# Liquidity and Liquidity Risk in the Corporate Bond Market[1]

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This draft: April 07, 2008

[1] The authors thank Satheesh Aradhyula, Ed Dyl, Alfonso Flores-Lagunes, Chris Lamoureux, Dong Wook Lee, Bill Maxwell, Andriy Shkilko, participants at the 2007 Conference on the Theories and Practices of Securities and Financial Markets, the 2007 Conference on Asia-Pacific Financial Markets, the 2007 FMA Meeting, the 2007 NFA Meeting, the 2007 China International Conference in Finance, and seminar participants at the Chiang Mai University Business School, the University of Rhode Island, and the MIT Finance and Economics Lunch Seminar for helpful comments and discussions. We are particularly grateful to Jean Helwege for her extremely valuable suggestions. Jacoby thanks the Social Sciences and Humanities Research Council of Canada for financial support. Any errors are our responsibility.
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**Liquidity and Liquidity Risk in the Corporate Bond Market**

This paper examines the effect of liquidity and liquidity risk on corporate bond prices using the newly formed TRACE data set. In the spirit of Acharya and Pedersen's (2005) liquidity-adjusted capital asset pricing model, we examine the impact of multiple sources of risk on corporate bond prices using three illiquidity measures, variants of the Amihud (2002) measure. The results lend support for the existence of liquidity risk in the corporate bond market. More illiquid portfolios have higher values for the three liquidity betas; betas that capture the commonality in liquidity with the market, the sensitivity in returns with the market-wide liquidity, and the liquidity sensitivity with the market returns. Furthermore, after running cross-sectional regressions we find evidence that liquidity risk is priced in the corporate bond market.

## 1. Introduction

The role of liquidity in asset pricing has attracted considerable attention in recent years. Liquidity risk is used by researchers to account for the portion of market prices that is unexplained by existing pricing models. In the bond literature, it has long been acknowledged that credit risk alone cannot capture the level of corporate bond yield spreads, and thus liquidity has been introduced to explain this so-called "credit spread puzzle". Investors demand a liquidity premium for holding illiquid securities, such as corporate bonds, thus increasing the level of spreads beyond what is explained by default risk (Elton et al., 2001).

There is strong evidence indicating that liquidity impacts asset returns due to either individual security characteristics (see Amihud, 2002; Amihud and Mendelson, 1986, 1989; Brennan and Subrahmanyam, 1996; Brennan et al., 1998; and Chen et al., 2007) or as a systematic risk factor (see Pastor and Stambaugh, 2003; and Sadka, 2006). Acharya and Pedersen (2005), motivated by previous empirical findings, present an equilibrium model with liquidity risk. Their Liquidity-Adjusted Capital Asset Pricing Model (LCAPM) captures multiple components of liquidity risk.[3] They show that their model is supported by U.S. stock market data, while Lee (2005) finds support of the model using international stock market data.

Most research in the asset pricing and liquidity literature has focused on the U.S. equity market. This is not surprising, given the availability of accessible and reliable high-frequency equity data. More recent work in this area explores the impact of liquidity on corporate bond prices. Since the corporate bond market is substantially less liquid than the equity or Treasury markets, it provides a natural setting to examine the impact of liquidity on asset prices.

This paper extends the application of the LCAPM to the corporate bond market and examines the impact of liquidity and liquidity risk on corporate bond prices using the Trade Reporting and Compliance Engine (TRACE) data set. To our knowledge, this is the first paper to demonstrate the impact of all sources of liquidity risk as advocated by Acharya and Pedersen's LCAPM (together with liquidity costs) on pricing in the

[3] Jacoby et al. (2000) present a static version of the LCAPM.

corporate bond market.[4] TRACE was introduced recently by the National Association of Securities Dealers (NASD) in an effort to make the corporate bond market more transparent. An important advantage of this data set, compared to previous sources of bond data, is that it is much more comprehensive; the TRACE sample utilized in this study includes all transactions by NASD members on all eligible bonds, and covers the period from January 1, 2003 to December 31, 2006. Issue- and issuer-specific variables are then obtained from the Fixed Investment and Securities Database (FISD).

Our results show that liquidity risk is priced in the corporate bond market. Illiquid corporate bond portfolios in our sample earn higher expected excess returns than liquid portfolios. Similar to Acharya and Pedersen's (2005) results for equity, we find that liquidity risk increases with illiquidity for corporate bonds. After estimating liquidity betas for the sampled bonds in the spirit of Acharya and Pedersen (2005), we show that illiquid portfolios have higher liquidity covariation with market liquidity, higher return covariation with market liquidity, and higher liquidity covariation with market returns.

The remainder of the paper is organized as follows. Section 2 discusses the relevant literature, both theoretical and empirical. Section 3 describes the data used in this study, the construction of expected bond returns, as well as the liquidity measure. Section 4 presents briefly the LCAPM. Section 5 describes the empirical methodology and findings. Summary and conclusions are offered in Section 6.

## 2. Related Literature

The early work on the impact of liquidity on equity pricing focuses on the effect of the individual asset's liquidity on its market price. For example, Amihud and Mendelson (1986, 1989) show that the level of bid-ask spreads are positively and significantly related to the expected return on a stock. Brennan and Subrahmanyam (1996) and Brennan et al. (1998) reexamine the relationship between return and illiquidity using

[4] Downing et al. (2005) examine how Pastor and Stambaugh's market liquidity-return beta is priced in the corporate bond market, but do not address the impact of the other sources of liquidity risk. De Jong and Driessen (2007) measure the impact of market liquidity-return beta employing systematic liquidity measures from the equity and Treasury bond market, rather than from the corporate bond market.

transactions data and find a significant and negative relation between trading volume and expected returns, after controlling for other traditional sources of risk (the Fama and French, 1993; and Connor and Korajczyk, 1998 factors). Chordia et al. (2001) look at the effect of both the level as well as the volatility of trading activity. Surprisingly, their findings indicate that the second moment of liquidity has a significant negative impact on equity returns.

Recent work has explored other liquidity-related sources of risk. Chordia et al. (2000), Hasbrouck and Seppi (2001), and Huberman and Halka (2001) document the existance of commonality in liquidity. That is, there is significant comovement of individual asset's liquidity with market-wide liquidity. Motivated by the above studies, Pastor and Stambaugh (2003) find that this comonality in liquidity is a systematic risk factor that is priced in the equity market. Furthermore, Amihud (2002) shows that illiquidity comoves with contemporaneous returns and it also predicts future returns.

Theoretical work in this area aims at incorporating liquidity risk into the traditional asset pricing theory. Jacoby, Fowler, and Gottesman (2000) develop a CAPM-based asset-pricing model that accounts for uncertain transaction costs. They show that the true measure of systematic risk is based on net after-spread returns. Holmstrom and Tirole (2001) develop a model where the corporate demand for liquidity is impacting asset pricing. Motivated by previous empirical findings, Acharya and Pedersen (2005) derive the LCAPM, where they decompose liquidity risk into three sources of risk: (1) the covariance of individual stock liquidity with market-wide liquidity (commonality in liquidity); (2) the covariance of individual stock return with market-wide liquidity; and (3) the covariance of individual stock liquidity with market returns.[5]

Liquidity is also used to address pricing anomalies in fixed-income markets. For example, Sarig and Warga (1989) employ liquidity considerations to explain the price discrepancies between two alternative government bond data sets. Warga (1992), Krishnamurthy (2002), and Goldreich et al. (2003) attribute the yield differential between on-the-run and off-the-run Treasuries to liquidity differences. Amihud and Mendelson (1991) and Kamara (1994) use a liquidity argument to explain the yield spread between,

[5] It can be shown that Jacoby, Fowler, and Gottesman’s (2000) model is a static version of Acharya and Pedersen’s (2005) LCAPM.

otherwise identical, Treasury notes and the more liquid Treasury bills with the same time remaining to maturity.[6]

Exisitng theoretical corporate-bond pricing models produce yield spreads that are consistently lower than observed spreads. Eom et al. (2003) and Huang and Huang (2003) show that traditional credit-risk models, whether structural models (such as Merton, 1974; Geske, 1977; Leland, 1994, 1998; Longstaff and Schwartz, 1995; and Leland and Toft, 1996) or reduced-form models (such as Jarrow and Turnbull, 1995; and Duffie and Singleton, 1999) cannot fully explain the level of corporate bond yield spreads. Elton et al. (2001) and Delianedis and Geske (2001) analyze the components of yield spreads and show that default and recovery risk alone cannot explain the level of these spreads. Collin-Dufresne et al. (2001) investigate the determinants of credit spread changes and conclude that only about one-quarter of the variation in credit spreads is attributed to factors suggested by theory. They also find that residuals from their regression for the determinants of yield spread changes are highly cross-correlated, and are mostly driven by a common factor.

