in my program. Because of them, the tedious procedure of thesis writing has become a pleasant journey. I enjoyed the times we spent together, be it studying, discussing problems or playing. We shared many happy moments. I would not have been able to make it if not for the constant encouragement of my classmates.

Also thanks professors and classmates in WISE; they make my study and life wonderful.

Last but not least, I dedicate this thesis to my parents, and I thank them for their unconditional love and support.

Chapter 1

Introduction: Objective of This Study

Liquidity and credit risk have long been perceived as two justifications for the existence of the yield spreads above benchmark Treasury notes and bonds (Fisher, 1959). Since Merton (1974), research has increasingly focused on the study of the credit risk[1]. Recently, studies on the liquidity of corporate bonds have grown very rapidly thanks to the availability of high-quality large corporate bond dataset[2].

The impact of liquidity on pricing of bonds has attracted a lot of consideration from both academicians and practitioners. In the academic literature, academicians are interested in the issue of corporate bond valuation, and a vast number of liquidity measures have been developed in an attempt to quantify the impact of liquidity risk. For US Treasury market, Fleming (2003) argues bid-ask spread is the better liquidity measure comparing with trading volume and trade

1. From then on, a lot of papers have come out to relate the credit risk, liquidity and yields spread, such as, Longstaff, Mithal, and Neis (2005), and Collin-Dufresne and Goldstein (2001).

2. In the United States, the vast majority of corporate bond trading occurs in an over-the-counter (OTC) dealer market. Broker-dealers execute the majority of customer transactions in a principal capacity. Today, the NYSE's Automate Bond System (ABS), an electronic limit order book, lists less than 5% of US dollar-dominated corporate bonds and attracts about 1% of total reported. However, TRACE, introduced in July of 2002, consolidates transaction data for all eligible corporate bonds - investment grade, high yield and convertible debt. As a result, individual investors and market professionals can have access information on 100 percent of OTC activity representing over 99 percent of total U.S. corporate bond market activity in over 30,000 securities; Mergent FISD contains issue details on over 140,000 corporate, corporate MTN (medium term note), supranational, U.S. Agency, and U.S. Treasury debt securities and includes more than 550 data items. FISD provides details on debt issues and the issuers, as well as transactions by insurance companies.

size; for stock market, Amihud proves Amihud illiquidity factor effect stock returns; for corporate bonds market, Bessembinder, Maxwell and Venkataraman (2005), Edwards, Harris and Piwowar (2005), Goldstein, Hotchkiss and Sirri (2005) all refer to the price impact based on Schultz (2001) approach to measure liquidity. Collin-Dufresne, Goldstein (2001) and Huang and Huang (2003), indicate that neither levels nor changes in the yield spread of corporate bonds over Treasury bond can be fully explained by credit risk proposed by structural form models. Since then, relating liquidity with yield spread has become popular. Driessen (2005) provides evidence for a liquidity component in corporate bond spreads using the Duffie and Singleton (1999) reduced-form pricing approach. Longstaff, Mithal, and Neis (2005) suggest that illiquidity may be a possible explanation for the failure of these models to more properly capture the yield spread variation. However, due to the OTC (over the counter) transaction of corporate bonds, and the difficulty in availing corporate bonds data, relative few studies have focused on the comparison of these liquidity measures for the corporate bond markets.

In this study, we attempt to shed additional light on the effect of liquidity by comparing the different liquidity measures in corporate bonds market; the main methodology is to compare the explanatory power of different liquidity measures in determining yield spread over the benchmark curve (SP)[3] for corporate bond markets and also assessing the relative importance of liquidity and credit rating for yield spread. Specifically, the analysis is based on a comprehensive data set of corporate bonds issued in USD. We begin by examining the relation between

[3] Yield spread over the benchmark curve (SP) is from DataStream. To calculate SP the maturity and yield of a bond is compared with the equivalent government benchmark bond for the bond's currency of denomination. The spread is expressed as yield difference (bond minus benchmark) in basis points. The bonds in the sample are in US dollar; the benchmark curves are comparable-maturity Treasury bond or Note. For the easy of expression, we refer "yield spread" to the yield over the benchmark yield curve.

liquidity estimators (zero-return percentage, and Amihud illiquidity factor) and the traditional transaction cost—bid-ask spread. Consistent with previous findings, we find that the zero-return percentage has a significant relation to the bid-ask spread, while Amihud illiquidity factor accounts for just few percentage points of bid-ask spreads. We next address the main question: which liquidity measure is more powerful in explaining yield spread for corporate bonds? Initially, correlation analysis and portfolio approach are adopted. The finding shows that zero-return percentage is more related to yield spread. Next we conduct regression analysis. In order to examine this issue, three kinds of regressions are employed: univariate analysis, regressing yields spread on the liquidity measures and credit rating score; and regressing yield spreads on a variety of controlling variables and liquidity measures across different risk-level bonds (investment-grade bonds, speculative-grade bonds). Given bonds' infrequent transactions, we conduct regression to compare the zero-return percentage with trading-based liquidity measure. The comparison supports our argument. The purpose of this study is to enhance our understanding of the relationship between bond yield and liquidity by testing the explanatory power of the different liquidity proxies to the yield spread. The study contributes to the ongoing debate over bond market liquidity and its impact on corporate bond yield spread. Compared with previous study, the main results of this study are that this study uses monthly data based US corporate bonds market to prove Amihud illiquidity factor does not work in the corporate bonds market; the zero-return percentage is more powerful than bid-ask spread in explaining yield spread; and zero-return percentage is a better predictor of yield spread based on the portfolio approach.

The study of corporate bond liquidity measures is interesting for at least three reasons. Firstly, US corporate bond markets have been growing dramatically recently. The corporate bond

market plays an important role in the financial system of our economies. While relatively little research has been done to examine the liquidity of the corporate bonds market, numerous studies have examined the liquidity of the equity and foreign exchange (FX) markets.

Secondly, it is meaningful in industry. As we discuss later, liquidity has a significant impact on the yield spread. The feature of the market affords us the opportunity to examine how the relationship between yields spread, liquidity and credit rating. This provides important information for corporations that raise funds with substantial cost in the corporate bonds market. A better understanding of the factors affecting liquidity thus helps corporations identify ways to lower their capital costs.

Lastly, the analysis will be useful for creditors. Liquidity affects the risk of investment in the bonds, and has a significant effect on offering yield (interest rate) of the bond issuance. What's more, creditors can assess better the investment risk when they know more about the corporate bonds' liquidity.

The remainder of this thesis is organized as follows. Chapter 2 presents a review of existing studies on liquidity measures, as well as the impact of liquidity on yield spread. Chapter 3 describes empirical methodology and details the variables used in this study. Chapter 4 explains in detail data and sample composition. Chapter 5 presents empirical results based on different liquidity measures and Chapter 6 concludes.

Chapter 2

Literature Review

A substantial volume of research on to corporate bond liquidity has come forth with the increasing availability of data. These studies mainly focus on the following three areas:

1. Measuring corporate bond market liquidity;
2. Quantifying the liquidity of corporate bonds;
3. Relating the liquidity to yield spreads.

The first two areas will be discussed in section 2.1 while the last area will be discussed in section 2.2.

2.1 Measuring Bond Liquidity

Liquidity is an elusive concept, with many dimensions (Pastor, 2003) and a lot of measures have been proposed to approximate the extent to which a bond is liquid or illiquid.

Fleming's (2003) classic paper on the US Treasury security market uses bid-ask spread, quote size, trade size, and price impact to measure the liquidity in U.S. Treasury securities and it is important to a range of market-related trading and analytical activities because of the securities' immense liquidity. This paper finds that for US treasury market, the commonly used bid-ask spread—the difference between bid prices and ask prices—is a useful tool for assessing and tracking liquidity. Other measures, such as trade size, quote size, prove to be only noisy

proxies for assessing and tracking liquidity, while trading volume and trading frequency are poor measures of liquidity for Treasury securities.

For corporate bond market, Howeling, Mentink and Vorst (2003) consider nine different proxies (issue amount, listing, Euro, on-the-run, age, missing prices, yield volatility, number of contributors and yield dispersion) to measure corporate bond liquidity and use a four-variable model to control for interest rate risk, credit risk, maturity and rating differences between bonds. There are two findings in this paper. One is that there are significant liquidity premium, ranging from 13 to 23 basis points. The other one is that a comparison test between liquidity proxies shows limited difference between these proxies.

Chordia, Roll and Subrahmanyam (2000) prove there is commonality in liquidity for corporate bond market where liquidity is more than just an attribute of a single asset. This paper documents the individual liquidity measures that co-move with each other. Even after accounting for well-known individual determinants of liquidity such as trading volume, volatility, and price, commonality retains a significant influence. Recognizing the existence of commonality in liquidity allows us to uncover evidence that inventory risks and asymmetric information both affect individual asset liquidity. Co-movements in liquidity also suggest transaction cost might be better managed with appropriate timing.

Transaction cost is an aspect of liquidity. Lesmond, Ogden and Trzcinka (1999) provide evidence that transaction costs are important for a host of empirical analyses from market efficiency to international market research. Considering that transaction costs estimates are not always available, Lesmond et al. present a model that requires only the time series of daily security returns to endogenously estimate the effective transaction costs for any firm, exchange, or time period. The model allows for the estimation of liquidity (transaction costs) as the

incidence of zero returns. Incorporating zero returns in the return-generating process, the model provides continuous estimates of average round-trip transaction costs from 1963 to 1990 that are 1.2% and 10.3% for large and small deciles firms, respectively. These estimates are highly correlated (85%), with the most commonly used transaction cost estimators.

Based on transaction data (from TRACE), Edwards, Harris and Piwowar (2005) report that bid-ask spreads on investment-grade corporate bonds are around 11 basis points for a typical institutional trade size. For speculative-grade bonds, the spreads are wider and are around 15 basis points. These bid-ask spreads are smaller than the spreads typically estimated for equity trades. Bessembinder, Maxwell and Venkataraman (2005), Edwards, Harris and Piwowar (2005), Goldstein, Hotchkiss and Sirri (2005) and Harris and Piwowar (2006), all examine the price impact based on Schultz (2001) approach to measure liquidity in corporate bond market.

The classical liquidity measures used in corporate bond markets are as follows,

- One-way or round-trip cost bid-ask spread (Chen, Lesmond, and Wei (2007), Goldstein, Hotchkiss and Sirri (2005));
- Price impact (Schultz (2001), Bessembinder, Maxwell and Venkataraman (2005), Edwards, Harris and Piwowar (2005), Goldstein, Hotchkiss and Sirri (2005));
- Frequency of zero returns (Lesmond, Ogden, Trzcinka (1999), Chen, Lesmond and Wei (2007), Chacko (2005))；
- Turnover of portfolios holding the bonds (Chacko, Mahanti, Mallik, and Subrahmanyam (2005)).

2.2 Relations of Liquidity and Yield Spreads

Since the appearance of the so-called "credit puzzle", where neither the level nor the change of the yield spread over the Treasury bonds can be fully explained by the credit risk in the corporate bond market[4], numerous papers have related liquidity to corporate bond yield spreads.

For stock markets, there are some important papers relating liquidity to the stock return, such as, Postor and Stambaugh (2003). In that paper, the authors investigate whether market-wide liquidity is a state variable important for asset pricing. They conclude that market-wide liquidity appears to be a state variable that is important for pricing common stocks and expected stock returns are related cross-sectionally to the sensitivities of stock returns to innovations in aggregate liquidity. Stocks that are more sensitive to aggregate liquidity have substantially higher expected return. Amihud (2002) tests the cross-section and time-series effects of the relation of illiquidity and stock return, and find that expected market illiquidity positively affects ex-ante stock excess return, suggesting that expected stock excess return partly represents illiquidity premium.

For the bond market, important studies include:

1. Driessen (2005) provides evidence for a liquidity component in corporate bond spreads using the Duffie and Singleton (1999) reduced-form pricing approach;

2. Longstaff, Mithal and Neis (2005) suggest that illiquidity is a possible explanation for the failure of these models to more properly capture the yield spread variation. They show that corporate bond yield spreads, in excess of CDS spreads, are cross-sectionally related to proxies for liquidity. Specifically, this paper uses the

[4] See Collin-Dufresne and Goldstein (2001) and Huang and Huang (2003).

information in credit default swaps to obtain direct measures of the size default and non-default components in corporate spreads. The conclusion of this paper is that the majority of the corporate spread is due to default risk. This result holds for all rating categories and is robust to the definition of the risk-less curve. The non-default component is time varying and strongly related to measures of bond-specific illiquidity as well as macroeconomic measures of bond market liquidity.

3. Chen, Lesmond and Wei (2007) examine whether liquidity is priced in corporate yield spreads. Using a battery of liquidity measures covering over 4000 corporate bonds and spanning investment grade and speculative grade categories, they find that more illiquid bonds earn higher yield spreads; and that an improvement of liquidity causes a significant reduction in yield spreads. These results hold after controlling for common bond-specific, firm-specific, and macroeconomic variables, and are robust to issuers' fixed effect and potential endogenous bias. Their finding mitigates the concern in the default risk literature that neither the level nor the dynamic of yield spreads can be fully explained by default risk determinants, and suggests that liquidity plays an important role in corporate bond valuation.

4. Hund and Lesmond (2006) get the similar results based on the emerging corporate bond markets and Covitz and Downing (2006) study the relationship between liquidity proxies, credit risk and yield spread based on commercial papers employing the database on the transactions of commercial paper issued by domestic corporations, suggesting the credit risk is the more important determinant of spread.

Chapter 3

Empirical Methodology and Variable Descriptions

An evaluation of the various liquidity measures is somewhat problematic because there is no single gauge of liquidity against which measures can be definitively judged. That being said, there are different methods in which the measures can be assessed. In this part, the methodology and variables are described.

3.1 Methodology and Procedure

The existence of the illiquidity in debt markets should lead to higher yield spreads as investors demand a premium for the inability to continuously trade their assets. According to previous empirical research (Amihud and Mendelson (1991) and Kamara (1994)), the liquidity has value, meaning that more liquid securities tend to have higher prices (lower yield) than less liquid securities. Additional tests given by Chen et al. (2007) and by Hund and Lesmond (2006) based on the emerging market; we might expect that yield spreads should incorporate some component of liquidity premium.

In order to assess liquidity measures, we need to disentangle the contribution of different liquidity measures in explaining corporate bond yield spreads. In this study, we compare different liquidity measures by conducting tests of the relation between yields spread and liquidity measures. We provide the following analysis: (1) correlation analysis, (2) portfolio analysis and (3) regression analysis.

For the regression analysis, we test the validation of zero-return percentage and Amihud illiquidity factor based on the bid-ask spread in the first place; secondly, we conduct univariate regressions to test the explanatory power of different liquidity measures; at last, we will give further evidence for the explanatory power under the regression of yield spread on the liquidity measure and other determinant factors. The regression models are as follows.

Model 1 is the *validation model*, which is to regress bid-ask spread [5](Chen, Lesmond and Wei, 2007), on the zero-return percentage and Amihud illiquidity factor (or it log value).

$$\begin{aligned} Bid-ask\ spread_{it} &= \alpha + \beta_l L_{it} + \beta_c Credit\ risk + \beta_m Maturity + \beta_a Age + \beta_o Amount\ outs\tan ding \\ &+ \beta_v Bond\ volatility\ + \sum_i \beta_b Other\ bond\ characteristics_{it} + u_t \end{aligned} \quad ...(3.1)$$

Model2 is the *liquidity-testing model*, which is to regress yields spread on different liquidity measures separately.

$$\begin{aligned} Yield\ spread_{it} &= \alpha + \beta_l L_{it} + \beta_{tax} Tax + \beta_c Credit\ risk \\ &+ \sum_i \beta_m Macroecomic\ \ \text{var}iables_{it} + \beta_t TERM_{it} + \sum_i \beta_f Firm\ characters \\ &+ \sum_i \beta_b Other\ bond\ characteristics_{it} + u_t \end{aligned} \quad ...(3.2)$$

Where the subscript "*it*" refers to bond *i* and month *t*, and liquidity proxies refer to the monthly bid-ask spread, bid-ask spread percentage, zero-return percentage and Amihud illiquidity factor as well as its log value, which will be detailed later.

For the model estimation, we use pooled OLS estimation procedure, which is simply pool the data and run ordinary least square regression (Chen, Lesmond and Wei, 2007). We present

[5] In the test of validation, we use bid-ask spread as our benchmark. Bid-ask spread, as reported by Bloomberg is not the inside quote, rather it is a consensus quote amalgamated across all available market. Hence, it is not the quote around actual trade could occur nor is it perceived to be current. Consequently, it is only partially reflects the trading costs faced by marginal, informed trader. However, it is a measure of liquidity costs that is commonly reported; hence it acts as the benchmark.

separate regression for each liquidity measure. For each regression model, we use two kinds of specifications; one uses only the liquidity measures, while the other one incorporates the rating information and firm-level, macro economic level determinants of yields spreads.

3.2 Analysis of Variables

Dependent Variables

As shown in the model, *yield spread* is the dependent variable, which is the short-form of yield spread over benchmark curve. *Yield spread* on a corporate bond is defined as the difference between the yields to maturity (YTM) of the corporate bond less the yield to maturity of a comparable-maturity default-free instrument such as a Treasury bond. Obviously, credit risk affects the yield spread of corporate bonds. Figure 1 shows this relation.

Figure 1 about here

There are two parts in the Figure 1: Figure 1-A shows the comparison between the yield spread and the yield spread over the swap curve. As shown, the yield spread over the swap curve is much smaller than the yield spread over the benchmark curve; however, the two kind yield spreads have almost identical behavior along time, implying that yield spread is affected by credit risk. The yield spreads for different rating categories are illustrated in figure 1-B.

As shown in Figure 1-B, yield spreads are sizable for corporate bonds under different ratings. The figure plots the simple average yield spreads by rating categories. The figure shows that average yield spread in the high credit rating category is low; for the low credit rating, yield spread is quite high, such as the yield spread for Aaa-rated issues is around 102 basis points,

while it is more than 268 basis points for the Ba-rated bonds. As illustrated, the rise in yield spreads along the credit quality dimension hints at an important role for credit risk.

Independent variables

Yield spreads in corporate bond market reflect the mixture of default risk, liquidity risk, and tax effects, as well as clientele effects. Factors affecting yield spread include bond characteristics (the credit risk component, the liquidity components and the impact of the coupon), and firm and market factors.

Variables for Liquidity

Liquidity component is the core objective in the thesis; we will give the detailed description in the subsection 3.3, where liquidity measures (bid-ask spread, bid-ask spread percentage, zero-return percentage, Amihud illiquidity factor and trading-related liquidity measures) and the liquidity-related controlling variables, such as issue size, maturity, price volatility will be described.

Variables for Credit Risk

Credit risk or default risk is the uncertainty surrounding a firm's ability to service its debts and obligations. Prior to default, it is difficult to determine when a bond may default. At best we can only make probabilistic assessments of the likelihood of default. As a result, bonds generally pay a spread over the default-free rate of interest that is proportional to their default probability to compensate lenders for this uncertainty.

As for credit risk, there are also different proxies, such as the expected default frequency, EDF, constructed by Moody's KMV corporation based on the Merton (1974) method. And another credit risk proxy, credit rating, is given by rating agencies.

In this study, the simple and explicit variable, credit rating, is employed as the credit risk proxies. For each bond, we collect historical rating given by Moody's and Standard &Poor's from the Mergent FISD. Moody's rating is used as the primary rating and will be substituted by the S&P rating only if the bond is not rated by Moody's. The credit rating is the proxy for the credit risk, so we coded credit rating as Aaa=1, Aa1=2, and so forth. The log value of rating score will be taken when regressions are conducted Covitz and Downing (2006).

Variables for Tax

Another difference between government bonds and corporate bonds is that the interest payments on corporate bonds are subject to state tax with maximum marginal rates generally between 5 and 10 percent [6](Elton et al., 2001). Because state tax is deductible from income for the purpose of federal tax, the burden of state tax is reduced by the federal tax rate. Nevertheless, state taxes could be a major contributor to the spreads. Since the higher the coupon size the higher the taxes paid on the corporate bond, as compared to the equivalent Government Issue, pre-tax yield spread is also affected by the bond's coupon. Thus, coupon size also serves as a proxy for tax effects (Longstaff et al., 2005).

Firm-Level Variables

[6] For a very few cities such as New York, interest income is taxable at the city level. Companies have wide latitude in determining where this interest is earned. Thus, they have the ability, in particular, to avoid taxation. Thus, the tax burden is almost exclusively at the state level and we will refer to it in this way.

Corporate bonds are issued by corporations. Yield spread of corporate bond is affected by firm characteristics. In the study we use the equity volatility of the firm to capture the firm-level determinant for the yield spread.

Macroeconomic Variables

The macroeconomic conditions will affect yield spread significantly (Chen, Lesmond and Wei, 2007). Three kinds of macro economy variables are employed into the study: one is 1-year Treasury note rate (T-Note), other is the difference between 10-year and 2-year Treasury rate which stands for the slope of the term structure (Gebhardt et al., 2005), and the last one is the difference between the 30-day Eurodollar rate and the 3-month T-bill rate (Eurodollar). These variables can be calculated based on the data from Federal Reserve Bank.

Bond Characteristics Variables

In order to meet the demands of different participators, corporate bonds are becoming more and more complicated with a lot of different provisions. These provisions will affect the bond liquidity and yield spread. Chen et al. (2007), Hund and Lesmond (2006) prove that callable feature of bond affects yield spread largely. In this study, a dummy variable is adopted to capture the information of the callable bonds as the controlling variable.

3.3 Liquidity Measures

Liquidity is a complex concept. In this chapter, we will delve into the definition of liquidity and examine the different liquidity measures that will be tested. We will also explain the various hypotheses relating liquidity to yields spread.

3.3.1 Definition of Liquidity

Liquidity is hard to define due to its complexity and abstractness. In the study, liquidity is defined as the ability to execute a transaction at low transaction cost (such as brokerage fees, order-processing costs, or transaction taxes), within a short time and with little impact on the price[7]. Generally, liquidity is created through a give and take process in which the following factors will affect liquidity:

- The private information[8] owned by different investors;
- The inventory risk;
- The difficulty in locating a counterparty that is willing to trade a particular bond or a large quantity of a given bond.

Therefore, measuring these components is not simple; the following part details the liquidity measures and related variables.

3.3.2 Liquidity Measures

Researchers have employed different liquidity proxies. We employ the following liquidity measures:

Bid-Ask Spread and Bid-Ask Spread Percentage

The first type liquidity measure is related to the bid price and ask price. During the give-and-take process, the gap between the transaction prices of an asset and its fundamental value is

[7] This definition is similar to but different from O'Hara (1995) and Engle and Lange (1997):
"A liquid market is defined as one in which trades can be executed with no cost. In practice, a market with very low transaction costs is characterized as liquid and one with high transaction costs as illiquid."

[8] Liquidity can be affected by private information, but liquidity is different information cost.

called as the half-spread. So it is common to employ bid-ask spread and the proportion of bid-ask spread, which is called bid-ask spread percentage and they are calculated as follows.

$$Bid\text{-}ask\ spread = ask\ price - bid\ price$$

$$Bid\text{-}ask\ spread\ percentage = \frac{ask\ price - bid\ price}{\frac{1}{2}(bid\ price + ask\ price)} \times 100\%$$

For ease of reference, we shall refer to bid-ask spread as “spread”, and bid-ask spread percentage as “spread-percent (or % spread)”.

Specifically, the hypothesis of relationship between the liquidity and bid-ask spread is as follows:

- Low liquidity leads to wide bid-ask spread (higher yield spread);
- High liquidity leads to tight bid-ask spread (lower yield spread).

Bid-ask spread is time-varying and has an underlying relation to yield spread, which are shown in Figure 2-A and Figure 3-A.

Figure 2-A and Figure 3-A about here

As illustrated in Figure 2-A, the behaviors of bid-ask spread and bid-ask spread percentage are quite similar; from Figure 3-A, the bid-ask spread and yield spread have a positive relationship. Yield spreads increase with the increase of bid-ask spread, which is consistent with the hypothesis.

Zero-Return Percentage

Zero-return percentage or the frequency of zero returns during a particular period is another liquidity proxy in the study (for convenience, we shall refer to zero-return percentage as "% zero"). This measure is proposed by Lesmond et al., (1999) and has been used by Chen, Lesmond and Wei (2003, 2007).

The intuition behind the percentage of zero returns as a proxy for liquidity is that investors will trade less frequently in the presence of transaction costs. The occurrence of zero return may happen when the volume of trade in a particular bond is virtually zero. In that case, a trader may report the previous day end price as the current day end price. In other words, a zero return is an unrecorded price change while the true price does change over time. We hypothesize a positive relation between zero returns percentage and yield spreads. The relation to yield spread is expressed in Figure 2. And the time-varying zero-return percentages across rating categories are plotted in Figure 3;

Figure 2-B and Figure 3-B about here

As shown in Figure 2-B, the zero-return percentage of investment-grade bonds is lower than that of the speculative grade bonds. As expected, the high rating bonds should be more liquid than the lower rating bonds. Figure 3-B shows that there is co-movement between yield spread and zero-return percentage; yield spreads will go up when zero-return percentage increases.

Amihud Illiquidity Factor

Different liquidity measures have also been applied in the context of stock markets. As proposed by Amihud (2002), illiquidity can be interpreted expressed as the daily ratio of the absolute stock return to its dollar volume, averaged over some period. The formula is as follows,

$$ILLIQ_{iy} = \frac{1}{T}\sum_{t=1}^{T}\frac{|R_{idy}|}{VOLD_{ivdy}} \text{ that is, } Amihud = average(\frac{|daily\ return|}{daily\ \$\ volume}).....(3.3).$$

R_{idy} *is the return on stock i on day d of month y,*

$VOLD_{iyd}$ *is the respective daily volume in dollars.*

The intuition of the Amihud illiquidity factor is the daily return response associated with only one dollar of trading volume, which serves as a rough measure of price impact. In our study, this illiquidity measure, called Amihud illiquidity factor, is employed into the corporate bond market, and the period is one month.

In order to get this ratio, we need to determine the bonds' return and bond dollar volume. Given that bond trading is much less than the stock, then the bond daily return is calculated as,

$$bond\ return\ (R_{idy}) = \frac{p_t - p_{t-a}}{p_{t-a}}$$

Where, p_t is the average price on the transaction-day; p_{t-a} is the average price on the last transaction-day for this bond. The daily volume is the accumulative volume during two transaction days. Given the infrequent transactions of corporate bonds, bonds which have at least 5-day transaction per month are chosen; in order to get both the large enough sample and reasonable Amihud illiquidity factor, the requirement of 5-day transactions per month for each bond is imposed. For each bond, the first observation will be deleted when the daily return is calculated. For example, there are 5-day transactions in the first month, and 5-day transactions in the following month for particular bond, and then there are 4 daily returns in the first month, while there are 5 daily returns in the following month. Daily volume is the sum of the face value

on the particular transaction day for the particular bonds. At last, we can get the Amihud illiquidity factor based on the formula (3.3). For the convenience, the magnitude of Amihud illiquidity factor will be multiplied by 10^6 when we do regression analysis.

The Amihud illiquidity factor gives the absolute percentage return change per dollar of daily trading volume or the daily price impact of the order flow in the corporate bond markets. As shown later, we test whether this proxy can contribute to the yield spread of corporate bonds and whether this proxy can explain the bid-ask spread of corporate bonds. Figure 2-C and Figure 3-C plot the changes of Amihud illiquidity factor across credit rating and the comparison of yield spread and Amihud illiquidity factor.

Figure 2- C and Figure 3- C about here

As shown in Figure 2-C, the difference of this factor across rating categories is not as obvious as the zero-return percentage. Interestingly, it is higher for the higher rating bonds, and as shown in Figure 3-C, there is weak relation between the Amihud illiquidity factor and yield spread. We can expect that the Amihud illiquidity factor to have weak explanatory power in regards to corporate bond yield spread.

Trade-based Liquidity Measure

Liquidity has many dimensions, in order to enhance the comparison of liquidity measures bid-ask spread, bid-ask spread percentage, zero-return percentage and the Amihud illiquidity factor, we also introduce the trading-based liquidity measures *(trade size, trading volume* and *dollar volume, turnover and trading frequency).* This is necessary because due to at least three additional reasons:

- Information for bid-ask spread is not always available;

- It is difficult to discriminate the information-effect from the liquidity effect when zero-return percentage is used;
- The Amihud illiquidity factor is more commonly applied in the context of stock markets, which have more frequent trading than corporate bond markets.

Therefore, it is necessary to take trading activity into bond liquidity.

The liquidity of a market is the ability to buy or sell large quantities of an asset quickly and at low cost; more generally, Kyle (1985) identifies three components of market liquidity—tightness, depth, which is the volume of transactions necessary to move prices, and resiliency, which is the speed that prices return to equilibrium following a large trade. Based on the components of liquidity, the trading activity should be the factor to affect bond liquidity. The following part, trading-based liquidity measure—*trade size, trading volume, dollar volume, trading frequency* and *turn over* (Fleming, 2003) are detailed.

Trade size

Traditionally, quote size, the quantity of the securities that can be traded at the bid and offer prices, is the estimate of the market depth. However, the data for quote size is not available in our dataset. Then we use a simple estimate—*trade size*.

Trade size is defined as the amount per transaction; the formula is as follows,

$$Trade\ size\ (the\ amount\ per\ transaction) = \frac{Total\ trading\ amount\ during\ a\ month}{The\ number\ of\ the\ transactions}$$

Trade size is an ex-post measure of the quantity of securities that can be traded at the bid and offer prices, reflecting any negotiation over quantity that takes place. A drawback of this

estimate is that trade size underestimates the true market depth; however, as a quantity traded at a given price is often less than that can be traded at the bid and offer prices, trade size does not reveal the full quantities traders are willing to transact.

Trading volume and dollar volume

Trading volume and *dollar volume* are other trading-based liquidity measures, which are widely used in equity markets (for example, Brennan and Subrahmanyan (1996) and Chordia, Roll and Subrahmanyan (2000)). *Trading volume* is the number of the bond traded during a calendar period, which is one month in the case. It is expressed in units of one bond.

$$Trading\ volume\ (monthly\ per\ bond) = Total\ trading\ amount\ during\ a\ month$$

Dollar volume ($ volume) equals to the number of shares multiplied by the transaction price for the particular transaction during a day.

Trading volume is a principal determinant of dealer inventory, its variation seems likely to induce co-movement in optimal inventory levels which lead in turn to co-movements in individual bid-ask spreads, quoted depth, and other measures of liquidity. So, *trading volume* is widely used measure of the market liquidity. Its popularity may also step from its simplicity and availability, with volume figures regularly reported in the press and released. A drawback of the *trading volume* is that it is also associated with the volatility (Karpoff, 1987), which is thought to impede the market's liquidity. The implications of changes in trading activities for market's liquidity are therefore not always clear.