Based on the above empirical findings, liquidity and differential taxation between Treasury and corporate bond issues are the primary candidates to serve as the main determinants of corporate bond yield spreads (excluding credit risk).[7] There is indeed substantial evidence which indicates that corporate bond prices reflect a premia for illiquidity (see Perraudin and Taylor, 2003; Houweling et al., 2005; and Chen et al., 2007).[8] Cossin and Lu (2004) and Longstaff et al. (2005) use information from credit-default swap (CDS) data to decompose the corporate bond spreads into default and nondefault components. They find evidence that the nondefault component is strongly related to bond-specific illiquidity measures. In a related study, Tang and Yan (2006) examine the effect of liquidity on CDS spreads as well as the spillover on those spreads

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[6] Longstaff (2004) also uses liquidity to explain the yield spread between REFCORP (a U.S. government agency) bonds and comparable Treasury issues. Boudoukh and Whitelaw (1993) address the large price differentials of identical Japanese bonds, using liquidity considerations. Elton and Green (1998) utilize trading volume as a proxy for liquidity, and find evidence of a liquidity effect on the pricing of Treasury bills, notes, and bonds. Liu, Longstaff, and Mandell (2004) find evidence of a liquidity premium in interest rate swap spreads.

[7] A recent paper by Ericsson and Renault (2006) develops a structural bond pricing model that incorporates both credit and liquidity risk.

[8] Hund and Lesmond (2006) extend these studies and examine the impact of liquidity on emerging bond markets (corporate and sovereign).

from other markets. Chen et al. (2005) use CDS data to show that the interaction of default and liquidity risk affects the term structure of credit spreads.[9] Nashikkar et al. (2007) using a new measure of liquidity, known as "latent liquidity", examine whether this measure is related to the basis between the credit default swap (CDS) price of an issuer and the par-equivalent corporate bond yield spread. This "latent measure" is defined as the weighted average turnover of funds holding the bond, where the weights are their fractional holdings of the bond.

The current paper is unique with respect to the extant literature in that it demonstrates that liquidity *risk*, in the context of the LCAPM, is priced in the corporate bond market. Previous research focused more on the pricing of liquidity *per se* (see Chen et al. (2007)), or on a *single* source of liquidity risk (see Downing et al. (2005), De Jong and Driessen (2007)).

## 3. Data and Liquidity Measures

### *A. Bond Data*

We extract corporate bond data from the TRACE system, which was established by the National Association of Securities Dealers (NASD) on July 1, 2002. In an effort to increase post-trade transparency for corporate bonds, the NASD requires all of its members to report in a relatively short-period of time all transactions on bonds that are eligible under the TRACE system. Thus, TRACE became the real-time price dissemination service for the NASD over-the-counter corporate bond market. It now provides information on 100% of the activity in this market, that constitutes over 99% of the total activity in the U.S. corporate bond market.[10]

The dissemination of trade information occurred in phases. Phase I included the dissemination of public transaction information for 550 investment-grade securities with an original issue size of at least $1 billion, as well as 50 high-yield bonds that were

[9] Covitz and Downing (2007) investigate the determinants of very short corporate yield spreads and conclude that credit risk is more important than liquidity risk in explaining these spreads.

[10] Real-time data is available for a fee at *https://www.nasdtrace.com*, while publicly disseminated data is available (on a delayed basis) at *http://www.nasdbondinfo.com* as well as through the Wharton Research Data Services (WRDS).

disseminated under the Fixed Income Pricing System (FIPS). Phase II started on March 3, 2003, with the dissemination of transactions on additional investment-grade securities with a rating of A3/A- or higher and at least $100 million in par value issued. Thus the number of bonds under dissemination has increased to 4,200. In April of 2003, another 120 Baa/BBB rated bonds were added. Phase III started on October 1, 2004 and was fully implemented by February 7, 2005, with the dissemination of information on 99% of all public transactions and 95% of par value for the TRACE-eligible securities. This includes the universe of corporate bonds which constitutes approximately 29,000 bonds. The majority of the transaction information is disseminated immediately upon receipt, with the exception of transactions on certain infrequently traded non-investment grade securities. However, since January 9th, 2006, information on all transactions in TRACE-eligible securities is now disseminated immediately.[11]

At the initiation of TRACE, the original time allowance for reporting a trade was 75 minutes, it was then reduced to 45 minutes on October 1, 2003, further reduced to 30 minutes on October 1, 2004, and finally, since July 1, 2005, the time allowance to report a trade was cut to 15 minutes. However according to a press release on February 7th, 2005, found on the NASD's website, by the end of 2004, 82% of transactions were reported in five minutes or less. Furthermore, the majority of transactions are by retail investors. According to the Corporate Bond Market Panel report published on September 30, 2004, 65% of all corporate bond market transactions are in quantities of $100,000 or less, a size representing individual-investor activity.

The time span of the sample that we utilize in this study covers the January 1, 2003 to December 31, 2006 period. We decided to exclude the six-month period from July 1, 2002 to December 31, 2002, since this was the starting period of TRACE that included only a very small part of the corporate bond market. The information provided by TRACE includes transaction dates and times, prices, and quantities traded.[12] As mentioned earlier, advantages of using this database compared to other sources of bond

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[11] Further information regarding TRACE can be obtained through the TRACE Fact Book that is found on the official TRACE website, *http://www.nasd.com/RegulatorySystems/TRACE/index.htm*.

[12] Information reported to TRACE but not yet disseminated includes indicators for whether it's a buy or sell by the customer; inter-dealer trades; whether the broker-dealer reporting the transaction is acting as agent or principal; and the identification of the dealer and the counterparty.

data, is that it is much more comprehensive. Furthermore, it provides actual transaction prices rather than algorithmically determined "matrix" prices. This data set is then merged with the Fixed Investment Securities Database (FISD) to obtain issue- and issuer-specific variables.

After placing a number of restrictions on the type of bonds to be included, our final sample includes 4,577,001 transactions from 1,502 unique issues. Appendix A details our screening procedure. To get a better sense of the number of observations as well as the level of spreads and expected returns, we group the transactions by year, credit rating, type of market (high-yield or investment-grade), industry (industrial, financial, utility), and maturity.[13]

Table I reports the number of transactions, issues, and issuers, by year, credit rating, industry, and maturity. Panel A shows that the bulk of the observations, issues, and issuers traded are in years 2005 and 2006. Furthermore, there are more transactions or issues per month for the above years. This is due to the different phases in the requirement for the dissemination of trade information, which imply that more bonds enter the sample at each phase. As we pointed out earlier, by February 7, 2005 Phase III of TRACE was fully implemented. Interestingly, the last column of Panel A indicates that, on average, a bond traded 51 times per month in 2003, whereas this number decreases in later years. We believe that this is because originally TRACE included only investment-grade bonds with a very large issue size. These are considered more liquid and trade more frequently than issues with a smaller size (see Alexander et al., 2000). Gradually smaller and less liquid issues became subject to dissemination.

Across credit ratings, Panel B reports that the bulk of the observations are on bonds with an A rating. Approximately 78% of the sample falls under the investment-grade category, and the rest under the high-yield market. The bulk of the observations are in the A-rating category (47%) and BBB (23%). The last column of Panel B indicates that the highest frequency of transactions occurs for CCC-rated issues, while the lowest frequency is for AA-rated issues. Specifically, an issue in the CCC and AA rating categories trade, on average, 151 and 34 times per month during our sample period,

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

respectively. Furthermore, high-yield issues trade, on average, more frequently than investment-grade issues; 87 transactions per issue per month for the high-yield sector, compared to only 36 transactions for the investment-grade market. The above findings are consistent with Alexander et al. (2000), who find that high-yield bonds reported on Fixed Icome Pricing System trade fairly frequent.