Turnover

A close related measure to the trading volume is *turnover*, which is like the analogue conception under the context of accountancy. It is defined as the number of shares traded for a period as a percentage of the total shares of a bond. It equals to the ratio of the total trading volume to the issue amount (issue size) or amount outstanding of this bonds and its formula is as follow:

$$Turnover\ (monthly\ per\ bond) = \frac{Total\ trading\ amount\ \ for\ a\ certain\ bond\ during\ one\ month}{The\ outs\tan ding\ amount\ of\ \ this\ bond}$$

We expect this variable to be negatively related yields spread. Higher turnover indicates greater liquidity for corporate bonds, and thus smaller yield spreads.

Trading frequency

Trading frequency equals the number of trades executed within a specified interval (one month in our case), regardless of the trade size. The formula is as follows,

$$Trading\ Frequency\ (monthly\ per\ bond) = \frac{The\ total\ transaction\ number\ \ per\ month}{The\ number\ of\ \ days\ during\ the\ month}$$

Like *trading volume*, high *trading frequency* may reflect more liquid market. However, *trading frequency* is also associated with volatility and lower liquidity. In fact, Jones, Kaul and Lipson (1994) show a positive volume and volatility relationship, and many equity market studies show the positive relationship between the number of trades and volatility, and that trade frequency has little incremental information content for the market liquidity.

Figure 4 plots the behavior of the trading-based liquidity measures and yield spreads. Figure 4-A and 4-C plot the time-varying of trading frequency and trade size; Figure 4-B and 4-D plots the comparison of yield spread and trading frequency and trade size.

Figure 4 about here

As shown in Figure 4, trade volume and turnover have the similar behavior with the yield spread. There seems to be a certain relation between the yield spread and trading-based liquidity measures.

3.3.3 Liquidity-Related Controlling Variables and Hypotheses

This section explains the controlling variables which are related to the liquidity and affect yield spreads for corporate bonds.

Issued-based Controlling Variables: Issue Amount, Maturity, Volatility

Issue Amount and Outstanding Amount

Issuance amount of a bond is often assumed to give an indication of its liquidity. Here, the hypothesis is that there is a positive effect of the issue amount on the liquidity, meaning larger issue indicates more liquid, as a consequence, the yield spread will be smaller. So is *amount outstanding*, which is based on the potential correlation between the existing shares of a particular bond and the flow of trade in this bond. Fisher (1959) and Garbade and Silber (1976) have documented this relation.

Intuitively, a larger issue amount will lower information costs, which in turn affects inventory costs, which is one source of illiquidity. Inventory costs are high if it is more difficult to obtain information about a security and if the expected holding time is long. Large issues may have lower information costs since more investors own them or have analyzed its features (Crabbe and Turner, 1995). In contrast, information about small issues may be less broadly disseminated among investors.

For the empirical aspect, this was first proposed by Fisher (1959), who claimed that large issues should trade more often, so that the issuance amount is actually a proxy for the direct liquidity measuring trading volume. Sarig and Warga (1989), Amihud and Mendelson (1991) show that bonds with smaller issued amounts tend to get locked in buy-and-hold portfolios more easily, in turn reducing the trade amount and thus their liquidity. In practice, many investment banks use issue amount as a liquidity criterion in building their bond indices; for example, Lehman Brothers uses these criteria for their Euro-Aggregate Corporate Bond Index. All in all, issuance and outstanding amounts predict a positive effect of issued on liquidity, and a negative effect to the yield spread for corporate bonds.

Bond Age

Bond age is a popular variable which is related to liquidity. Generally, the bond's age is the time between issue date and transaction date in year. In this study, bond age is used as a liquidity-related controlling variable. Bond liquidity tends to decrease with its age.

Why? The liquidity of a bond is systematically related to certain of its characteristics over time; for a particular bonds issue, they are observed into investors' portfolios (e.g. pension funds) easily with time; and the fraction that has been absorbed into investors' inactive portfolios tends to increase over time. Moreover, once a bond becomes illiquidity, it tends to stay illiquid until it matures. Therefore, a bond's liquidity tends to decrease with its age, and the yield spread is expected to be larger with longer-age bond. Empirical research strongly confirms the positive effect of bond's age on yields: Schultz (2001) found evidence and Sarig and Warga (1989) argued this issue. This finding holds for corporate and sovereign bonds based on US and European data sets (Houweling, Mentink and Vorst, 2003).

Maturity

Maturity is another liquidity-related controlling variable. Since bonds' age and their time-to-maturity upon issuance are correlated, the above analysis implies that illiquid bonds are more prevalent among long maturity bond than short-maturity bonds, implying that bonds with longer maturity tend to be more illiquid and have bigger yield spread.

A potential reason behind this hypothesis is that bond liquidity and maturity refers to the relation between the maturity and uncertainty. The more uncertainty, the higher dealers' inventory costs. It is becoming more uncertain if the expected holding time is longer, and then there is negative impact on bond liquidity from bond maturity.

Price-based Controlling Variables: Bond Volatility

The more liquid the bond is, and the less impact of trading on bond price. An alternative variable which relate to the liquidity is based on the price volatility of bonds. Because illiquid bonds are poorly priced, it implies that price errors engendered by illiquidity are systematically related. Thus, it is necessary to take price-based controlling variables into account.

Bond Volatility

Bond volatility is the measure of the price (or yield) uncertainty. In the market macrostructure, the dealers' inventory costs are higher if information uncertainty is higher (Houweling, Mentink and Vorst, 2003 and 2005). The empirical results prove that price volatility is related to liquidity. Shuman et al., (1993) use price volatility as proxy for price uncertainty and find a significantly positive effect on bond spreads. Hong and Warga (2000) proxy uncertainty with squared price return and find a positive and significant coefficient in regression using bid-ask spread as dependent variable, implying a positive effect on bond yield spreads.

In this study, price volatility is used as liquidity-related variable—bond volatility is calculated as the standard deviation of bond transaction yield over a month trading period. Therefore, we hypothesize that price volatility has a negative relation with the corporate bond's liquidity, which results from the inventory cost argument that the dealers face more uncertainty if prices are more volatile. A higher price volatility leads to a larger bid-ask spreads, and thus to lower liquidity and higher yield spread.

Chapter 4

Data and Descriptive Statistics

4.1 Data Source Descriptions

Filter Rules

For the study, we will be focusing on the US corporate bond market. The sample is selected based on the following considerations:

1. The sample is restricted to bonds that have not matured before 1 July 2002 and are issued prior to 30 Mar 2007. The reason is that Amihud illiquidity factor is used as one of main liquidity estimators in corporate bond market, which is calculated by daily return and dollar volume. This information is only obtainable from transaction data, which is only available on TRACE. For comparability across different liquidity measures, the sample is limited by what is available on TRACE, which only reports transaction data for the period covering 1 July 2002 to 30 March 2007[9].

2. As the frequency of corporate bonds transactions is very low, in order to get a reasonably large sample, we choose bonds that should have at least 5-day transactions per month.

[9] Data after 30 March 2007 was not available at the time of our study.

3. When collecting bond data (yield spread, bid ask yield and so on), the following criteria are applied, which is similar to that proposed by Longstaff, Mithal and Neis (2005).

    - Dollar-denominated issues are included;
    - Perpetual bonds are avoided but the medium-term notes are included;
    - Only fixed coupon issues are used due to the consideration of the tax effect on the yield spread;
    - Where possible, large issues are chosen. Issues with total notional amount less than $1 million are excluded;
    - The bonds with callable, putable, sinking fund, or redeemable are included. These features will be used as controlling variables when we test the liquidity effect on the yield spread by assigning the dummy variables;
    - Delete the bonds which are Rule144a and privately offered but the bonds which are Rule-145 registered[10] are included.

Data Sources

In the study we employ different variables which are available from different data sources. We extracted the data from the following sources: TRACE, Mergent FISD, Bloomberg, DataStream, and Federal Reserve Bank.

[10]Rule 415 indicates whether the issue is a SEC Rule 415 shelf registration, SEC Rule 415 allows issuers to pre-register an amount of securities for up to two years. On short notice, the issuer may take securities off of the shelf and offer them to the public. At the time of the actual sale of securities, the issuer may have issue a new prospectus or supplement.

TRACE

TRACE (Trade Reporting and Compliance Engine) reports over-the-counter transactions for the eligible fixed-income securities. Introduced in July of 2002, TRACE historical time and sales data are available through WRDS, where we get transaction data over the period 07/2002 to 03/2007 for each corporate bond in the sample, including the price, the volume, the yield and the transaction date.

Mergent FISD

Mergent FISD (Fixed Income Securities Database) is a comprehensive database of publicly-offered U.S. bonds, which provides details on debt issues and the issuers, as well as transactions by insurance companies. The characteristics of corporate bonds are obtained from FISD: issue date, maturity, outstanding amount, currency, callable, putable, convertible, sinking fund, Rule-114 and Rule-145 and so on. The rating changes also come from this database, which can be checked with the information from Bloomberg. That is, the historical ratings for each bond are available from FISD, and are matched with the data from Bloomberg.

Bloomberg

Bloomberg provide the required bond characteristics and monthly bid price and ask price, and bid and ask yields, which are the foundation of one liquidity measure—bid-ask spread. Using the tickers that are given by TRACE, these data can be downloaded. In case a ticker code is not recognized by Bloomberg the bonds are checked from Mergent FISD, which gives the local identifiers which are consistent with ISIN[11] codes of corporate bonds. The download information

[11] A uniquely identifies a security. Its structure is defined in ISO 6166. Securities for which ISINs are issued include bonds, commercial paper, equities and warrants. The ISIN code is a 12-character alpha-

from Bloomberg is: issued amount, issue date, maturity from issue (term information), call date, put date and sinking fund dates, and the bid-ask spread.

DataStream

Thomson DataStream is the most respected historical financial numerical database, covering an unparalleled breadth of financial instruments, equity and fixed-income securities and indicators for over 175 countries and 60 markets worldwide. DataStream provides the ISIN codes of corporate bonds and it is convenient to choose corporate bonds based on a number of criteria provided by DataStream, which facilitate the way we identify our data sample. We get the historical data of yield spread over the benchmark curve, which is the explained variable, daily gross price and clean price, which are the basic factors to calculate the liquidity measure—zero-return percentage. The historical bond life (time to maturity) and modified duration data are also from DataStream.

Data source of the US macroeconomic variables—1-year, 2-year and 10-year Treasury rates, 30-day Eurodollar rate and 3-month T-bill rate (Eurodollar)–is Board of Governors of the Federal Reserve System. The data for the firm-level specification—equity volatility which is calculated from equity daily returns is available from CRSP by WRDS.

4.2 Sample Composition

Applying the filter rules above to merge the different data sources to get the variables we need, the last sample composes of 3237 bonds issued by more 1000 firms. Among which, we get the yield spreads for 3206 bonds; only 3197 bonds, with 102092 months, are given bid price and ask

---

numerical code that does not contain information characterizing financial instruments but serves for uniform identification of a security at trading and settlement.

price by Bloomberg Generic. Only 3005 bonds get the Amihud illiquidity factor allowing for the transactions data and the requirement for calculating the Amihud illiquidity factors. We exclude the bonds with negative yield spread over the benchmark. From this procedure, around 70 bonds are excluded out of our sample. Taking the firm information into account, we merge all the information to get the final sample including 2918 bonds, and around 700,000 months. Table 4.1 reports the sample.

Table 4.1 about here

As shown in the Panel A of Table 4.1, we classify sample into different categories according to the maturity and rating, long-term bonds have more than 15 years to maturity, median-term bonds are with the more than 7 and less 15 years' life; short-term bonds mean the bonds have less 7 years left. Maturity is represented in a row, in columns we present rating symbol. For each number, it is the total number of bonds which meet the two requirements. Short-term and speculative-grade bonds dominate in the sample. The potential reason is that we merge the sample with the bonds reported transaction data in TRACE. It is normal that there are much more transaction bond months for short-term speculative-grade bonds category. Panel C shows us bond provisions for the sample. As presented, the sample covers most kinds of bonds, callable, putable and the bonds with sinking fund and so on.

4.3 Summary Statistics

Table 4.2 reports the summary statistics of independent and dependent variables.

Table 4.2 about here

Yield spread

We employ yields spread over benchmark curve as our dependent variable, and Table 4.2 presents its summary statistics. The average of spreads is 159.76 basis points, with a standard deviation of 174.86 and the median is 96.5 basis points. As can be seen from the quantiles, the distribution of the yield spread over the benchmark is skewed to the right, reflecting some very large spreads in the right tail of the distribution, which is consistent with the previous results (Covitz and Downing, 2006).

Credit rating

Up-to-date credit ratings for each bond are from the FISD; the summary statistics for rating score are present in the last row of Panel B of Table 4.2, which means the speculative-grade bonds dominate the sample.

Bid-ask spread

Data on the monthly bid-ask spread quotes are hand-collected form the Bloomberg Terminal, and the price provider is Bloomberg Generic Quote. Most quotes are available from 2002 to 2007. For each month, we calculate the bond bid-ask spread as the ask price minus bid price (%), and we also calculate the proportional spread as the bid price minus ask price divided the average of bid and ask prices. As shown in Table 4.2, the average bid-ask spreads is 0.45% with 0.32% median, which has the similar rough distribution with yield spread. For bid-ask spread in percentage, its mean is 0.4365%, with standard deviation of 0.3933%, and median of 0.3112%.

Zero-return percentage

We obtain prices from DataStream, and calculate zero-return percentage per month. Similar to Chen et al. (2007), we record the clean price of each bond on a daily basis, deleting prices that

deviate more than 50% from the prior day's price. We separate the data into bond-months, that is, using daily data for each bond with in each month. We jointly estimate the bond's return and liquidity costs applicable to that month.

The correlations between credit risk and different liquidity measures are reported in Table 4.3 Panels A and B.

Table 4.3 about here

As shown, credit rating is correlated to the liquidity measures which will be tested, and is quite strongly correlated to the zero-return percentage. It is weakly positively correlated to the Amihud illiquidity factor and is also weakly but negatively correlated to the log value of the Amihud illiquidity factor.

In theory, the variables in this section are all related to the corporate bond liquidity; Table 4.3 Panel B represents the pair wise correlations among the liquidity-related variables and credit rating. As expected, *Amount Issued* and *Amount Outstanding* are highly correlated with a coefficient of 0.95. So are the *Dollar Volume* and *Trade Volume*, with a correlation coefficient of about 0.99. *Turnover* has a negative correlation with *Amount Issued* and *Amount Outstanding;* and there is little relation to other trading activity variables. *Bond Volatility* can be expected to have no correlation with other variables, since price standard deviation has a correlation near zero with other variables. Compared with other variables, credit rating is correlated with the liquidity–related variables, with a correlation coefficient ranging from -0.16 to 0.04.

Chapter 5

Empirical Results

5.1 Preliminary Findings

5.1.1 Mean Correlation Analysis

In order to deal with both the possible time trend impact on yield spread and liquidity measures and the fixed effect of panel data, correlation analysis is employed to compare different liquidity measures. We calculate two kinds of mean correlations:

- Mean correlation for each month: firstly, the correlations of yield spread and liquidity measures are calculated for particular month, and then averaged over all months;
- Mean correlation for each bond: firstly, the correlations of yield spread and liquidity measures are calculated for particular bond, and then averaged for all the bonds;

We report the mean correlation matrix of yield spreads and different liquidity measures in Table 5.1. And t-values are reported for the hypothesis that correlation coefficients are zero.