Across industries, Panel C of Table I reports that the bulk of the observations, issues, and issuers are in the industrial sector, followed by the financial and utility sectors. Furthermore, the last column of Panel C indicates that, on average, there are more transactions per issue per month on bonds that fall under the industrial sector, followed again by the financial and utility sectors. Finally, Panel D reports that across maturity, most of the observations are on bonds with short (zero to seven years) time remaining to maturity (62% of the sample), followed by medium (seven to fifteen years) and long-term (fifteen to thirty years). A very small portion of the sample (1%) represents bonds with more than 30 years remaining to maturity. The last column of Panel D indicates that, on average, there are more transactions per issue for medium-term bonds, compared to short-term bonds or long-term bonds. Specifically, a medium-term issue trades on average 49 times per month, compared to 39 and 34 times for a short- and long-term issue, respectively.

Table II reports statistics on selected bond characteristics for our sample. The average issue size is $250 million, whereas the largest issue size is $3 billion. Furthermore, the majority of the sample is medium-size issues (between $50 million and $500 million dollars), whereas small- and large-size issues constitute only a small part of the sample (around 10% each).[14] In terms of original maturity, the average is 14 years, whereas the maximum is 100 years. For years remaining to maturity, the average is approximately 7.92 years while the median is 4.89. These numbers are consistent with Table I, where the majority of the transactions are on bonds with a short- or medium-time remaining to maturity. The mean and median age of the bonds in the sample (time that elapsed since the bond started earning interest) is 5.53 and 4.85 years, respectively.

For trade size and daily volume, Table II reports that the numbers are highly

[14] Small-size issues are issues of less than $50 million, while large-size issues are more than $500 million. For the sake of brevity these results are not reported in the table.

skewed. The average trade size is $440,000, while the median is only $25,000. Also, the average daily volume per issue is $2.22 million, while the median is only $200,000. The skewness in the above characteristics is due to the fact that the majority of trades are by retail investors.[15] The largest trade size is $5 million, while the largest daily volume is approximately $435 million. The average number of daily trades for an issue is 4.3, while the largest number of trades reported for a specific issue is 1,452. Finally, the mean of the average days between trades is 4.07, while the median is only 1. The skewness exhibited in this bond characteristic is consistent with the findings of Goldstein et al. (2007). They argue that dealers might have incentives to keep low inventory positions in illiquid bonds, and thus sell bonds quickly as soon as they are bought from a customer. In general, the above findings on bond characteristics are fairly consistent with those reported by Downing et al. (2005).

*B. Construction of Expected Bond Returns*

To proxy for expected excess bond returns, we use two proxies: yield spreads, and a second measure that subtracts an expected default loss rate and expected tax compensation component from the yield spread. To be more precice, we first calculate the yield to maturity and then compute the corporate bond spread which is defined as the difference between the bond's yield to maturity and the interpolated yield to maturity of the benchmark U.S. Treasury. For the benchmark Treasuries, we use linear interpolation to obtain estimates of the yield curve from the Federal Reserve's Constant Maturity Treasury (CMT) daily series.[16]

For our second measure, we use a methodology along the lines of Campello et al.

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[15] We experimented with screening all trades that are less than $100,000, however this procedure reduces substantially our sample (about 2/3rds of the original sample is removed). Note also that the trade and volume figures represent the par value volume of the reported trade. Furthermore, if the par value of the trade is greater than $1 million (for the HY sector) and $5 million (for the IG sector), TRACE truncates those values.

[16] From the information provided by the CMT daily series, we do not use the 7-year yield since it is not auctioned anymore. Furthermore, beginning February 18, 2002, the Treasury ceased publication of the 30-year CMT yield. Instead, they provide an extrapolation factor that can be added to the 20-year yield, to get the 30-year yield. We use this extrapolation factor. The 30-year CMT yield was reintroduced on February 9, 2006. For any observation above the 30-year level, we compute the spread based on the extrapolated 30-year yield.

(2007) to construct expected excess bond returns as follows:

$$R^i_{Bt} - r^f_t = YS_{it} - EDL_{it} - ETC_{it}, \qquad (1)$$

where $R^i_{Bt}$ is the expected bond return, $r^f_t$ is the risk-free rate, $YS_{it}$ is the yield spread (or expected bond excess return if there is no change in the bond yield), $EDL_{it}$ is the expected default loss rate (accounts for the fact that default events decrease the bond value), and $ETC_{it}$ is the expected tax compensation (accounts for the fact that Treasury bondholders are exempt from state and local taxes). Given the improvement that this measure has over yield spreads, it will serve as our main measure of expected excess bond returns. Appendix B provides a detailed explanation of the empirical procedure.[17]

Table III reports average corporate bond yield spreads (Panel A) and expected excess bond returns (Panel B), stratified by year, for all credit ratings as well as for all industry sectors. As expected, yield spreads increase with credit risk. Specifically, average spreads are 109 and 521 basis points (bp) for the investment-grade and high-yield market, respectively. Similarly, expected excess bond returns are 83 and 343 bp for the investment-grade and high-yield market, respectively. The same pattern can be observed as the rating level decreases from AAA to the high-yield ratings. Across industries, the utility sector has the highest spreads or expected excess returns, followed by the industrial and financial sectors. Table III further reports average yield spreads (Panel C) and expected excess returns (Panel D), stratified by maturity, for all credit ratings as well as for all industry sectors. As we expect, spreads and expected excess bond returns increase, on average, with time remaining to maturity. This is generally the case also for investment-grade bonds and bonds issued by industrial and financial companies. However, for high-yield bonds as well as bonds issued by utility companies, the term structure of yield spreads for both variables is either U-shaped or humped shaped.

[17] Similar methodology is used by Elton et al. (2001) and De Jong and Driessen (2007).

*C. Liquidity Measures*

Following Acharya and Pedersen (2005), we measure liquidity costs using three variants of Amihud's (2002) measure for illiquidity (ILLIQ). The first measure follows closely the original Amihud measure, while the other two are used for robustness purposes. Intuitively, Amihud's (2002) ILLIQ captures the price impact of trades. Although liquidity is hard to capture (since it's unobservable), this measure has been widely accepted as a good *proxy* of liquidity, and has been applied to both equity and bond markets. Intuitively, this measure tells us that an asset is illiquid if the price moves substantially given a small change in volume. It is also closely related to other measures of liquidity that have been applied in the past in the liquidity/microstructure literature (such as price impact of trade, Amivest measure, etc.).

The first measure, $ILLIQ^1$, is calculated as follows:

$$ILLIQ^1_{i,t} = \frac{1}{N_{i,t}} \sum_{j=1}^{N_{i,t}} \frac{|(P_{i,t,j} - P_{i,t,j-1}) / P_{i,t,j-1}|}{Volume_{i,t,j}} \tag{2}$$

where $P_{i,t,j}$ and $P_{i,t,j-1}$ represent the price for bond *i* for transaction *j* and *j-1* during week *t*, respectively. $Volume_{i,t,j}$ is the total amount traded for this bond during the same week, and $N_{i,t}$ represents the total number of trades for bond *i* during week *t*. Obviously, to construct this measure there has to be at least two trades for a specific issue during the week.

The second measure, $ILLIQ^2$, is a variant of the above and is given as follows:

$$ILLIQ^2_{i,t} = \frac{St.\,Dev.\ of\ \mathrm{Pr}ices_{i,t}}{Volume_{i,t}} \tag{3}$$

where $St.\,Dev.\ of\ \mathrm{Pr}ices_{i,t}$ is the price volatility for bond *i* during week *t*. The third illiquidity measure we use, $ILLIQ^3$, is also based on Amihud's (2002) illiquidity measure and is computed in the following way:

$$ILLIQ_{i,t}^{2} = \frac{(P_{i,t}^{max} - P_{i,t}^{min})/P_{i,t}^{median}}{Volume_{i,t}} \tag{4}$$

where $P_{i,t}^{max}$, $P_{i,t}^{min}$, and $P_{i,t}^{median}$ represent the maximum, minimum, and median prices for bond *i* during week *t*.[18] Note again that for the above two measures, we restrict our sample so that a specific issue must have at least five observations in a given week to be included. Although this screening eliminates some observations, it's used in order to get a meaningful measure of price volatility during a given week.

As one may expect, the correlation between the three illiquidity measures is very high. We calculate this correlation in two ways. First, we calculate a time-series average of the correlation between the three measures, and then obtain the cross-sectional average for the sample. The second way to calculate the correlation is to first compute a cross-sectional average correlation for every trading week, and then a time-series average for all trading weeks. Table IV reports the correlation results based on the above two methodologies. As expected, all the measures are highly correlated (especially between $ILLIQ^2$ and $ILLIQ^3$). The correlation of our main measure, $ILLIQ^1$, with the other two is around 0.50.

## 4. The LCAPM

Acharya and Pedersen (2005) propose a liquidity-adjusted capital asset pricing model (LCAPM) to capture various components of liquidity risk. The LCAPM adds three liquidity betas, $\beta^{L1}$, $\beta^{L2}$, *and* $\beta^{L3}$, to the traditional market beta, $\beta$. The conditional version of LCAPM can be represented by the following equation:

$$E_t(r_{t+1}^{i} - c_{t+1}^{i}) = r^f + \lambda_t \frac{cov_t(r_{t+1}^{i} - c_{t+1}^{i}, r_{t+1}^{M} - c_{t+1}^{M})}{var_t(r_{t+1}^{M} - c_{t+1}^{M})}, \tag{5}$$

[18] All measures are scaled accordingly for presentation purposes.

where $r_t^i$ is the gross return on asset *i* at time *t*, $r^f$ is the gross risk-free rate, $r_t^M$ is the market return at time *t*, $c_t^i$ is the relative illiquidity cost for asset *i*, $c_t^M$ is the aggregate market illiquidity cost, and $\lambda_t = E_t(r_{t+1}^M - c_{t+1}^M - r^f)$ is the risk premium. Based on the assumption of constant conditional variance of innovations in illiquidity and returns (since illiquidity is persistent), the unconditional version of the model can be written as:

$$E(r_t^i) - r_t^f = E(c_t^i) + \lambda(\beta^i + \beta^{i,L1} - \beta^{i,L2} - \beta^{i,L3}), \qquad (6)$$

where

$$\beta^i = \frac{cov(r_t^i, r_t^M - E_{t-1}(r_t^M))}{var(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}, \qquad (7)$$

$$\beta^{i,L1} = \frac{cov(c_t^i - E_{t-1}(c_t^i), c_t^M - E_{t-1}(c_t^M))}{var(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}, \qquad (8)$$

$$\beta^{i,L2} = \frac{cov(r_t^i, c_t^M - E_{t-1}(c_t^M))}{var(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}, \qquad (9)$$

and

$$\beta^{i,L3} = \frac{cov(c_t^i - E_{t-1}(c_t^i), r_t^M - E_{t-1}(r_t^M))}{var(r_t^M - E_{t-1}(r_t^M) - [c_t^M - E_{t-1}(c_t^M)])}. \qquad (10)$$

Equation (6) states that the required excess return is composed of the following terms:

(1) The relative illiquidity cost, $E(c_t^i)$.[19]

(2) A component that is due to the covariation of individual asset return with the market

[19] The way in which illiquidity costs affect required returns is originally demonstrated by Amihud and Mendelson (1986, 1989), and then later by a number of other researchers.

return, i.e. the standard market beta, $\beta^{i}$ .

(3) A component that arises due to the covariation of individual asset liquidity with market liquidity, $\beta^{i,L1}$. It captures the commonality in liquidity (See Chordia et al., 2000; Hasbrouck and Seppi, 2001; and Huberman and Halka, 2001)] This risk factor is expected to load positively with the expected excess returns, since investors need to be compensated for holding stocks whose liquidity drops when the market liquidity diminishes.

(4) A component that arises due to the covariation of individual asset returns with marketwide illiquidity, $\beta^{i,L2}$ (See Pastor and Stambaugh, 2003; and Sadka, 2006). Investors are willing to accept low returns on an asset that provides high returns during periods of market illiquidity. Thus, this risk factor is expected to load negatively with required excess returns.

(5) The final component of expected excess returns arises due to the covariance of individual asset illiquidity with market returns, $\beta^{i,L3}$. It is also expected to load negatively as investors are willing to accept lower returns on assets that are liquid in a down market.

## 5. Empirical Methodology and Findings

The following empirical procedure is based on that applied by Acharya and Pedersen (2005):

(i) We first construct portfolios to be used as test assets in our analysis, sorted on maturity, credit rating, and illiquidity. This grouping helps reduce the noise that is embedded in tests on individual assets. We also construct market-wide portfolios. We then compute the return and illiquidity measures of each portfolio for each trading week.

(ii) Due to the documented persistence in liquidity, we form innovations in illiquidity, $c_t^p - E_{t-1}(c_t^p)$, for each portfolio.

(iii) We then estimate the liquidity betas using the illiquidity innovations and returns.

(iv) We run cross-sectional regressions using a GMM framework to test the fit of the

LCAPM.

### *A. Portfolio Formation*

The return on each portfolio (test and market portfolios) in week $t$ is computed as follows:

$$r_t^p = \sum_i w_t^{ip} r_t^i, \tag{11}$$

where $i$ represents bond issues that are allocated to portfolio $p$ in week $t$, and $w_t^{ip}$ are equal-weights. Table V reports characteristics of portfolios formed after sorting using the three illiquidity measures. The results are for both our two measures of expected excess returns (results for yield spreads are in parentheses). For the most part, the expected excess returns increase monotonically with illiquidity, as expected. This is true also for the standard deviation of returns. All illiquid portfolios exhibit a high degree of persistence. Furthermore, the return difference between the most and least illiquid portfolio is statistically significant at the 1% level. The above patterns can be seen for both our measures of excess returns. These results suggest that liquidity is priced and investors require higher expected returns in order to hold illiquid corporate bonds. However, more tests are needed to arrive to such a conclusion.[20]

Table VI reports characteristics of portfolios sorted on maturity, credit rating, and illiquidity. Panel A represents five equal-weighted bond portfolios sorted every week on time remaining to maturity. The first quintile is the portfolio that includes bonds with the shortest time to maturity, while the fifth quintile includes bonds with the longest term to maturity. Average expected excess returns seem to increase as time to maturity increases.

[20] To check the robustness of these results, we consider three other measures of liquidity in addition to the *ILLIQ* measures. These are *trading frequency* (number of transactions), *dollar trading volume*, as well as *turnover*. In general, the results of these three additional measures when used in the tests applied in this paper are not always in agreement with the results using the *ILLIQ* and *ILLIQ* measures. However, all of the above three measures are highly correlated with volatility in the markets that can cause them to wrongly predict the liquidity level for an asset/market. For example, during liquidity crises we usually observe "*flight to quality and liquidity*" episodes where investors are getting out of risky securities and move to the safety of Treasury bonds. Although trading can pick up during these periods, these are considered "illiquid" times as documented by the price impact of the trades.

Furthermore, all portfolios exhibit high persistence in returns, indicative by the high degree of first-order autocorrelation. The difference in returns between the longest and shortest maturity portfolios is 31 bp (30bp if we use spreads), and is significant at the 1% level.

Panel B of Table VI reports characteristics for portfolios sorted on credit rating. As we move from the AAA-rated portfolio to lower credit ratings, returns increase monotonically, a probable outcome of the higher credit risk of lower-rated bonds. All portfolios exhibit high persistence in returns, while the difference in returns between the junk- and AAA-rated portfolios is 216 bp (368bp for spreads) and significant at the 1% level.

Test assets are also constructed by sorting bonds first on maturity and then on illiquidity, as well as on credit rating and then on illiquidity. Panels C and D report portfolio characteristics for these test assets, using $ILLIQ^1$ as the illiquidity measure; Panels E and F report the same characteristics using $ILLIQ^2$, while Panels G and H report the results using $ILLIQ^3$ as a proxy of illiquidity. The column labeled portfolio 5-1 represents the difference in returns between the most illiquid and least illiquid portfolio, for each maturity and rating class. The results reported are for our main measure of exceess returns.[21]

For the most part, more illiquid portfolios seem to exhibit higher returns than less illiquid portfolios, controlling for either the level of maturity, or credit risk. This is also indicative by the differences between the most and least illiquid portfolios, for every maturity and rating class. In all cases but two (using $ILLIQ^2$), the differences are positive and statistically significant at the 1% level.