Table 5.1 about here

There are two panels in Table 5.1. As shown in Panel A, given the time impact, zero-return percentage is strongly correlated to the yield spread with mean correlation coefficient of 0.38, which is significantly different from zero at 1% significance level; while the correlations between

yield spread and Amihud illiquidity factor are weak and the hypothesis that correlation coefficient equals to zero cannot be rejected. So is the Panel B: zero-return percentage are correlated to yield spreads significantly with 10% significance level while Amihud illiquidity factor is not significantly related to yield spreads at the same level.

The correlations between different liquidity measures adhere to the expectation: bid-ask spread percent is highly correlated to the bid-ask spread, with correlation coefficient of 0.98 for monthly mean correlation, and 0.94 based on mean correlation of individual bonds; and zero-return percentage is strongly correlated to the spread, with a correlation of 0.10 to bid-ask spread, and a correlation of 0.13 to the bid-ask spread percentage. There seems no correlation between Amihud illiquidity factor and the bid-ask spread or bid-ask spread percentage, implying that the Amihud illiquidity factor captures little liquidity information. The log value of the Amihud illiquidity factor is weakly correlated to the bid-ask spread and bid-ask spread percentage, with separate correlation coefficients of 0.027 and 0.023 (in Panel B of Table 5.1).

5.1.2 Portfolio Approach: Sorting by Liquidity Measures

As shown above, zero-return percentage seems to have more powerful explanatory in determining yield spread than other liquidity measures. It can be expected that zero-return percentage is more powerful to be the predictor of both current and future yield spreads. If zero-return percentage is sufficiently powerful and stable over time, sorting on the historical zero-return percentage alone could produce dispersion in the post yield spreads. This section shows that is indeed the case.

At the end of the month, bonds are sorted by liquidity measures (zero-return percentage, bid-ask spread and Amihud illiquidity factor) and assigned to three portfolios: “Low” means the

high liquidity portfolio, expecting the low yield spread; “High” means the low liquidity portfolio, expecting the high yield spread. Based on the liquidity-ranked portfolios, we calculate and compare the average yield spreads in the same month (t=0) and the following month (t=1) in each portfolio. And t-values are for the hypothesis that the difference between low and high portfolios is zero. The empirical results are presented in Table 5.2.

Table 5.2 about here

As shown in Panel A of Table 5.2, for % zero-ranked portfolios, the yield spread for both the same period and next period increases as %zero increases in a monotonic way for all the type categories. However, for the Amihud illiquidity factor-ranked portfolios, there is no strict pattern, for example, yield spread (242.56 bps) for the low portfolio which has higher liquidity is bigger than yield spread (232.22 bps) of the middle portfolio which has lower liquidity, implying that the Amihud illiquidity factor is not a good liquidity measure for the corporate bonds market.

We also test whether the difference in the yield spread between high illiquidity portfolio and low illiquidity portfolio equals zero. Based on the t-values, the hypothesis is rejected at a 1% significance level in the overall type for the %zero-ranked portfolios, as shown in Panel A of Table 5.2. for example, for the speculative grade bonds, %zero-ranked portfolios, the difference in yield spread for next period between the high and low portfolio is 118.74 basis points, which is significantly different from zero with t-value of 4.25; while for bid-ask spread –ranked portfolios and Amihud illiquidity factor portfolios, they are not significantly different from zero.

Overall, the evidence strongly implies that percent of zero-return percentage has highest power in explaining yield spread among the three liquidity measures. Not only is the higher the

yield spread in the same period, the bigger the zero return percentage is; but also it is the same for the next period.

5.2 Regression Analysis

Preliminary findings of mean correlation analysis and portfolio approach show that zero-return percentage has more power than the Amihud illiquidity factor in explaining yield spreads in the corporate bonds market. We next conduct regression analysis to provide more evidence.

5.2.1 Validation Test on Liquidity Measures

Amihud illiquidity factor, zero-return percentage and bid-ask spreads are the main liquidity measures which are being tested and compared. There are reasons to be cautious in employing Amihud illiquidity factor and zero-return percent as liquidity measures in the corporate bond market. Amihud illiquidity factor is initially used for the stock market and it may not work for the bond market where infrequent trading is typically a problem; the zero-return percentage is a noisy measure that is unable to distinguish the lack of trading due to the low information or low liquidity (Hund and Lesmond, 2006).

In this subsection, we first examine the correspondence between the liquidity measures—testing the relationship between Amihud illiquidity factor, zero-return percentage and the underlying bid-ask spread. The basic regression model is validation model (3.1) (Chen et al., 2007),

$$\begin{aligned} Bid-ask\ spread_{it} = {} & \alpha + \beta_l L_{it} + \beta_c Credit\ risk + \beta_m Maturity + \beta_a Age + \beta_o Amount\ outs\tan ding \\ & + \beta_v Bond\ volatility\ + \textstyle\sum_i \beta_b Other\ bond\ characteristics_{it} + u_t \end{aligned} \quad ...(3.1)$$

The subscript *"it"* refers to bond *i* at month *t.* The liquidity variable L_{it} includes Amihud illiquidity factor and zero-return percentage (% zero). Other bid-ask spread (transaction costs) determinants—credit rating, maturity, age, amount outstanding and volatility—are chosen according to the models used by Houweling, Mentink and Vorst (2003, 2005), Chen, Lesmond and Wei (2007). The credit risk is simply expressed by bond rating, which is assigned a cardinal scale rating from unit for Aaa-rated bonds to C-rated bonds.

In this test, two separate regressions for each liquidity measure are conducted. The first one only use single liquidity measure and bid-ask spread and the second one is regression of bid-ask spread on liquidity measure by controlling other variables. In order to control the impact of credit rating, we do the regression analysis for two sub-samples, which are the investment-grade bonds and speculative-grade bonds, and the whole sample. In all, there are 12 regressions are reported. The regression results are presented in Table 5.3.

Table 5.3 about here

As shown in Table 5.3 zero-return percentage is more related to bid-ask spread than the Amihud illiquidity factor. For the whole sample, zero-return percentage alone gives an R-square of 3.7%, while Amihud illiquidity factor seems to give nothing. For investment-grade bonds, the zero-return percentage alone explains 3.9% of the cross-sectional variation in the bid-ask spread, and coefficient is quite significant; while the Amihud illiquidity factor only gives 1.4% explanations of the variation of the bid-ask spread and the coefficient is not significantly different from zero when other variables are included for investment-grade bonds. In comparison to the research given Schutlz (2001), who reported an R-square of 3.4% in regressions on the trading costs determinants for investment-grade bonds, the Amihud is not so well related to the bid-ask spread in the corporate bond market. And zero-return percentage always keeps its significance

whether other determinants are added or not and whatever sample is used. Interestingly, neither are the coefficients of Amihud illiquidity factor significant at 1% significance level, nor the signs are reasonable. It seems that the Amihud illiquidity factor extracts little liquidity information in the corporate bonds market, even though it works very well in the stock market (Amihud, 2002). By contrast, the coefficients of zero-return percentage are quite stable for both investment-grade bonds as well as speculative-grade bonds; it denotes that zero-return percentage always captures the liquidity information in the corporate bonds market. In comparison, the Amihud illiquidity factor is significant sometimes, and not significant sometimes, suffering more specification error.

5.2.2 Yield Spread and Liquidity: Univariate Regression

As an indication of economic significance of liquidity in explaining the variation in the yield spread, we report the univariate regression results. The objective is to test whether cross-sectional difference in the yield spread reflects the relative illiquidity of individual bonds. We regress the yield spread for each bond in the sample on different liquidity measures separately. In order to provide a consistent comparison we match yield spread, bid-ask spread, zero-return percentage and Amihud illiquidity factor to the available sample. The results are presented in Table 5.4.

Table 5.4 about here

As shown in Panel A, overall the zero-return percentage gives the most explanatory power in explaining the yield spread according to the R-square of 26%, the next one is the bid-ask spread percentage, with 8.78% R-square, and the Amihud illiquidity factor seems to give nothing in the explanation of the variation of the yield spread, whose R-squares are near zero even they have the significant coefficients at only the 10% significance level.

Credit rating is the important component of yields spread; Panel B of Table 5.4 shows the regression results. By controlling the credit rating, overall zero-return percentage gives the highest R-squares.

For investment-grade bonds, all the liquidity measures are positively and significantly associated with the underlying yield spread. All the liquidity measures give the most explanation of the variation in the yield spread, but zero-return percentage gives more explanation power than other liquidity measures based on the R-squares, which is near to 13%. Comparing with the yearly research of Chen et al. (2007), for zero-return percentage, which have only 5.7% of explanation power; zero-return percentage can be expected to capture more information about yield spread during short observation period (it is monthly data in this study). For the Amihud illiquidity factor, the log value of the Amihud illiquidity factor are able to explain yield spread more than the simple Amihud illiquidity factor, meaning that there may be non-linear relation between the Amihud illiquidity factor and yield spread, but the sign of the coefficient is often wrong (negative).

For speculative-grade bonds, zero-return percentage has more explanatory power than that in the investment-grade bonds, which explains more than 25% of variation in yield spread. The explanatory power of Amihud illiquidity factor drops dramatically, and it is not significant for non-rated bonds. For the non-rated bonds, zero-return percentage works quite well; it explains more than 12% of yield spread variations. In all, again, Amihud illiquidity factor works badly in the corporate bonds market. Further, the coefficients of Amihud illiquidity factor under different rating categories are unstable, which implies that the Amihud illiquidity factor is noisier.

5.2.3 Relative Importance of Liquidity Measures by Controlling the Rating Effect

Noting the importance of the liquidity and credit risk in explaining yield spread, we provide further tests of liquidity measures based on the model with credit rating and liquidity at the same time. The results are reported on Table 5.5.

Table 5.5 about here

Table 5.5 gives OLS regression results for the relative explanatory power of alternative liquidity measures and credit rating in explaining the variation of yield spread. Model 1 uses only credit rating as independent variable; Models 2 to 6 include credit rating and a liquidity measure together. In all specifications, the credit rating is significantly different from zero at the 1% significance level. The liquidity measures increase R-squares, where the magnitude from the model with % zero is the highest. Zero-return percentage increases R-square by up to 7%, while only 1%-2% for bid-ask spread measures and Amihud illiquidity factor seems not to work under the control of credit risk. Base on the regression result that rating alone gives R-squares of more than 30%; we conclude that the credit rating is more important than our liquidity measures in explaining yield spread.

5.3 Liquidity Effects on Yield Spread Levels

Liquidity is an important component of yield spread; and zero-return percentage has shown its preponderance in explaining yields spread. In this section, we give further evidence on different power of different liquidity measures.

Regressing yield spread on liquidity measures and other spread determinants is the main methodology; the regression model is generally stated as follows,

$$\begin{aligned} Yield\ spread_{it} &= \alpha + \beta_l L_{it} + \beta_{tax} Tax + \beta_c Credit\ risk \\ &+ \sum_i \beta_m Macroecomic\ \text{var}iables_{it} + \beta_t TERM_{it} + \sum_i \beta_f Firm\ characters \quad ...(3.2) \\ &+ \sum_i \beta_b Other\ bond\ characteristics_{it} + u_t \end{aligned}$$

The subscript *"it"* refers to bond *i* at month *t;* the liquidity variable L_{it} the liquidity factors only include zero return percentage, bid-ask spread percentage and the log value of the Amihud illiquidity factor, since bid-ask spread percentage works better than bid-ask spread and log value of Amihud illiquidity is better than Amihud illiquidity factor itself; Credit risk is the log values of the credit rating score for each bond (Covitz and Downing, 2006); Macroeconomic variables include the 30-day Eurodollar rate minus the 3-month T-bill Rate (Eurodollar) and the 1-year Treasury note rate (T-Note); term slope variable is the difference between 10-year and 2-year Treasury. The firm-specific variable is the equity volatility (Covitz and Downing, 2006); bond character variables include bond age, maturity (time to maturity, or the average life left for particular bond), amount outstanding, bond volatility and dummy variable for callable bonds. The estimation procedure is based on ordinary least square regression (Chen et al., 2007). We present separate regression for each liquidity measure. The regression results are present in Panel A of Table 5.6.

Table 5.6 Panel A about here

The most telling finding is the zero-return percentage gives the highest R-squares regardless of the specification of investment-grade bonds, speculative-grade bonds and the whole sample. The magnitudes of explanatory power (R-squares) of zero-return percentage are quite high, which is up to 56.43% for speculative-grade bonds, 49.36% and 54.33% for investment-grade bonds and the whole sample separately, implying the liquidity influence varies across the rating categories; the higher adjusted R-square is, the lower the rating.

The zero-return percentage and bid-ask spread are significant for all samples; while the coefficients for log value of Amihud illiquidity factor change over sample denoting a larger specification error and carry a wrong sign. The coefficients of bond life, bond volatility, credit rating and equity volatility all have the expected signs and are all significantly different from zero. While bond age in investment grade bonds has the expected sign, the sign is not as expected for the speculative-grade bonds and the whole sample. The potential explanation is that the investment-grade bonds go into buy-and-hold portfolios more easily than speculative grade bonds. The fact that speculative grade bond dominates the sample, causes age to have a reverse sign for the whole sample. Amount outstanding has also strange behavior in the investment grade bonds, which has positive sign. The potential reason is that bonds go to the institutional investors, such as pension fund, and become less liquid. The coefficients of callable provision have the expected sign and mostly are significant.

The magnitudes of the coefficients of different liquidity measures are different. This also demonstrates the power of zero-return percentage in determining yield spread in corporate bond markets.

Definitely, comparison in R-squares has given us the rough explanatory power test on different liquidity proxies. However, R-squares can increase even adding an unimportant variable to the regression. To overcome the limitation of R-squares, BIC (Bayesian Information Criterian)[12] is adopted to give further evidence. Panel B of Table 5.4 reports the result of BIC for models with different liquidity measures.

[12] BIC is a popular model selection criterion. The formula is $BIC = \ln(\frac{e'e}{n-k}) + \frac{K\ln(n)}{n}$, where K is the number of the regressors.

Panel B1 shows the results from the univariate regression of yield spread on different liquidity measures alone or on only credit rating; Panel B2 reports the BIC of yield spread regression on different liquidity measures and credit rating; Panel B3 present BIC of regression of yield spread on different liquidity measure by controlling other bond-specific, firm-specific and macroeconomic variables.

Table 5.6 Panel B about here

As shown in of Panel B1, the credit rating matters most in the determining the yield spread since the model with rating only has the much lower SIC than the model with only liquidity estimators. However, among the models with liquidity measure alone, the model with % zero as independent variable gives the smallest BIC, meaning it works better than others.

Based on the Panel B2, the order of the explanatory power of liquidity estimator in explaining yield spread is zero-return percentage, bid-ask spread percentage, bid-ask spread, the log value of Amihud illiquidity factor, and the last one is the Amihud illiquidity factor, which are consistent with the conclusion in previous finding.

Panel B3 confirms the order further, and also demonstrates that it is necessary to including other variables into the yield spread determinants since the overall magnitude of SIC is much smaller than the number in Panel B2, for example, when zero-return percentage is chosen as liquidity measure, the BIC under model only with the liquidity measure and credit rating is 9.9; while BIC in Panel 3 under liquidity, credit rating and other determinants is 9.3, which is obviously smaller than 9.9, means the model with other controlling variables is better than the model only with liquidity measure and credit rating.

Overall, whatever model specification is chosen, the magnitude of BIC with zero-return percentage as the liquidity measure is the smallest, implying that zero-return percentage works best in explaining yield spread among the liquidity measures which are being tested.

5.4 Liquidity, Trading Activities and Yield Spread

Based on the tests above, the order of explanatory power is zero-return percentage, bid-ask spread and the Amihud illiquidity factor. We next compare zero-return percentage with liquidity-related liquidity measures since trading activity in corporate bonds market is quite different from stock market.