*B. Illiquidity & Illiquidity Innovations*

The next step is to compute the illiquidity measures for each portfolio (test and market portfolio). This is done as follows:

[21] Results for yield spreads are quatitavely similar and are not reported here for brevity, but can be provided upon request.

$$c_t^p = \sum_i w_t^{ip} c_t^i, \tag{12}$$

where the index $i$ represents all the bond issues that are allocated to portfolio $p$ in week $t$, $w_t^{ip}$ are equal-weights, and $c_t^i$ is the illiquidity level for each issue during week $t$. As it was pointed out by Acharya and Pedersen (2005), illiquidity is very persistent. This is also the case in the corporate bond market. For that reason, and similar to previous studies (see Pastor and Stambaugh, 2003; and Acharya and Pedersen, 2005), we follow the same approach and form innovations in illiquidity, $c_t^p - E_{t-1}(c_t^p)$, for all test and market portfolios. These innovations are then used to compute all the liquidity betas. To this end, we emloy an AR(2) specification.[22] Specifically, we use the following regression:

$$ILLIQ_t^p = \alpha_0 + \alpha_1 ILLIQ_{t-1}^p + \alpha_2 ILLIQ_{t-2}^p + \varepsilon_t \tag{13}$$

The residual, $\varepsilon_t$, of the above regression is then used as the illiquidity innovation. To demonstrate the results from using innovations, figure 1 exhibits the innovations in market illiquidity for all illiquidity measures, each series scaled by its standard deviation. From the graph, one can see that the innovations now appear stationary. Furthermore, because of the high correlation between the three illiquidity measures, their innovations move together.

*C. Estimation of the LCAPM betas*

The next step is to compute the four betas for all test portfolios, according to Eqs.(7)-(10). To calculate the four betas, we are utilizing the illiquidity innovations of all test portfolios as well as the market portfolio. Furthermore, we are employing an AR(2) specification to calculate innovations in market portfolio returns. Table VII reports descriptive statistics for the five test portfolios sorted on illiquidity (Panel A), as well as

[22] We have experimented with other specifications, such as AR(1) and AR(3), and it seems that neither of them produces a lower correlation of innovations or a better fir of the regression.

for a selected group from the 50 portfolios sorted on maturity and illiquidity (Panel B) and credit rating and illiquidity (Panel C). These statistics include the computed values of the four betas for each test portfolio, as well as the average illiquidity level of each portfolio.

Sections A, B, and C display the results for $ILLIQ^1$, $ILLIQ^2$, and $ILLIQ^3$, respectively, using our main measure of excess returns.[23] Panel A displays the results for five portfolios sorted on illiquidity, whereas panels B and C display descriptive statistics for the most illiquid and least illiquid portfolios for each maturity group and credit rating category, respectively. Observing the first liquidity beta, we can observe that the more illiquid portfolios (that have a higher level of illiquidity, $E(c^p)$) have a higher level of liquidity risk. This is true for all cases, using all our measures of illiquidity. In terms of the second liquidity beta, results are less strong in the sense that we do not observe uniformly that more illiquid portfolios tend to exhibit a higher level of this source of liquidity risk. For the third liquidity beta, we again observe higher levels of liquidity risk for the more illiquid portfolios. These results are fairly consistent with Acharya and Pedersen (2005) where more illiquid equity portfolios have higher level of liquidity risk.

*D. Cross-Sectional Regressions*

In this section we follow the methodology of Acharya and Pedersen (2005) and run cross-sectional regressions for all test portfolios (for all illiquidity measures) using a GMM framework, to test the unconditional version of LCAPM (eq. (6)). Our goal is to observe how liquidity risk as captured by the three liquidity betas, affects expected excess returns. The betas are pre-estimated using Eqs.(7)-(10). Our analysis is done for all illiquidity measures and for our portfolios sorted on illiquidity, maturity and illiquidity, as well as credit rating and illiquidity.[24] The first specification that we examine includes the constraint imposed by the model, that is all the different betas command the same risk premium. Similar to Acharya and Pedersen, we define the net beta as:

[23] Again, results based on yield spreads are not reported here for brevity, but can be provided upon request.
[24] The results reported here are for our main measure of excess returns. The results based on yield spreads are again omitted for brevity but can be provided upon request.

$$\beta^{NET,p} = \beta^{p} + \beta^{L1,p} - \beta^{L2,p} - \beta^{L3,p} \quad (14)$$

Therefore, we have the following specification:

$$E(r_t^p - r_t^f) = \alpha + \gamma E(c_t^p) + \lambda\beta^{NET} \quad (15)$$

Line 1 of Table VIII reports the results for the above specification. Section A, B, and C, represent the results for the three illiquidity measures, while Panels A, B, and C, sort the portfolios based on illiquidity, maturity and illiquidity, and credit rating and illiquidity, respectively. In all cases apart from the portfolios sorted on credit rating and illiquidity using $ILLIQ^1$ and $ILLIQ^3$, the risk premium $\lambda$ is positive and significant at the 1% level (*t*-statistics are in parentheses). This implies that liquidity risk does matter in corporate bonds. One reason why we do not observe this for the rating/illiquidity group might be because the number of observations in the rating buckets are dissproportionate. For example, A and BBB ratings combine for about 70% of our sample, while the AAA rating group contains only 2.4% of the sample. The intercept $\alpha$ in all of our regressions is positive and significant, while the adjusted $R^2$ is substantially lower than what is reported in Acharya and Pedersen (2005). However, this is expected as the CAPM or LCAPM are expected to have more explanatory power for stocks, rather than bonds. The important conclusion that we can derive from the first regression is that liquidity *risk*, captured by the three liquidity betas, affects corporate bonds. In our second specification we run a specification that includes a net liquidity beta, computed as follows:

$$\beta^{L4,p} = \beta^{L1,p} - \beta^{L2,p} - \beta^{L3,p} \quad (16)$$

Line 2 of Table VIII reports the results for the above specification. In all cases but one, the net liquidity beta is positive and significant at the 1% level, reinforcing our previous finding. In the last specification (line 3), we allow each beta to have a different risk premium. That is, we run the following specification:

$$E(r_t^p - r_t^f) = \alpha + \gamma E(c_t^p) + \lambda\beta^p + \lambda^{L1}\beta^{L1,p} + \lambda^{L2}\beta^{L2,p} + \lambda^{L3}\beta^{L3,p} \quad (17)$$

In terms of the first liquidity beta, i.e. the covaration of the individual portfolio's illliquidity with market illiquidity, the risk premium is positive and significant at the 1% level in all but two cases, consistent with our prediction. Investors require a compensation for holding stocks whose liquidity drops when the market liquidity diminishes. This is also the case for the second liquidity beta, i.e. the covariation of the individual portfolio's returns with market illliquidity. In all but two cases, the risk premium is negative and significant at the 1% level. For assets that provide high returns during periods of market illiquidity, investors are willing to accept low returns. However, our results for the third liquidity beta do not conform with our earlier prediction. We expect this liquidity beta to load negatively with the expected excess returns as investors are willing to accept lower returns on assets that are liquid in a down market. However, we observe this in only two out of nine regressions. One plausible explanation is due to the multicollinearity between the liquidity betas, creating difficulties in indentifying their individual effects. This is consistent with the findings of Acharya and Pedersen (2005) for U.S. equity.

Overall the results reported in this paper are supportive of the hypothesis that liquidity risk, as captured by the three liquidity betas of LCAPM, is priced in the corporate bond market.

## 6. Summary and Conclusions

This study examines the effect of liquidity on corporate bond prices in the spirit of Acharya and Pedersen's (2005) Liquidity Adjusted Capital Asset Pricing Model. According to the LCAPM, liquidity risk can affect expected returns in various ways: due to the commonality in liquidity with the market, due to the covariation of individual asset's return with the market liquidity, and lastly, due to the covariation of individual asset's liquidity with market returns. Using a large panel data set of corporate bond market transactions from TRACE that cover the period January 1, 2003 to December 31, 2006, we examine whether these various sources of liquidity risk are priced in corporate bonds.

Our results show that liquidity risk is priced in the U.S. corporate bond market. Illiquid corporate bond portfolios in our sample earn higher expected excess returns than liquid portfolios. Similar to Acharya and Pedersen's (2005) results for U.S. equity, we find that liquidity risk monotonically increases with illiquidity for corporate bonds. After estimating liquidity betas for our constructed portfolios in the spirit of Acharya and Pedersen (2005), we show that, on average, illiquid portfolios have higher illiquidity covariation with market illiquidity, higher return covariation with market illiquidity, and higher illiquidity covariation with market returns. Furthermore, cross-sectional regressions using a GMM framework lend support for the pricing of liquidity risk, captured by the LCAPM betas, in corporate bond prices.

In conclusion, our results provide evidence that liquidity risk matters for corporate bonds. Collin-Dufresne et al. (2001) show that residuals from their regression analysis for the determinants of yield spread changes are driven by a common factor. Given our results that the covariance of bond return/liquidity with market wide return/liquidity (the betas of the LCAPM) are priced in the corporate bond market, one may conclude that the common factor found by Collin-Dufresne et al.'s (2001) is captured by the LCAPM's liquidity risk betas. We leave this research avenue for the future.

**References**


[1] Acharya, V.V. and L.H. Pedersen, 2005, Asset pricing with liquidity risk, *Journal of Financial Economics*, 77, 375-410.

[2] Alexander, G.J., A.K. Edwards, and M.G. Ferri, 2000, The determinants of trading volume of high-yield corporate bonds, *Journal of Financial Markets*, 3, 177-204.

[3] Altman, E. and V. Kishore, 1996, Almost everything you wanted to know about recoveries on defaulted bonds, *Financial Analysts Journal*, reprinted in *High Yield Bonds: Market Structure Portfolio Management and Credit Models*, T. Barnhill and W. Maxwell, editors, McGraw-Hill, 1999.

[4] Amihud, Y., 2002, Illiquidity and stock returns: Cross-section and time-series effects, *Journal of Financial Markets*, 5, 31-56.

[5] Amihud, Y. and H. Mendelson, 1986, Asset pricing and the bid-ask spread, *Journal of Financial Economics*, 17, 223-249. Reprinted in: *Empirical Research in Capital Markets*, G. William Schwert and Clifford W. Smith (eds.), McGraw Hill, 1991; and in *Asset Pricing and Portfolio Performance: Models Strategy and Performance Metrics*, Robert Korajczyk (ed,), Risk Books, 1999.

[6] Amihud, Y. and H. Mendelson, 1989, The effects of beta, bid-ask spread, residual risk and size on stock returns, *Journal of Finance*, 44, 479-486.

[7] Amihud, Y. and H. Mendelson, 1991, Liquidity, maturity, and the yield on U.S. Treasury securities, *Journal of Finance*, 46, 479-486.

[1] Boudoukh, J. and R. Whitelaw, 1993, Liquidity as a choice variable: a lesson from the Japanese government bond market, *Review of Financial Studies*, 6, 265-292.

[8] Brennan, M.J. and A. Subrahmanyam, 1996, Market microstructure and asset pricing: On the compensation for illiquidity in stock returns, *Journal of Financial Economics*, 41, 441-464.

[9] Brennan, T. Chordia, and A. Subrahmanyam, 1998, Alternative factor specifications, security characteristics, and the cross-section of expected stock returns, *Journal of Financial Economics*, 49, 345-373.

[10] Campello, M., L. Chen, and L. Zhang, 2007, Expected returns, yield spreads, and asset pricing tests, *Review of Financial Studies*, forthcoming.

[11] Chen, R., X. Cheng, and L. Wu, 2005, Dynamic interactions between interest rate, credit, and liquidity risks: Theory and evidence from the term structure of credit default swap spreads, Rutgers University, Working Paper.

[12] Chen, L., D. Lesmond, and J. Wei, 2007, Corporate yield spreads and bond liquidity, *Journal of Finance*, 62, 119-149.

[13] Chordia, T., R. Roll, and A. Subrahmanyam, 2000, Commonality in liquidity, *Journal of Financial Economics*, 56, 3-28.

[14] Chordia, T., A. Subrahmanyam, and V.R. Anshuman, 2001, Trading activity and expected stock returns, *Journal of Financial Economics*, 59, 3-32.

[15] Collin-Dufresne, P., R. Goldstein, and S. Martin, 2001, The determinants of credit spread changes, *Journal of Finance*, 56, 2177-2208.

[16] Connor, G. and R. Korajczyk, 1988, Risk and return in an equilibrium APT: Application of a new test methodology, *Journal of Financial Economics*, 48, 255-290.

[17] Cossin, D. and H. Lu, 2004, Are european corporate bond and default swap markets segmented?, Working Paper.

[18] Covitz, D.M. and C. Downing, 2007, Liquidity or credit risk? The determinants of very short-term corporate yield spreads, *Journal of Finance,* 62, 2303-2328.

[19] De Jong, F. and J. Driessen, 2007, Liquidity risk premia in corporate bond markets, University of Amsterdam, Working Paper.

[20] Delianedis, G. and R. Geske, 2001, The components of corporate credit spreads: Default, recovery, tax, jumps, liquidity, and market factors, Working Paper.

[21] Downing, C., S. Underwood, and Y. Xing, 2005, Is liquidity risk priced in the corporate bond market?, Rice University, Working Paper.

[22] Duffie, D. and K. Singleton, 1999, Modeling the term structure of defaultable bonds, *Review of Financial Studies*, 12, 687-720.

[23] Elton, E.J. and T.C. Green, 1998, Tax and liquidity effects in pricing government bonds, *Journal of Finance*, 53, 5, 1533-1562.

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

[25] Eom, Y., J. Helwege, and J. Huang, 2003, Structural models of corporate bond pricing: an empirical analysis, *Review of Financial Studies*, 17, 499-544.

[26] Ericsson, J. and O. Renault, 2006, Liquidity and credit risk, *Journal of Finance*, forthcoming.

[27] Fama, E. and K. French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics*, 33, 3-56.

[28] Geske, R., 1977, The valuation of corporate liabilities as compound options, *Journal of Financial and Quantitative Analysis*, 12, 541-552.

[29] Goldreich, D., B. Hanke, and P. Nath, 2003, The price of future liquidity: Time-varying liquidity in the US Treasury market, *Review of Finance*, 9, 1-32.

[30] Goldstein, M.A., E.S. Hotchkiss, and E.R. Sirri, 2007, Transparency and liquidity: A controlled experiment, *Review of Financial Studies,* 20, 235-273.

[31] Hasbrouck, J. and D. Seppi, 2001, Common factors in prices, order flows and liquidity, *Journal of Financial Economics*, 59, 383-411.

[32] Holmstrom, B. and J. Tirole, 2001, LAPM: A liquidity based asset pricing model, *Journal of Finance*, 56, 1837-1867.

[33] Houweling, P., A. Mentinck, and T. Vorst, 2005, Comparing possible proxies of corporate bond liquidity, *Journal of Banking and Finance*, 29, 1331-1358.

[34] Huang, J. and M. Huang, 2003, How much of the corporate-treasury yield spread is due to credit risk? a new calibration approach, Stanford University, Working Paper.

[35] Huberman, G. and D. Halka, 2001, Systematic liquidity, *Journal of Financial Research*, 24, 161-178.

[36] Hund, J. and D. Lesmond, 2006, Liquidity risk in emerging bond markets, University of Texas - Austin, Working Paper.

[37] Jacoby, G., D.J. Fowler, and A.A. Gotteshman, 2000, The capital asset pricing model and the liquidity effect: A theoretical approach, *Journal of Financial Markets*, 3, 69-81.

[38] Jarrow, R. and S. Turnbull, 1995, Pricing derivatives on financial securities subject to default risk, *Journal of Finance*, 50, 53-85.

[39] Kamara, A., 1994, Liquidity, taxes, and short-term Treasury yields, *Journal of Financial and Quantitative Analysis*, 29, 403-417.

[40] Krishnamurthy, A., 2002, The bond/old bond spread, *Journal of Financial Economics*, 66, 463-506.

[41] Lee, K.H., 2005, The World price of liquidity risk, Korea University, Working Paper.

[42] Leland, H., 1994, Corporate debt value, bond covenants, and optimal capital structure, *Journal of Finance*, 49, 1213-1252.

[43] Leland, H., 1998, Agency costs, risk management, and capital structure, *Journal of Finance*, 53, 1213-1243.

[44] Leland, H. and K. Toft, 1996, Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads, *Journal of Finance*, 51, 987-1019.