Following the same methodology, validation test (model 5.1) is given first and then the testing-regression (model 5.2). Table 5.7 presents the results.

Table 5.7 about here

As shown in Panel A of Table 5.7—the relationship between bid-ask spread and trading-based liquidity measures, trading-based liquidity measures give little explanation of bid-ask spread variations; the model with trading-based liquidity measures and other determinants have R-squares up to 12%, while they are still smaller than the R-squares under the model with zero-return percentage as the liquidity measure reported in Table 5.3. Trade size, trading volume and dollar volume, the controlling variables (bond age bond life and amount outstanding) all have expected signs and statistically significant coefficients. And for the turnover and trading frequency, the coefficients vary with the models. Consistent with our hypothesis, the turnover and the trading frequency have varying impact on the liquidity or yield spread. According to R-squares and coefficients' analysis, zero-return percentage is more stable and powerful in capturing liquidity information.

The results of regressing yield spread on trading-based liquidity measures in Table 5.7-B, the coefficients of trading-based liquidity measures—turnover, trade size, trade volume, dollar volume and trading frequency are always significant. The coefficients of the trade size have the expected sign and are significant at the 1% level in all specifications. The coefficients of the log value of dollar volume change with the models. It has the expected negative sign and significantly different from zero when it is included with other variables. The sign reverses when it is the only trading-based liquidity in the specifications (model 5). Comparing with the zero-return percentage, it is clear that zero-return percentage works better than trading-based liquidity measures in explaining yield spread.

Based on R-squares, trading-based liquidity measures explain a large share of total variation of yield spread. The adjusted R-square is up to 22.12% for the regression including our trading-based variables without credit rating (model 6), but it is smaller than the R-square of 25% when using zero-return percentage as the explanatory variable (in Table 5.1 Panel A). Overall, zero-return percentage is more powerful than trading-based liquidity measures in capturing liquidity information.

Chapter 6

Conclusion and Future Work

6.1 Conclusions

Liquidity matters greatly for the determinants of yields spread for US corporate bonds (both investment grades and speculative grades). Using a comprehensive dataset of the US corporate bond market, we test the explanatory power of different liquidity measures and demonstrate not only the importance of modeling liquidity risk as a component of yield spread, but also the difference of liquidity measures' explanatory power to yield spread. The summary of findings is as follows.

- Based on mean correlation analysis, zero-return percentage works well in capturing liquidity information and explaining yield spread.
- Based on results of the portfolio approach, zero-return percentage is more powerful to be the predictor to both current and future yield spreads. Zero-return percentage is sufficiently stable over time. Sorting on the historical zero return percentage alone produces significant dispersion in the post yield spreads.
- For the explanatory power of different liquidity measurements, our regression results indicate the following order: zero-return percentage is the most powerful liquidity measure, the next is the bid-ask spread in percentage followed by bid-ask spread, and Amihud illiquidity factor does not work well in corporate bond markets, even though the log value of Amihud illiquidity factor performance better, the improvement is marginal.

- The paper provides further evidence on the explanatory power of zero-return percentage by comparing it with trading-based liquidity measures. Trading-based liquidity measures perform well judging from the magnitude of R-squares and the expected signs based on the regression analysis. However, according to R-squares and the stability of coefficients, zero-return percentage perform better than trading-based liquidity measures.

- Bond age and life (time to maturity) and amount-outstanding are the liquidity-related controlling variables. They perform well in the regression test with the expected sign and significant coefficients, which are consistent with the hypothesis.

6.2 Limitations and Future Direction of Research

Given the work done in this paper, there are some limitations in our study. Firstly, the estimation procedure—pooled OLS without considering fixed and random effect estimation in panel data. Secondly, we simply apply Amihud illiquidity factor to the corporate bond market, which may be a potential reason for the falloff of Amihud illiquidity factor explanatory power to yield spread. Thirdly, the potential endogenously problems are not taken into account when the regression models 3.1 and 3.2 are conducted. Lastly, little research work on dynamic relation between yield spread and liquidity measures has been given in our study. The time-varying relationship between the yield spread and its determinants is an open question. Future work should look into the dynamic relationship between yield spread and yield spread's determinants andconsider the proper econometric issues. It is also important to document the proper reasons that the Amihud illiquidity factor does not work in US corporate bond markets. We leave these for future work.

References

1. Amihud, Y., and Mendelson, H., (1991), "Liquidity, maturity, and the yield spread on US treasury securities," *Journal of Finance* 46, 1411-1425.

2. Amihud, Y., (2002), "Illiquidity and stock returns: Cross-section and time series effects," *Journal of Financial Markets* 5, 31-56.

3. Bessembinder, H., Maxwell, W., and Venkataraman, K., (2005), "Optimal market transparency: Evidence from the initiation of trade reporting in corporate bonds," *Unpublished working paper*.

4. Brennan, M., J., and Subrahmanyan, A., (1996), "Market microstructure and asset pricing: On the compensation for illiquidity in stock return," *Journal of Financial Econometrics* 41, 441-464.

5. Chacko, G., (2005), "Liquidity risk in the corporate bond markets," Harvard University and State Street Global Markets, *working paper*, January.

6. Chacko, C., Mahanti, S., Mallik, G., and Subrahmanyam, M., (2005), "The determinants of liquidity in the corporate bond markets: An application of latent liquidity," *Unpublished working paper*.

7. Chen, L., Lesmond, D. A., and Wei, J., (2003), "Bond liquidity estimation and liquidity effect in yield spreads," University of Toronto, *working paper*.

8. Chen, L., Lesmond, D. A., and Wei, J., (2007), "Corporate Yield Spreads and Bond Liquidity," *Journal of Finance* 62, 119-149.

9. Chordia, T., Roll, R., and Subrahmanyam, A., (2000), "Commonality in Liquidity," *Journal of Financial Economics* 56, 3-28

10. Collin-Dufresne, P., and Goldstein, R., (2001), "Do credit spreads reflect stationary leverage ratios," *Journal of Finance* 56, 1929-1957.

11. Crabbe, L. E., and Turner, C. M., (1995), "Does the liquidity of a debt issue increase with its size? Evidence from the corporate bond and medium-term note markets," *Journal of Finance* 50, 1719-1734.

12. Covitz, D., and Downing, C., (2006), "Liquidity or credit risk? The determinants of very short-term corporate yield spread," Federal Reserve Board, *working paper*.

13. Driessen, J., (2005), "Is default event risk priced in corporate bonds," *Review of Financial Studies* 18, 165-195.

14. Duffie, D., and Singleton, K. J., (1999), "Modeling term structures of default able bonds," *Review of Financial Studies* 12, 687-720.

15. Edwards, A. K., Harris, L. , and Piwowar, M. S., (2005), "Corporate Bond Market Transparency and Transaction Costs," University of Southern California, *working paper*, December;

16. Elton, E. J., Gruber, M. J., Agrawal, D., and Mann, C., (2001), "Explaining the rate spread on corporate bonds," *Journal of Finance* 56, 247-277.

17. Engle, R. F., and Lange, J., (1997), "Measuring, Forecasting and Explaining Time Varying Liquidity in the Stock Market," NBER Working Paper, 6129.

18. Fisher, L., (1959), "Determinants of the risk premiums on corporate bonds," *Journal of Political Economy* 67, 217-237.

19. Fleming, M. J., (2003), "Measuring Treasury market liquidity," *Economic Policy Review*, 83-108.

20. Garbade, K. D., and Silber, W. L., (1976), "Price dispersion in the government securities market," *The Journal of Political Economy* 84, 721-740.

21. Gebhardt, W. R., Hvidkjaer, S., and Swaminathan, B., (2005), "The cross-section of expected corporate bond return: betas or characteristics," Journal of financial economics 75, 85-114.

22. Goldstein, M., Hotchkiss, E., and Sirri, E., (2005), "Transparency and liquidity: a controlled experiment in corporate bonds," Babson College, *working paper*, June;

23. Harris, L. E., and Piwowar, M. S., (2006), "Secondary trading costs in the municipal bond market," *Journal of Finance* 61, 1361-1397.

24. Hong, G., and Warga, A., (2000), "An empirical study of bond market transactions," *Financial Analysts Journal* 56, 32-46.

25. Houweling, P., Mentink, A., and Vorst, T., (2003), "How to measure corporate bond liquidity?" Erasmus University Rotterdam, *working paper*, March.

26. Houweling, P., Mentink, A., and Vorst, T., (2005), "Comparing possible proxies of corporate bond liquidity," *Journal of Banking & Finance* 29, 1331-1358.

27. Huang, J., and Huang, M., (2003), "How much of the Corporate-Treasury yield spread is due to credit risk," Stanford University, *working paper*.

28. Hund, J., and Lesmond, D. A., (2006), "Liquidity and credit risk in emerging debt Markets," Rice University, *working Paper*, March.

29. Jones, C. M., Kaul, G., and Lipson, M. L., (1994), "Transaction, volume, and volatility," *Review of Financial Studies* 7, 631-651.

30. Kamara, A., (1994), "Liquidity, taxes and short-term treasury yields," *Journal of Finance and Quantitative Analysis* 29, 403-417.

31. Karpoff, J. M., (1987), “The relationship between price changes and trading volume: A survey.” *Journal of Financial and Quantitative Analysis* 22, 109-126

32. Kyle, A. S., (1985), “Continuous auctions and insider trading,” *Econometrica* 53, 1315-1335.

33. Lesmond, D., Odgen, J., and Trzcinka, C., (1999), “A new estimate of transaction costs,” *Review of Financial Studies* 12, 1113-11441.

34. Longstaff, F. A., Mithal, S., and Neis, E., (2005), “Corporate yield spreads: Default risk or liquidity? New evidence from the credit default swaps market,” *Journal of Finance* 60, 2213-2253.

35. Merton, R. C., (1974), “On the trading of corporate bond debt: The risk structure of interest rates,” *Journal of Finance* 29, 449-470.

36. O'Hara, M., (1995) “Market Microstructure Theory,” *Cambridge: Blackwell.*

37. Pastor, L., and Stambaugh R. F., (2003), “Liquidity risk and expected stock return,” Wharton School, University Pennsylvania, *working paper*, July.

38. Sarig, O., and Warga, A., (1989), “Bond price data and bond market liquidity,” *Journal of Financial and Quantitative Analysis*, 24, 367-378.

39. Schultz, P., (2001), “Corporate bond trading costs: A peek behind the curtain,” *Journal of Finance* 56, 677-698.

40. Shulman, J., Bayless, M., and Price, K., (1993), “Marketability and default influences on the yield premia of speculative-grade debt,” *Financial Management* 22, 132-141.

Figure 1—4[13]

Figure 1- A

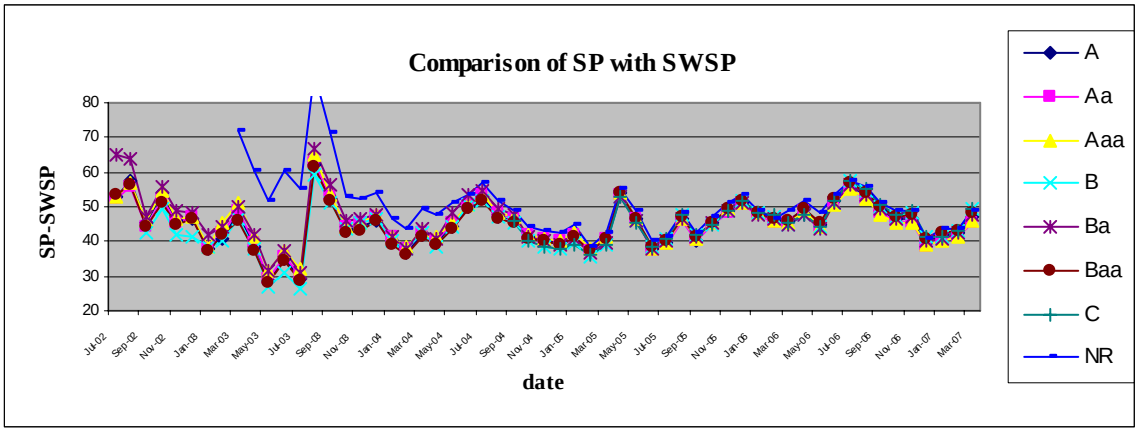

Figure 1-B

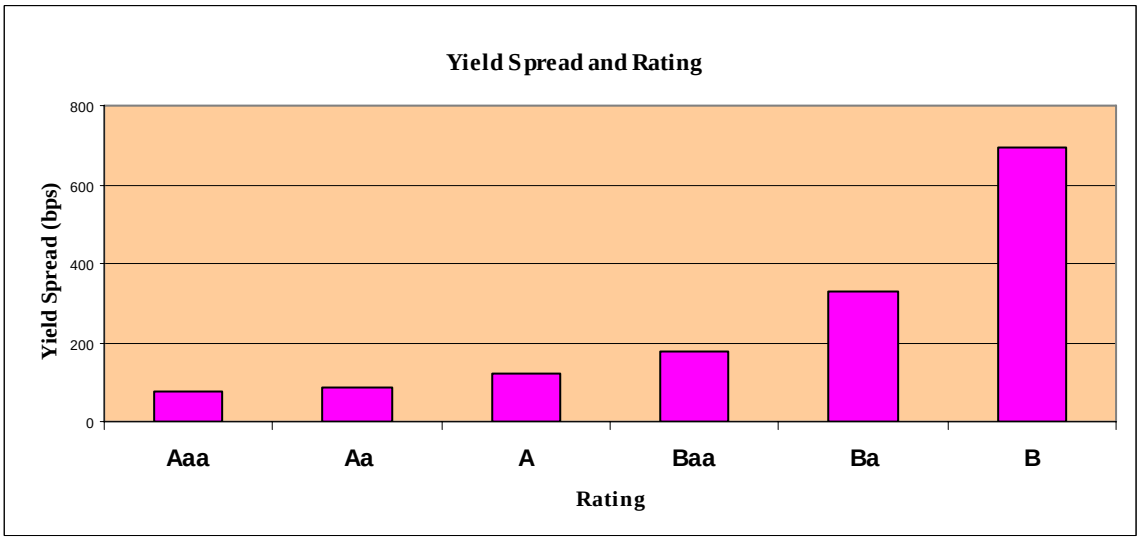

Figure 1 Comparison of Yield and Yield Spread over Swap

Figure1-A plots the average difference of yield spread over benchmark curve (SP) and yield spread over swap curve (SWSP) by month during period of 07/2002 to 03/2007. The patterns there show the similar movement between SP and SWSP.

Figure1-B plots the average yield spread over benchmark curve during the whole period for different rating categories. The prominent features of this figure are the upward tendency in yield spread along the rating.

Both figures show the hypothesis that credit quality dimension can be expected to a component of yield spread.

[13] For easy of expression, we refer "SP" to "yield spread over benchmark curve", "SWSP" to "yield spread over swap", "investment" to "investment-grade bonds", "speculative" to "speculative-grade bonds", "non rated" to "non-traded bonds".