[45] Liu, J., F.A. Longstaff, and R.E. Mandell, 2004, The market price of risk in interest rate swaps: the roles of default and liquidity risks, *Journal of Business*, forthcoming.

[46] Longstaff, F.A., 2004, The flight-to-liquidity premium in U.S. Treasury bond prices, *Journal of Business*, 77, 511-526.

[47] Longstaff, F.A., S. Mithal, and E. Neis, 2005, Counterparty yield spreads: default risk or liquidity? new evidence from the credit default swap market, *Journal of Finance*, 60, 2213-2253.

[48] Longstaff, F. and E. Schwartz, 1995, Valuing risky debt: A new approach, *Journal of Finance*, 50, 789-820.

[49] Merton, R., 1974, On the pricing of corporate debt: the risk structure of interest rates, *Journal of Finance*, 29, 449-470.

[50] Nashikkar, A., M. Subrahmanyam, and S. Mahanti, 2007, Latent liquidity and corporate bond yield spreads, Stern School of Business, New York University, Working Paper.

[51] Pastor, L. and R.F. Stambaugh, 2003, Liquidity risk and expected stock returns, *Journal of Political Economy*, 111, 642-685.

[52] Perraudin, W. and A. Taylor, 2003, Liquidity and bond market spreads, Working Paper.

[53] Sadka, R., 2006, Momentum and post-earnings-announcement drift anomalies: The role of liquidity risk, *Journal of Financial Economics*, 80, 309-349.

[54] Sarig, O. and A. Warga, 1989, Bond price and bond market liquidity, *Journal of Financial and Quantitative Analysis*, 24, 367-378.

[55] Tang, D.Y. and H. Yan, 2006, Liquidity and Credit Default Swap Spreads,

Working Paper.

[56] Warga, A. 1992, Bond returns, liquidity, and missing data, *Journal of Financial and Quantitative Analysis*, 27, 605-617.

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

We impose the following restrictions on the type of bonds: (1) we include corporate debentures, corporate issues backed by letter-of-credit, corporate medium-term notes, corporate medium-term note zeros, corporate zeros, and corporate insured debentures; (2) we include only fixed-rate bonds, with a credit rating, from U.S. issuers, with semi-annual coupons; (2) the industry groups include the industrial, financial, and utility sectors; (3) we exclude bonds that are puttable, convertible, perpetual, exchangeable, and have announced calls; and (4) we exclude asset-backed issues, credit enhancements, yankees, canadian, issues denominated in foreign-currency, as well as issues offered globally. A small number of observations are also excluded where spreads or expected excess bond returns turn out to be negative. Furthermore, to eliminate any outliers, we remove observations with spreads that fall in the top and bottom 1% of our sample. These screens reduce the sample to $4,577,001$ transactions.

**Appendix B: Empirical methodology to compute expected excess bond returns.**

Along the lines of Campello et al. (2007), we use the following expression for the expected excess bond returns:

$$R_{Bt}^{i} - r_t^f = YS_{it} - EDL_{it} - ETC_{it}, \quad (18)$$

where

$$EDL_{it} = \pi_{it} * \theta_t / dt, \quad (19)$$

$$ETC_{it} = ((1-\pi_{it}) * \frac{C_i}{B_{it}} \frac{1}{dt} - EDL_{it})\tau, \quad (20)$$

and $R_{Bt}^{i}$ is the expected bond return on bond *i* at time *t*; $r_t^f$ is the risk-free rate; $YS_{it}$ is the bond yield spread; $EDL_{it}$ is the expected default loss rate; and $ETC_{it}$ is the expected tax compensation. $EDL_{it}$ is given by multiplying the default probability, ($\pi_{it}$), by the default loss rate ($\theta_t$) and then scaling by the time period ($dt$ = one year). $ETC_{it}$ is given by first multiplying the probability of survival, (1 - $\pi_{it}$), by the current yield ($C_i / B_{it}$) and scaling by the time period $dt$. Then, the expected default loss, $EDL_{it}$, is subtracted from this term. Finally, the difference obtained is multiplied by the tax rate ($\tau$).

We follow Campello et al. (2007) in constructing the above terms. Starting from the yield spread (excess of bond yield over the treasury yield of similar maturity), we first subtract the expected default loss term. To compute this latter term, we first use the Moody's default reports to compute default probabilities for the years that we examine. These are annual issuer-weighted corporate default rates by alphanumeric rating.[25] Similar to Campello et al. (2007), since default probabilities are time-varying, we use the three-year moving average default probability (from year *t-2* to year *t*) to replace the one-

[25]Corporate Default & Recovery Rates: 1920 - 2006, Moody's Investors Service, February 2007, revised June 27, 2007.

year expected default probability for year t. We then multiply the default probability with the default loss rates ( or 1 - recovery rate) provided by Altman and Kishore (1996) to get the expected default loss rate. The recovery rates provided by these authors for bonds rated by S&P are the following: 68.34% (for AAA bonds), 59.59% (for AA), 60.63% (for A), 49.42% (for BBB), 39.05% (for BB), 37.54% (for B), and 38.02% (for CCC). Similar to previous studies, we assume an equivalence between ratings by S&P and Moody's (Aaa = AAA, Aa2 = AA, A2 = A, Baa = BBB, and so on).

The last term required to compute the expected excess bond return is the expected tax compensation, $ETC_{it}$. Following Elton et al. (2001) and Campello et al. (2007), we use an effective tax differential rate of 4% for all bonds. In computing this term, a very small part of our sample produces a negative value (less than 3%). We replace negative values with a zero value.

# Table I
## Number of Transactions, Issues, and Issuers

We include corporate bonds with a fixed rate, credit rating, from U.S. issuers, with semi-annual coupons, nonputtable, and nonconvertible. We exclude asset-backed securities, credit enhancements, yankees, Canadian, bonds in foreign currencies, issues offered globally, bonds with announced calls, perpetual, exchangeable, and preferred securities. The industry groups include the industrial, financial, and utility sectors.

| **Panel A: No. of trans. by year** | | | **Issues/year** | **Issuers/year** | **No. of trans./month** | **No. of issues/month** | **No. of trans./issue/month** |
|---|---|---|---|---|---|---|---|
| | **N** | **%** | **N** | **N** | **N** | **N** | **N** |
| **2003-2006** | 4,577,001 | 100.0 | 5,673 | 1,502 | 95,354 | 2619 | 40 |
| **2003** | 767,041 | 16.8 | 2,327 | 696 | 63,920 | 1,475 | 51 |
| **2004** | 908,602 | 19.9 | 4,061 | 1,124 | 75,717 | 2073 | 37 |
| **2005** | 1,415,186 | 30.9 | 5,010 | 1,421 | 117,932 | 3602 | 33 |
| **2006** | 1,486,172 | 32.5 | 4,329 | 1,298 | 123,848 | 3328 | 37 |
| **Panel B: No. of trans. by rating** | | | **Issues/rating** | **Issuers/rating** | **No. of trans./month** | **No. of issues/month** | **No. of trans./issue/month** |
| | **N** | **%** | **N** | **N** | **N** | **N** | **N** |
| **AAA** | 112,131 | 2.4 | 151 | 36 | 2,336 | 67 | 36 |
| **AA** | 293,507 | 6.4 | 490 | 112 | 6,115 | 183 | 34 |
| **A** | 2,148,340 | 46.9 | 2,354 | 512 | 44,757 | 1171 | 39 |
| **BBB** | 1,050,027 | 22.9 | 2,409 | 656 | 21,876 | 835 | 41 |
| **BB** | 522,197 | 11.4 | 691 | 241 | 10,879 | 201 | 66 |
| **B** | 339,640 | 7.4 | 458 | 224 | 7,075 | 144 | 100 |
| **CCC** | 99,476 | 2.2 | 130 | 58 | 2,261 | 27 | 151 |
| **Below CCC** | 11,720 | 0.3 | 36 | 16 | 434 | 7 | 55 |
| **Inv-Gr.** | 3,604,006 | 78.7 | 5,045 | 1,163 | 75,083 | 2,252 | 36 |
| **High-Yield** | 972,995 | 21.3 | 1,128 | 439 | 20,271 | 371 | 87 |
| **Panel C: No. of trans. by industry** | | | **Issues/industry** | **Issuers/industry** | **No. of trans./month** | **No. of issues/month** | **No. of trans./issue/month** |
| | **N** | **%** | **N** | **N** | **N** | **N** | **N** |
| **Industrial** | 2,625,902 | 57.4 | 2,846 | 822 | 54,706 | 1359 | 44 |
| **Financial** | 1,518,512 | 33.2 | 1,893 | 411 | 31,636 | 842 | 39 |
| **Utility** | 432,587 | 9.5 | 1,134 | 269 | 9,012 | 419 | 26 |
| **Panel D: No. of trans. by maturity** | | | **Issues/maturity** | **Issuers/maturity** | **No. of trans./month** | **No. of issues/month** | **No. of trans./issue/month** |
| | **N** | **%** | **N** | **N** | **N** | **N** | **N** |
| **Short (0-7 yrs)** | 2,850,511 | 62.3 | 4,121 | 1,338 | 59,386 | 1614 | 39 |
| **Medium (7-15 yrs)** | 947,807 | 20.7 | 1,403 | 776 | 19,746 | 503 | 49 |
| **Long (15 yrs-30 yrs)** | 737,897 | 16.1 | 1,015 | 497 | 15,373 | 468 | 34 |
| **V. Long (30 yrs-onwards)** | 40,786 | 0.9 | 148 | 110 | 868 | 44 | 20 |