Figure 2 - A:

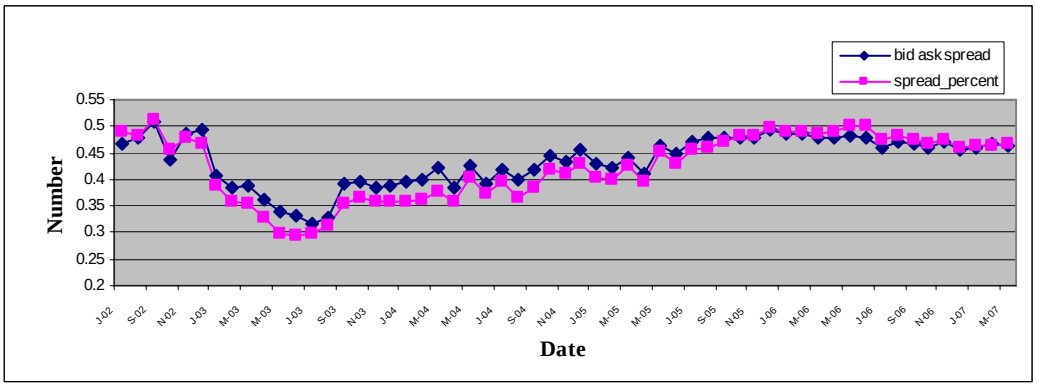

Figure 2 - B:

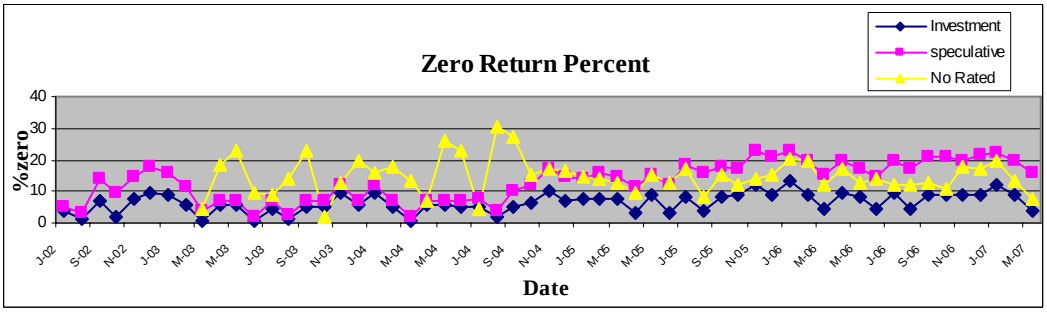

Figure 2 - C:

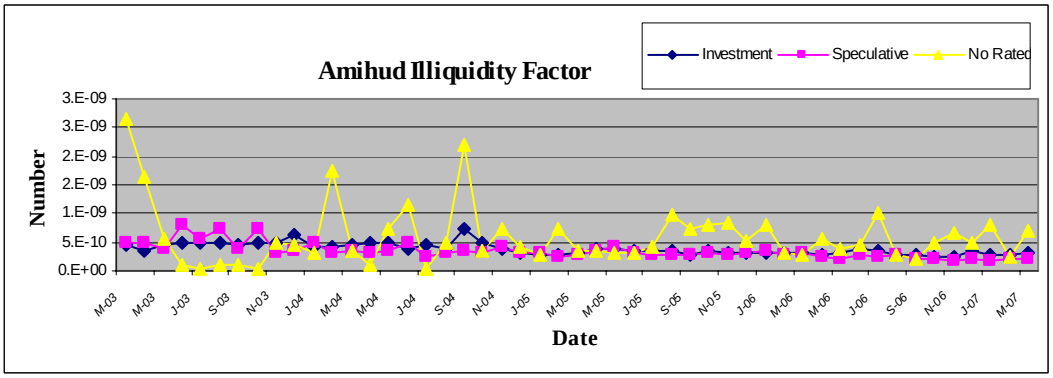

Figure 2: Time-Varying Liquidity Measures

Figure 2 –A plots average *bid-ask spread* and *bid-ask spread percentage* by month for the period from 07/2002 to 03/2007, both of them are quite correlated. This figure is based on the sub-sample of only including bid-ask spread measure.

Figure 2 –B plots average *zero-return percentage* by month for the period from 07/2002 to 03/2007 across rating categories. As shown, the % zero for speculative-grade bonds is higher than the investment-grade bonds. For non-rated bond, it changes dramatically; this figure is based on the sub-sample of only including zero returns percentage measure.

Figure 2 –C plots the average *Amihud illiquidity factor* by month for the period from 07/2002 to 03/2007. This figure is based on the sub-sample of only including Amihud illiquidity factor.

Figure 3-A

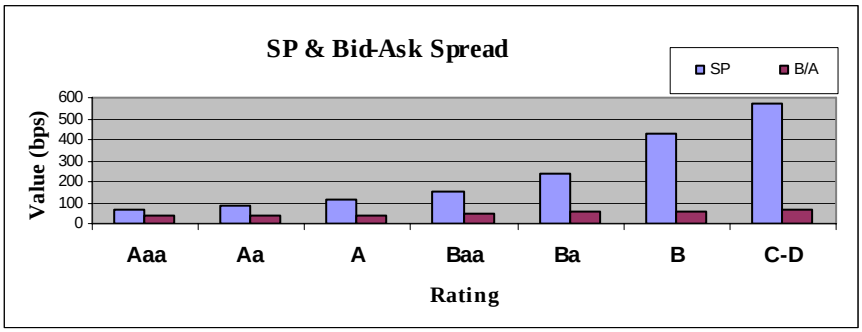

Figure 3-B

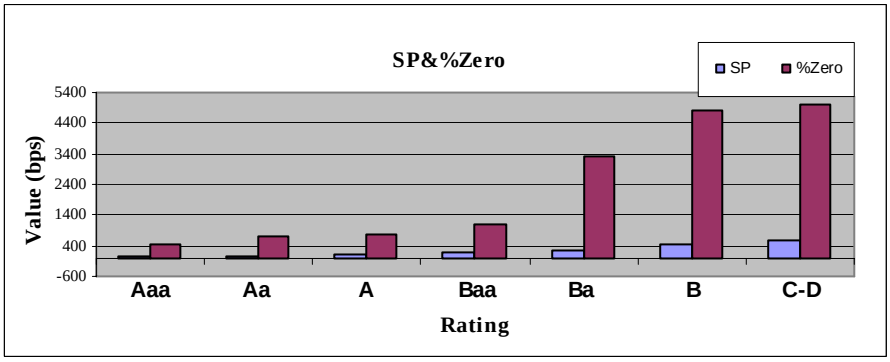

Figure 3-C

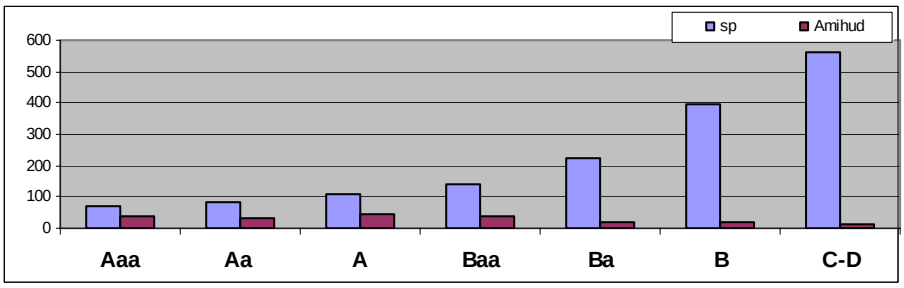

Figure 3 Yield Spread and Liquidity Measures

Figure 3-A plots the relation of the yield spread and *bid-ask spread* across rating, illustrating a reasonable relation between yield spread and bid-ask spread, which means bid-ask spread may be a good specification of the yields spread in corporate bond markets. The figure is based on the sub-sample including bid-ask spread liquidity measure.

Figure 3-B plots the relation of the yield spread and *zero-return percentage*, illustrating a reasonable relation between yield spread and zero returns percentage that is yield spreads increase as zero returns percent goes up, implying zero return percentage may be a good specification of the yields spread in corporate bond markets. The figure is based on the sub-sample including zero returns percentage.

Figure 3-C plots the relation of the yield spread and *Amihud illiquidity factor*, illustrating an opposite tendency between yield spread and Amihud illiquidity factor, which means Amihud illiquidity factor may not be a good specification of the yields spread in corporate bond markets. The figure is based on the sub-sample including Amihud illiquidity factor.

Figure 4 –A

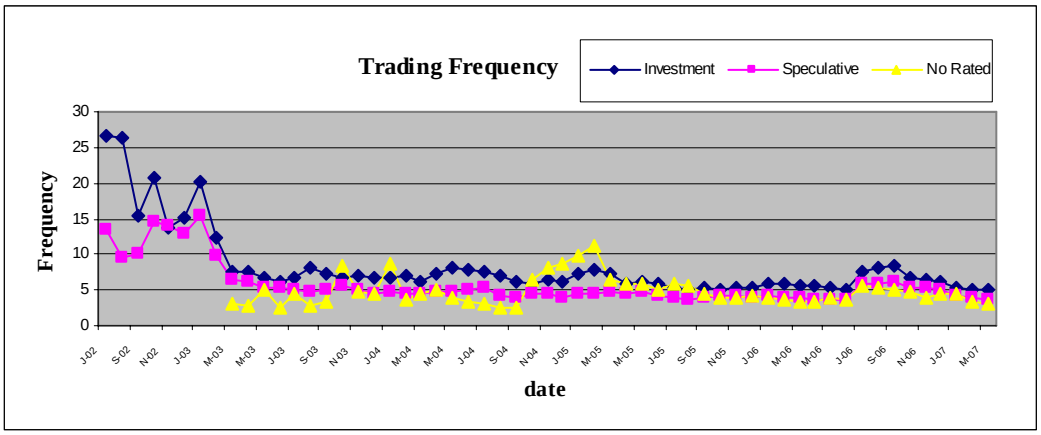

Figure 4 - B

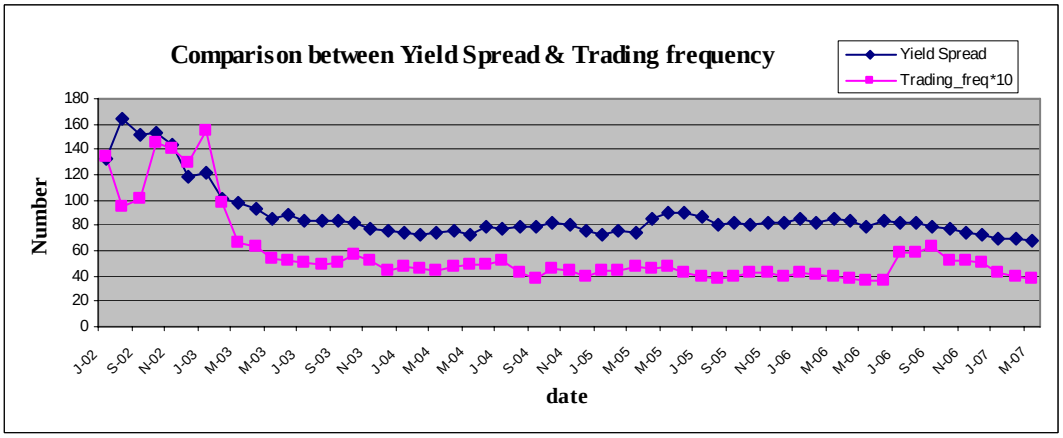

Figure 4 Trading Activity and Yield Spread

Figure 4–A plots average *Trade Frequency* by month for the period from 07/2002 to 03/2007 across rating categories; for different rating categories, *Trade Frequency* are not so clear as *Trade Size* in figure 4-C.

Figure 4–B plots the comparison between the *Trade Frequency* and yield spread over benchmark curve. At the beginning, the behaviors of yield spread and *Trade Frequency* are quite different.

Figure 4 - C

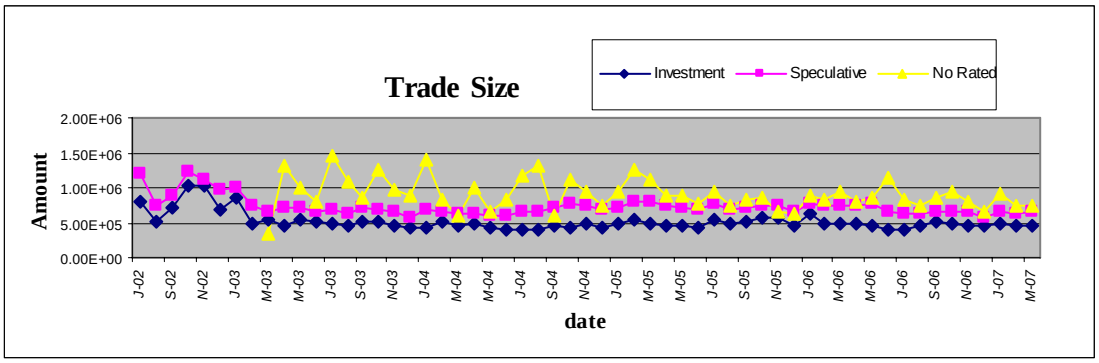

Figure 4 - D

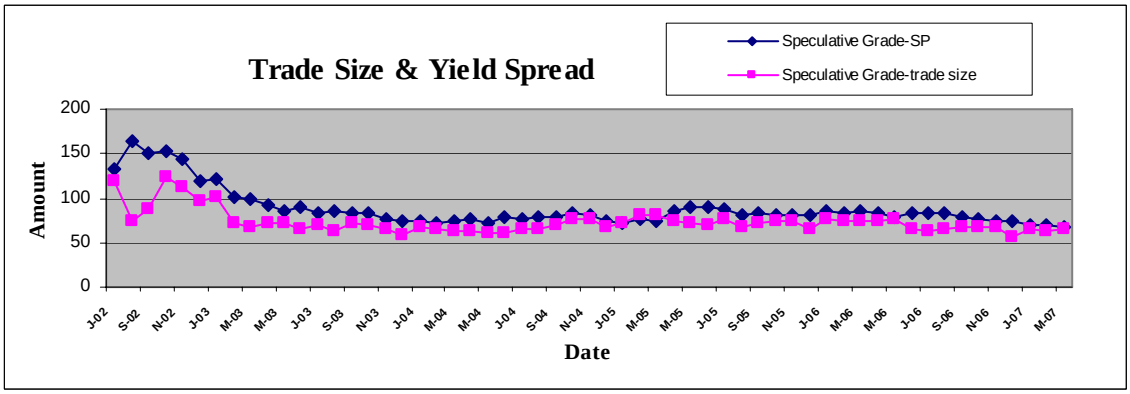

Figure 4 Trading Activity and Yield Spread

Figure 4–C plots average *Trade Size* by month for the period from 07/2002 to 03/2007 across rating categories; *Trade Size* is shown to decline in Augest/2002 and March/2003. For different rating categories, the *Trade Size* is different, implying that trading activity (*Trade Size)* is effected by credit rating.

Figure 4–D plots the comparison between the average *Trade Size* and average yield spread over benchmark curve by month for the period of from 07/2002 to 03/2007. There are corresponded tendency between the yield spread over benchmark curve and *Trade Size*.

Table 4.1–4.3

Table 4.1 Sample Compositions

This table reports the composition of the sample, Panel A reports the number of bond in the different categories: long-term bonds have more than 15 years to maturity, median-term bonds are with the more than 7 and less 15 years' life; short-term bonds mean the bonds have less 7 years left. Maturity is represented in a row, and rating categories are presented in columns. For each number, it is the total number of bonds which meet the two requirements. Panel B reports bond months based on the rating and maturity categories; Panel C reports the bond provisions.

Panel A: The Number of Bonds

Rating	maturity			Total
	L(>15Y)	M (7-15Y)	S (<7Y)	
Investment-Grade Bonds	86	89	210	385
Speculative-Grade Bonds	451	619	1445	2515
Non-Rated Bonds	1	7	10	18
Total	538	715	1665	2918

Panel B: The Number of Bond Months

Rating	maturity			Total
	L(>15Y)	M (7-15Y)	S (<7Y)	
Investment-Grade Bonds	1974	2374	5666	10014
Speculative-Grade Bonds	8636	12514	30134	51284
Non-Rated Bonds	6	104	136	246
Total	10616	14992	35936	61544

Panel C: Bond Provision Composition

Type	Tag	Frequency	Percent
Putable	N	2865	98.18
	Y	53	1.82
Callable	N	1075	36.84
	Y	1843	63.16
Bullet	N	1882	64.5
	Y	1036	35.5
Redeemable	N	1043	35.74
	Y	1875	64.26
Median Term Notes	N	2656	91.02
	Y	262	8.98
Sinking Fund	N	2915	99.9
	Y	3	0.1

Table 4.2 Summary of Dependent Variables and Independent Variables

This table displays pooled summary statistics of dependent variable (Yield Spread) and independent variables. For convenience, the table is separated into two panels: Panel A and B.

Panel A reports the summary statistics yield spread and the main liquidity variables; Spread is the bid-ask spread, calculating by ask price less bid price; % spread is the bid ask spread percentage, which is calculate the spread divided by mid price; % zero is the zero-return percentage; Amihud stands for the Amihud illiquidity factor based on the traditional formula, with its log value expressed by Log-Amihud;

Panel B reports the summary statistics of other liquidity-related variables. Amt Issued stands for the issue size, the third row represents the statistics for the amount outstanding; trade share measures the number of the trade during the month; trading volume is the face value on these trades; dollar volume takes the percent price into the trading volume. And p10, q1, q3, p90 mean the 10%, ¼, ¾ and 90% quantiles separately. The sample period is 07/2002 to 03/2007.

"Amihud‡" equals to Amihud illiquidity factor*10^9.
"Credit rating**", for the convenience of expression, the number is not in the log value.

Panel A									
Name	**Mean**	**Std**	**Min**	**p10**	**q1**	**Median**	**q3**	**p90**	**Max**
Number	61544	61544	61544	61544	61544	61544	61544	61544	61544
Yield Spread	159.76	174.87	0	51	66.9	96.5	188.4	348.7	3686.3
Spread	0.4459	0.4097	0	0.087	0.25	0.317	0.661	0.9	8.06
Mid Price	103.06	9.276	28.375	94.34	97.67	101.67	108.39	114.6	147.6
% Spread	0.4365	0.393	0	0.086	0.22	0.311	0.605	0.902	7.136
% Zero	14.53	21.945	0	0	4.348	4.7619	9.09	52.17	100
Amihud‡	1.625	3.298	0.00001	0.005	0.018	0.081	0.277	0.712	81734
Log-Amihud	-9.599	1.922	-18.15	-12.24	-10.91	-9.416	-8.192	-7.25	4.403

Panel B									
Variable name	**mean**	**std**	**min**	**p10**	**q1**	**median**	**q3**	**p90**	**max**
Amount Issued (MM)	512	445	3	200	250	400	600	1000	5000
Amount Outstanding (MM)	477	438	0	1.50	248	350	527	1000	5000
Trade Share	47.9	104	0.03	2.33	7.49	20.6	50.4	111	5850
Trade Volume(B)	5720	37500	3.05	238	769	2110	5130	11400	4040000
Dollar Volume(B)	56.1	375	0.03	2.28	7.43	20.6	50.5	112	4230
Price Range	4.11	15.67	0.05	1.19	1.87	3.13	5.15	7.77	3707.79
Bond Volatility	1.05	2.54	0.00	0.28	0.46	0.78	1.31	2.02	559.02
Modified Duration	6.08	3.20	0.31	2.60	3.76	5.48	7.32	11.67	16.43
Age	3.76	3.48	0.01	0.62	1.27	2.41	5.53	8.73	23.64
Life	9.47	8.10	0.32	2.86	4.36	7.11	9.61	23.82	94.24
Turn Over	2.83	122.51	0.00	0.01	0.03	0.06	0.11	0.21	25920.13
Trade Size (in 1000)	0.65	0.65	0.00	0.07	0.19	0.47	0.84	1.5326	5
Day Freq	5.33	7.52	1.00	1.75	2.29	3.26	5.50	10.43	35.67
Credit Rating**	8.12	4.09	0	4	5	7	10	15	20

Table 4.3 Correlation Analysis of Variables[14]

This table displays the pair wise correlations for the liquidity variables in our regression model. The Panel A reports the correlations between the credit rating and liquidity measures. The Panel B reports the pair wise correlations of liquidity-related variables and credit rating.

Panel A Correlation of Liquidity Measures and Credit Rating

Name	Amihud*	Log Amihud	%zero	Spread	% Spread	Credit Rating
Credit Rating	0.010	-0.084	0.617	0.239	0.284	1

Panel B Correlation Matrix of Trading-Based Liquidity Measures and Others

Name	Amt Issued	Amt Out standing	Age	Life	Turn Over	Trade Size	Day Freq	Trade Volume	Dollar Volume	Bond volatility	Credit Rating
Amt Issued	1										
Amt Outstanding	0.95	1									
Bond Age	-0.24	-0.25	1								
Life	0.03	0.03	0.11	1							
Turn Over	-0.01	-0.02	-0.01	0.00	1						
Trade Size	0.13	0.14	-0.26	0.17	0.00	1					
Day Freq	0.49	0.46	-0.09	-0.02	0.01	-0.10	1				
Trade Volume	0.18	0.18	-0.07	0.02	0.00	0.12	0.17	1			
Dollar Volume	0.17	0.17	-0.07	0.02	0.00	0.12	0.17	0.99	1		
Bond volatility	0.00	0.00	0.01	0.00	0.00	0.01	-0.01	0.00	0.00	1	
Credit Rating	-0.16	-0.21	-0.07	-0.03	0.03	0.04	-0.02	-0.04	-0.04	0.00	1

"Amihud*" means Amihud illiquidity factor $\times 10^6$.

[14] For the concision, the correlations of liquidity measures (zero-return percentage, bid-ask spread, bid-ask spread percentage, Amihud illiquidity factor and its log value are reported in Table 5.1.

Table 5.1–5.7

Table 5.1 Mean Correlation Analysis

Table 5.1 reports the mean correlation matrix of yield spreads and different liquidity measures. There are two panels in this table, Panel A is the mean correlations between yield spread and liquidity measures for each month. Firstly, the correlation of yield spread and liquidity measures is calculated for each month, and then get to mean correlation to average the correlation across all the months; t-values, which are reported in parenthesis, are for the hypothesis that correlation coefficients are zero. As the same way, the average correlation for each bond and t-values are reported in Panel B. The correlations between yield spreads and different liquidity measures are in bold. And "*" and "†" stand for 1% and 10% significance level separately.

Panel A: Mean Correlations for Each Month

NAME	Amihud*	Log (Amihud)	**Yield Spread**	Spread percent	Spread	% Zero
Amihud*	1					
Log (Amihud)	0.57* (49.4)	1				
Yield Spread	**0.012 (0.9)**	**-0.019 (-0.62)**	**1**			
%Spread	0.053* (3.98)	0.072* (5.32)	**0.25* (11.99)**	1		
Spread	0.058* (3.8)	0.081* (6)	**0.159* (8.65)**	0.98* (271.6)	1	
% Zero	-0.018 (-1.48)	-0.044* (-2.56)	**0.38* (16.68)**	0.13* (7.8)	0.104* (6.22)	1

Panel B: Mean Correlations for Individual Bonds

NAME	Amihud*	Log (Amihud)	**Yield Spread**	% Spread	Spread	% Zero
Amihud*	1					
Log (Amihud)	0.855* (572.57)	1				
Yield Spread	**0.006 (0.9)**	**0.005 (0.06)**	**1**			
% Spread	0.017* (2.73)	0.027* (4.1)	**0.12* (15.4)**	1		
Spread	0.014* (2.4)	0.023* (3.66)	**0.069* (9.32)**	0.94* (213.4)	1	
% Zero	0.008 (1.3)	0.009 (1.49)	**0.01† (1.69)**	0.029* (4.7)	0.035* (5.96)	1

"Amihud*"is the Amihud illiquidity factor $\times 10^6$.

Table 5.2 Yields Spread of Portfolios Sorted on Different Liquidity Measures

This table reports the yield spread for different portfolios sorted by liquidity measures. At the end of the month, bonds are sorted by liquidity measures (zero-return percentage, bid-ask spread and Amihud illiquidity factor) and assigned to three portfolios:

"Low" means the high liquidity portfolio, expecting the low yield spread;
"High" means the low liquidity portfolio, expecting the high yield spread;
"Mid" means the portfolio with the liquidity which is between "Low" and "High" portfolios;
"Difference" is the value of "High" portfolio less the value in "Low" portfolios.

Based on the liquidity-ranked portfolios, we will calculate and compare the average yield spreads in the same month (t=0) and the next month (t=1) in each portfolio.

An asterisk (*) stands for the value is significantly different from zero at the 1% significance level. And t-values are presented in parentheses.

There are three panels in the table:
Panel A reports the results from sorting by zero returns percentage.
Panel B reports the results from sorting by bid-ask spread.
Panel C reports the results from sorting by Amihud illiquidity factor.

Panel A: Sorting by Zero Returns Percentage				
Types	Rank % zero	% zero	Yield Spread (t=0)	Yield Spread (t=1)
All Bonds	Low	6.48	144.61	219.78
	Mid	21.12	250.71	245.75
	High	46.97	348.04	346.11
	Difference	40.48	203.43* (9.71)	126.32* (3.84)
Investment Grade Bonds	Low	4.84	83.59	83.73
	Mid	20.84	126.08	135.02
	High	38.19	135.86	135.35
	Difference	33.35	52.27* (5.84)	51.62* (4.8)
Speculative Grade Bonds	Low	6.81	157.47	228.14
	Mid	19.93	267.94	295.87
	High	49.54	366.76	347.02
	Difference	42.73	209.28* (10.1)	118.74* (4.25)

Panel B: Sorting by Bid-Ask Spread				
Types	Rank Spread	Bid-ask Spread	Yield Spread (t=0)	Yield Spread (t=1)
All Bonds	Low	0.1444	188.20	234.08
	Mid	0.4049	154.41	190.39
	High	0.8059	256.37	287.91
	Difference	0.6614	68.17* (4.96)	53.84 (1.69)
Investment Grade Bonds	Low	0.1314	75.97	76.88
	Mid	0.3224	90.11	95.73
	High	0.6482	129.03	155.69
	Difference	0.5169	53.06* (5.97)	78.88* (4.87)
Speculative Grade Bonds	Low	0.1582	218.27	258.26
	Mid	0.4297	164.92	192.39
	High	0.8268	277.26	292.1
	Difference	0.6687	58.99* (3.49)	33.83 (1.01)

Panel C: Sorting by Amihud Illiquidity Factors				
Types	Rank Amihud	Amihud‡	Yield Spread (t=0)	Yield Spread (t=1)
All Bonds	Low	0.011	206.66	242.56
	Mid	0.083	191.73	232.22
	High	3.762	214.29	258.44
	Difference	37.51	7.63 (0.5)	20.86 (0.68)
Investment-Grade Bonds	Low	0.009	73.56	82.92
	Mid	0.091	95.07	106.62
	High	0.926	128.99	147.24
	Difference	0.917	55.43* (5.71)	64.32* (4.12)
Speculative-Grade Bonds	Low	0.012	231.28	258.2
	Mid	0.085	207.99	243.46
	High	4.249	229.92	256.84
	Difference	4.23	-1.37 (-0.08)	-1.36 (-0.05)

Amihud‡ is the Amihud illiquidity factor$\times 10^9$.

Table 5.3 Regress Bid-ask Spread on Other Liquidity Estimators

The table reports the results of models $Bid-ask\ spread_{it} = \alpha + \beta_l L_{it} + u_t$, and

$$Bid-ask\ spread_{it} = \alpha + \beta_l L_{it} + \beta_c Credit\ risk + \beta_m Maturity + \beta_a Age + \beta_o Amount\ outs\tan ding + \beta_v Bond\ volatility + \sum_i \beta_b Other\ bond\ characteristics_{it} + u_t$$

The liquidity measures include the Amihud Illiquidity factor, zero-return percentage (% zero). The estimators, the t-values in parenthesis and R-Squares are reported. Liquidity measures are in bold. And "*" and "†" stand for 1% and 10% significance level separately.

	Speculative-Grade Bond				**Investment-Grade Bond**				**All Bonds**			
Variable	m1	m2	m3	m4	m1	m2	m3	m4	m1	m2	m3	m4
Intercept	0.41* (183.0)	0.09* (2.52)	0.46* (250)	0.04 (1.15)	0.34* (86.39)	0.81* (8.7)	0.34* (94.28)	0.82* (8.64)	0.39* (202.6)	0.3* (8.91)	0.44* (269.7)	0.34* (10.14)
% Zero	0.003* (42.9)	0.002* (18.27)			0.003* (10.3)	0.001* (4.43)			0.004* (48.76)	0.002* (29.37)		
Amihud*			-0.045 (-0.81)	25.2* (10.1)			50.9* (11.7)	-6.5 (-1.53)			-0.003 (-0.77)	17.5* (8.22)
Life to maturity		0.012* (56.04)		0.012* (54.1)		0.017* (44.53)		0.017* (43.27)		0.013 (66.67)		0.01 (19.67)
Age in year		0.014* (24.96)		0.011* (18.53)		0.005* (4.71)		0.005* (5.23)		0.11* (22.42)		-0.17* (-10.9)
Log (amount)		-0.01* (-6.06)		-0.011* (-7.19)		-0.03* (-6.9)		-0.03* (-6.85)		-0.01* (-8)		-0.0001 (-0.23)
Bond volatility		-0.0001 (-0.37)		-0.0001 (0.34)		-0.04† (-2.32)		-0.038† (-2.11)		-0.001 (-0.32)		-0.063* (-3.15)
Rating		0.19* (32.29)		0.24* (54.99)		-0.02* (-3.57)		-0.017* (-3.11)		0.09* (28.6)		0.14 (45.1)
Callable		0.006 (0.14)		-0.003 (-0.46)		0.015† (2.14)		0.014† (1.96)		0.01* (2.23)		0.01* (3.03)
Adjusted R-Sq	0.0354	0.127	0.001	0.123	0.039	0.2124	0.014	0.211	0.0373	0.1351	0	0.1238

"Amihud*" means Amihud illiquidity factor$\times 10^6$.

Table 5.4 Univariate Regression of Yield Spread on Single Liquidity measures

This table reports the comparison of different liquidity measures based on the univariate analysis. In order to provide a consistent comparison we match yield spread, bid-ask spread, zero-return percentage and Amihud illiquidity factor to the available sample which include 2980 bonds with 65114 bond months.

The regression model is: $Yield\ spread_{it} = \alpha + \beta_l L_{it} + u_t$, where yield spread means the yield spread over benchmark curve for corporate bonds; L_{it} includes bid-ask spread, the bid-ask spread percentage, the zero-return percentage, Amihud illiquidity factor and the log value of the Amihud illiquidity factor.

There are two panels in the table, Panel A is for regression without consideration of rating; Panel B presents regression results under different rating categories: investment-grade bonds (Baa-rated bonds and above), speculative-grade bonds (Ba-rated bonds and below) and all the bonds.

For every variable, there are two estimated values, one of which is the estimated coefficient, and the other (in parenthesis) is the t-value. Coefficients are marked with an asterisk are significant to at least the 1% level, "†" means coefficients have significance at 10% significance level. Bold numbers means biggest R-square.

Panel A: Pooled OLS					
Intercept	118.92* (116.87)	102.3* (101.7)	100.72* (138.5)	159.75* (226.64)	116.69* (18.44)
Spread (bps)	0.92* (54.51)				
% Spread (bps)		1.32* (76.88)			
% Zero			4.06* (147.04)		
Amihud ‡				4.2† (1.94)	
Log Amihud					-3.3* (-9.05)
Adjusted R-Sq	0.04603	0.08761	**0.25996**	0.0001	0.0013

"Amihud‡" means Amihud illiquidity factor $\times 10^9$.

Panel B: Univariate Regression across Rating							
Rating Categories	Intercept	Spread (bps)	% Spread (bps)	% Zero	Amihud *	Log of Amihud	Adjusted R-Square
Investment-Grade Bonds	62.997* (76.74)	0.46* (27.4)					0.0697
	60.369* (73.1)		0.55* (31.2)				0.0885
	68.35* (111.08)			1.62* (39.44)			**0.1344**
	76.03* (123.45)				18.94* (16.14)		0.0253
	211.82* (42.37)					7.73* (26.71)	0.0664
Speculative-Grade Bonds	134.5* (112.36)	0.89* (131.59)					0.0401
	115.66* (97.75)		1.32* (67.68)				0.082
	110.3* (127.53)			4.06* (131.59)			**0.2524**
	175.57* (214.27)				0.004† (1.74)		0.000059
	86.953* (11.76)					-5.2* (-12.06)	0.00283
Non-Rated Bonds	49.39* (4.49)	2.56* (9.95)					0.0721
	50.9* (4.45)		2.52* (9.34)				0.0596
	114.51* (14.182)			2.28* (5.78)			**0.1203**
	142.68* (19.52)				-4.03 (-0.24)		0.0077
	61.1* (0.98)					-4.6 (-1.31)	0.0644

"Amihud *" means Amihud illiquidity factor$\times 10^6$.

Table 5.5 Assessing Relative Importance of Liquidity and Credit Risk

This table reports the comparison of different liquidity measures under controlling credit rating. The models are as follows,

Model 1 $Yield\ spread_{it} = \alpha + \beta_c Credit\ Rating_{it} + u_t$

Model 2-Model 6 $Yield\ spread_{it} = \alpha + \beta_l L_{it} + \beta_c Credit\ Rating_{it} + u_t$

In order to provide a consistent comparison we match yield spread, bid-ask spread, zero return percentage and Amihud illiquidity factor to the available sample which include 2980 bonds with 65114 bond months.

The first column is the results of model with rating only, others are the results from regressions of credit rating and single liquidity measure together. For every estimator, there are two estimated values, one of which is the estimated coefficient, and the other of which is the t-values, which are presented in parentheses. Coefficients (*) are marked with an asterisk are significant to at least the 1% level. Bold numbers means biggest R-square.

Model	M1	M2	M3	M4	M5	M6
Intercept Estimate	-173.01* (-81.03)	-179.58* (-84.3)	-180.75* (-86.13)	-113.29* (-53.08)	-172.997* (-81.02)	-160.57* (-28.85)
Spread (bps)		0.441* (30.3)				
%Spread (bps)			0.757* (49.99)			
%Zero				2.51* (85.63)		
Amihud ‡					1.77 (1.27)	
Log Amihud						-1.5* (-5.11)
Credit Rating	169.33* (162.02)	162.64* (153.34)	156.45* (148.11)	120.38* (105.49)	169.33* (162.01)	169.49* (161.85)
Adjusted R-Sq	0.3004	0.3107	0.3278	**0.3753**	0.3004	0.3004

"Amihud‡" means Amihud illiquidity factor$\times 10^9$.

Table 5.6 Liquidity Effects on Yield Spread Levels

This table reports the comparison of different liquidity measures based on model below,

$$Yield\ spread_{it} = \alpha + \beta_l L_{it} + \beta_{tax} Tax + \beta_c Credit\ risk + \sum_i \beta_m Macroecomic\ \text{var}iables_{it} + \beta_t TERM_{it} + \sum_i \beta_f Firm\ characters + \sum_i \beta_b Other\ bond\ characteristics_{it} + u_t$$

where L_{it} only includes the bid-ask spread percentage, zero-return percentage, the log value of the Amihud illiquidity. In order to provide a consistent comparison we match yield spread, bid-ask spread, zero-return percentage and Amihud illiquidity factor to the available sample which include 2918 bonds with 61554 bond months.

There are tow panels: Panel A reports the regressions' results under investment-grade bonds, speculative-grade bonds and all the bonds; Panel B reports the model comparison based on BIC.

The estimated coefficients and the t-value in parenthesis are reported. Coefficients are marked with an asterisk are significant to at least the 1% level. In panel A, bold numbers means biggest R-squares. In Panel B, bold numbers indicate the smallest values of BIC under liquidity measures.

Panel A: Regression Results

Categories	Investment-Grade Bonds			Speculative-Grade Bonds			All Bonds		
Intercept	-146.53* (-9.06)	-128.08* (-8.37)	-129.91* (-7.99)	-237.17* (-17.98)	-221.05* (-16.99)	-240.32* (-18.05)	-105.3* (-8.8)	-111.95* (-9.72)	-97.37* (-8.03)
%Spread	0.17* (10.52)			0.26* (20.44)			0.36* (30.74)		
%Zero		1.21* (33.29)			1.18* (40.98)			1.72* (70.29)	
Amihud ‡			-1.94* (-3.1)			-0.33 (-0.52)			-1.45 (-2.5)
Life	2.3* (33.88)	2.32* (38.72)	2.6* (40.92)	1.12* (17.81)	1.62* (26.9)	1.44* (23.26)	0.8* (14.19)	1.5* (28.76)	1.26* (22.85)
Age	1.94* (8.86)	1.13* (5.39)	2.1* (9.52)	-2.3* (-11.5)	-1.15* (-5.83)	-2.02* (-9.95)	-4.84* (-28.28)	-2.88* (-17.3)	-4.59* (-26.22)
Log Amount	5.37* (7.57)	4.38* (6.54)	4.61* (6.47)	-4.28* (-8.26)	-1.92* (-3.73)	-4.76* (-9.08)	-3.8* (-7.9)	-0.82† (-1.77)	-4.67* (-9.56)
Coupon	6.52* (10.63)	8.29* (14.2)	6.14* (9.98)	23.65* (51.14)	20.17* (43.53)	23.64* (50.86)	31.46* (61.89)	24.85* (61.47)	31.88* (77.66)
Bond volatility	57.82* (12.74)	55.75* (12.94)	60.3* (12.92)	0.03* (3.18)	0.03* (3.19)	0.029* (3.08)	0.03* (3.24)	0.03* (3.31)	0.029* (3.1)
Rating	22.8* (25.26)	19.96* (23.21)	22.57* (24.87)	160.86* (90.12)	136.93* (72.75)	167.12* (94.54)	64.87* (61.89)	53.16* (51.81)	68.53* (62.22)
Callable	-1.99 (-1.8)	-4.91* (-4.63)	-1.86 (-1.66)	-16.25* (-13.78)	-14.19* (-12.2)	-16.65* (-14.05)	-12.05* (-11.66)	-10.9* (-10.95)	-12.29* (-11.79)

Term Slope	-7.74* (-3.54)	-6.99* (-3.37)	-7.22* (-3.28)	-26.05* (-11.14)	-27.61* (-11.99)	-24.64* (-10.48)	-30.31* (-14.68)	-29.85* (-15.02)	-28.81* -13.83)
Difference Eurodollar Rate	-16.82* (-2.32)	-16.18* (-2.35)	-18.21* (-2.49)	116.57* (14.66)	106.16* (13.552	113.93* (14.26)	67.4* (9.67)	60.74* (9.05)	63.52* 9.03)
T note Rate	-1.15 (-0.78)	-1.74 (-1.25)	-0.62 (-0.42)	-12.05* (-8.04)	-13.58* (-9.19)	-10.57* (-7.03)	-9.13* (-6.84)	-11.23* (-8.74)	-7.17* (-5.32)
Equity Volatility	1.95* (20.32)	1.78* (19.52)	2.02* (20.94)	4.22* (65.86)	4.19* (66.33)	4.26* (66.25)	4.8* (80.8)	4.53* (78.83)	4.92* (82.06)
Adjusted R-Sq	0.4375	**0.4936**	0.4312	0.5508	**0.5643**	0.5462	50.74	**0.5433**	0.498

Panel B: Model Comparison

Regression model: $Yield\ \text{spread}_{it} = \alpha + \beta_l L_{it}\ (or\ \beta_c Credit\ \text{risk})$

B1: Single Variable (Liquidity or Rating)

Independent variable	Log Amihud	Amihud ‡	%Spread	%Zero	Spread	only rating
-2 times Log Likelihood	639825.8	639831.7	635673.7	623370.5	637473.6	608577
BIC (smaller is better)	10.463	10.463	10.395	**10.19**	10.42	9.95

Regression model: $Yield\ \text{spread}_{it} = \alpha + \beta_l L_{it} + \beta_c Credit\ \text{risk}$

B2: Liquidity and Rating

Liquidity Measure	Log Amihud	Amihud‡	%Spread	%Zero	Spread
-2 times Log Likelihood	608463.8	608559.6	607517.4	606365.4	608185.2
BIC (smaller is better)	9.9499	9.95	9.934	**9.916**	9.945

Regression model:

$$Yield\ spread_{it} = \alpha + \beta_l L_{it} + \beta_{tax} Tax + \beta_c Credit\ risk + \sum_i \beta_m Macroecomic\ \text{var}iables_{it} + \beta_t TERM_{it} + \sum_i \beta_f Firm\ characters + \sum_i \beta_b Other\ bond\ characteristics_{it} + u_t$$

B3: Liquidity, Rating and other Specifications

Liquidity Measure	Log Amihud	Amihud ‡	%Spread	%Zero	Spread
-2 times Log Likelihood	571979.2	571948.9	571545.2	569841.4	571959.6
BIC (smaller is better)	9.353	9.353	9.346	**9.318**	9.353

"Amihud‡" is the Amihud illiquidity factor $\times 10^9$

Table 5.7-A: Regress Bid-ask Spread on Trading-Based Liquidity Measures

The table reports validation tests of trading-based liquidity measures; the models are as follows,

$$Bid-ask\ spread_{it} = \alpha + \beta_l Trading-based\ liquidity\ \text{var}iables_{it} + u_t$$

$$Bid-ask\ spread_{it} = \alpha + \beta_l Trading-based\ liquidity\ \text{var}iables_{it} + \beta_c Credit\ risk + \beta_m Maturity + \beta_a Age + \beta_o Amout\ outs\text{tan}ding + \beta_v Bond\ volatility + \sum_i \beta_b Other\ bond\ characteristics_{it} + u_t$$

Coefficients and t-values in the parenthesis are shown in the table. "*" indicate the coefficients are significantly different from zero at least 1% significance level.

Model	**M 1**		**M2**		**M 3**		**M 4**		**M5**	
Intercept	0.44* (266.5)	0.38 * (11.4)	0.45* (236.7)	0.4* (11.86)	0.46* (194.8)	0.32* (9.66)	0.97* (38.4)	0.54* (14.83)	1.08* (35.39)	0.61* (15.4)
Turn Over‡	0.01 (0.83)	-0.03* (-2.71)								
Day Frequency			-0.002* (-7.58)	0.001* (5.05)						
Trade Size(MM)					-0.02* (-9.54)	-0.05* (-21.05)				
Trading Volume							-0.02* -(21)	-0.014* (-11.21)		
Dollar Volume									-0.02* (-20.87)	-0.014* (-11.4)
Life		0.013* (65.22)		0.013* (65.08)		0.014* (68.06)		0.013* (65.54)		0.013* (65.44)
Bond Age		0.011 (21.36)		0.011* (21.89)		0.009* (16.62)		0.009* (15.82)		0.009* (16.12)
Log (Amount)		-0.02* (-12.25)		-0.02* (-12.82)		-0.02* (-9.61)		-0.01* (-6.54)		-0.01* (-6.44)
**Bond Volatility		-0.008 (-0.23)		-0.008 (-0.24)		-0.013 (-0.37)		-0.008 (-0.25)		-0.009 (-0.26)
Credit Rating		0.14* (44.78)		0.14* (44.78)		0.15* (46.44)		0.14* (45.89)		0.14* (45.84)
Callable		0.011* (2.95)		0.013 (3.49)		0.017* (4.45)		0.04 (2.43)		0.009 (2.44)
Adjusted R-square	0.0001	0.1229	0.0009	0.1232	0.0015	0.1292	0.007	0.1246	0.0071	0.1247

** Bond Volatility equals to standard deviation of yield spread$\times 10^{-3}$; ‡ Turn Over is value of turnover $\times 10^{-3}$.

Table 5.7-B: Yield Spread and Trading-Based Liquidity Measures

The table displays regression results of trading-based liquidity measures. The regressions are based on models below,

$$Yield\ spread_{it} = \alpha + \beta_l Trading-based\ liquidity\ \text{variables}_{it} + u_t$$

$$Yield\ spread_{it} = \alpha + \beta_l Trading-based\ liquidity\ \text{variables}_{it} + \beta_c Credit\ risk + \beta_m Maturity + \beta_a Age + \beta_a Amout\ outstanding + \beta_v Bond\ volatility + \sum_i \beta\ Other\ bond\ characteristics_{it} + u_t$$

The sample is more than 2900 bonds with 61423 months during 07/2002 to 03/2007. Coefficient estimators and t values in parenthesis are presented. "M1" means the model 1, and so on so forth. Coefficients marked with an asterisk are significant to at least the 1% level; "†" indicates the 10% significance level.

Model	M1	M2	M3	M4	M5	M6	M7	M8
Intercept	63.92 * (5.12)	192.15* (15.86)	17.87 (1.48)	-140.9* (-10.5)	-146.98* (-10.17)	4099.21* (113.73)	4424.04* (131.02)	2875.58* (92.78)
Turn Over	-0.025* (-5.29)					0.012† (2.35)	-0.05* (-11.36)	-0.006 (-1.47)
Day Freq		4.73* (60.25)				0.57* (5.76)	1.11* (12.44)	1.85* (22.05)
Trade Size (MM)			-36.8* (-39.59)			-17.46* (-14.52)	-36.29* (-32.4)	-29.86* -29.36)
Trading Volume				15* (33.5)		868.57* (125.56)	957.46* (140.61)	670.24* (113.7)
Dollar Volume					11.41* (25.42)	-865.4* (-124.26)	-930.36* (-136.8)	-666.7* (-112.3)
Life	1.826* (25.22)	1.91* (27.2)	2.38* (32.67)	1.69* (23.5)	1.71* (23.73)		2.42* (33.93)	
Bond Age	0.179 (0.95)	1.07* (5.79)	-1.38* (-7.24)	2.78* (13.7)	2.07* (10.26)		13.26* (64.31)	
Log (amount)	-12.27* (-20.70)	-20.2* (-34.7)	-9.13* (-15.83)	-19.96* (-31.8)	-18.01* (-28.6)		-35.36* -56.93)	
Bond Volatility	0.076* (6)	0.075* (6.11)	0.073* (5.8)	0.077* (6.12)	0.077 (6.09)		0.068* (5.55)	
Credit Rating	161.9* (141)	161.2* (144.6)	165.3* (145)	157.5* (137.5)	158.9* 138.34)			151.77* (163.27)
Callable	-2.87† (-2.05)	5.74* (4.19)	1.05 (0.76)	-0.45 (-0.32)	-1.06 (-0.76)		76.6* (61.07)	
Adjusted R-square	0.3146	0.3532	0.3317	0.3269	0.3216	0.2205	0.3597	0.4585