## Table II
## Bond Characteristics

We report bond characteristics for the TRACE sample for the period January 1, 2003 to December 31, 2006. These are the issue size (in million of U.S. dollars), the original maturity (in years), the years remaining to maturity, the age of the bond (time that elapsed since the bond started earning interest), the trade size (in thousand of U.S. dollars), the daily volume (in thousand of U.S. dollars), the number of daily trades, and the number of days between trades.

| | Mean | Median | 25% quantile | 75% quantile | Max |
|---|---|---|---|---|---|
| **Issue Size ($million)** | 250 | 200 | 100 | 300 | 3,000 |
| **Original maturity (years)** | 14 | 10 | 9 | 15 | 100 |
| **Years to maturity** | 7.92 | 4.89 | 2.31 | 9.10 | 100.02 |
| **Age (years)** | 5.53 | 4.85 | 2.32 | 8.15 | 69.52 |
| **Trade size ($K)** | 440 | 25 | 10 | 200 | 5000 |
| **Daily volume ($K)** | 1,874 | 200 | 40 | 1,340 | 434,771 |
| **Number of daily trades** | 4.3 | 2.0 | 1.0 | 5.0 | 1452.0 |
| **Days between trades** | 4.07 | 1.00 | 1.00 | 4.00 | 1059.00 |

# Table III
# Average Corporate Bond Spreads and Expected Excess Bond Returns

Using panel data between January 1, 2003 to December 31, 2006, we report corporate bond spreads (in basis points) and expected excess bond returns (in basis points). For the benchmark Treasuries, we use linear interpolation to obtain estimates of the yield curve from the Federal Reserve's Constant Maturity Treasury (CMT) series. We include bonds with a fixed rate, credit rating, from U.S. issuers, with semi-annual coupons, nonputtable, and nonconvertible. We exclude asset-backed securities, credit enhancements, yankees, Canadian, bonds in foreign currencies, issues offered globally, bonds with announced calls, perpetual, exchangeable, and preferred securities. The industry groups include the industrial, financial, and utility sectors.

| | AAA | AA | A | BBB | BB | B | CCC | Below CCC | Inv-Gr. | High Yield | Total Market | Industrial Total | Financial Total | Utility Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Panel A: Breakdown by Year, All Maturities (Spreads)** | | | | | | | | | | | | | |
| **2003-2006** | 66 | 77 | 92 | 159 | 373 | 483 | 1228 | 2170 | 109 | 521 | 197 | 225 | 114 | 317 |
| **2003** | 75 | 92 | 112 | 227 | 548 | 993 | 1683 | N/A | 131 | 969 | 199 | 224 | 103 | 444 |
| **2004** | 64 | 68 | 86 | 152 | 263 | 495 | 1335 | 2419 | 99 | 509 | 139 | 152 | 90 | 263 |
| **2005** | 61 | 71 | 81 | 160 | 384 | 434 | 1310 | 2167 | 110 | 517 | 230 | 254 | 132 | 398 |
| **2006** | 66 | 78 | 89 | 136 | 366 | 413 | 906 | 2156 | 102 | 458 | 200 | 240 | 121 | 205 |
| | **Panel B: Breakdown by Year, All Maturities (Expected Excess Bond Returns)** | | | | | | | | | | | | | |
| **2003-2006** | 46 | 55 | 68 | 126 | 324 | 330 | 476 | 453 | 83 | 343 | 138 | 158 | 89 | 193 |
| **2003** | 54 | 69 | 86 | 181 | 424 | 630 | 553 | N/A | 102 | 553 | 138 | 151 | 77 | 314 |
| **2004** | 44 | 46 | 63 | 109 | 187 | 261 | 558 | 110 | 72 | 185 | 90 | 99 | 64 | 150 |
| **2005** | 41 | 50 | 59 | 132 | 337 | 284 | 579 | 379 | 86 | 349 | 163 | 180 | 107 | 241 |
| **2006** | 44 | 56 | 65 | 108 | 327 | 317 | 258 | 509 | 78 | 322 | 145 | 175 | 96 | 111 |
| | **Panel C: Breakdown by Maturity, 2003-2006 (Spreads)** | | | | | | | | | | | | | |
| **Short (0-7 yrs)** | 63 | 73 | 79 | 141 | 321 | 449 | 1280 | 2163 | 93 | 548 | 179 | 204 | 106 | 382 |
| **Medium (7-15 yrs)** | 505 | 490 | 513 | 582 | 816 | 973 | 1338 | 2625 | 118 | 487 | 215 | 242 | 121 | 307 |
| **Long (15-30 yrs)** | 81 | 103 | 141 | 203 | 455 | 471 | 893 | 2210 | 161 | 478 | 235 | 254 | 196 | 156 |
| **Very Long (30 yrs-onwards)** | 101 | 134 | 149 | 260 | 583 | 351 | 476 | N/A | 185 | 577 | 326 | 353 | 123 | 208 |
| | **Panel D: Breakdown by Maturity, 2003-2006 (Expected Excess Bond Returns)** | | | | | | | | | | | | | |
| **Short (0-7 yrs)** | 43 | 52 | 56 | 96 | 109 | 275 | 527 | 472 | 68 | 318 | 115 | 127 | 81 | 211 |
| **Medium (7-15 yrs)** | 71 | 69 | 96 | 161 | 380 | 541 | 924 | 2196 | 91 | 353 | 160 | 179 | 96 | 220 |
| **Long (15-30 yrs)** | 56 | 78 | 114 | 167 | 404 | 363 | 203 | 361 | 131 | 391 | 192 | 208 | 164 | 117 |
| **Very Long (30 yrs-onwards)** | 76 | 109 | 122 | 220 | 531 | 203 | 1 | N/A | 154 | 523 | 287 | 313 | 98 | 170 |

## Table IV
## Correlation of Bond Illiquidity Measures

We report the correlation between three bond illiquidity measures for the period January 1, 2003 to December 31, 2006; $ILLIQ^1$, $ILLIQ^2$, and $ILLIQ^3$ are all variants of the Amihud (2002) illiquidity measure. $ILLIQ^1$ is calculated by computing first the absolute change in returns for every trade of bond *i* during week *t* divided by the corresponding volume, summing all the ratios together, and then dividing by the number of transactions during the week. $ILLIQ^2$ is calculated by dividing the standard deviation of prices of bond *i* during week *t* with the total amount transacted for the bond during the same week. $ILLIQ^3$ is calculated by first dividing the difference between the maximum and minimum price of bond *i* during week *t* with the median price to get a measure of volatility of prices, and then dividing by the volume transacted during the week. Panel A is constructed by first taking a time-series average of the correlation between any two measures, and then a cross-sectional average for the sample. Panel B on the other hand is first a cross-sectional average for every trading week, and then a time-series average for all trading weeks. p-values are in parentheses.

| | $ILLIQ^1$ | $ILLIQ^2$ | $ILLIQ^3$ |
|---|---|---|---|
| **Panel A : Time-series average, followed by cross-sectional average** | | | |
| $ILLIQ^1$ | 1.00 | | |
| $ILLIQ^2$ | 0.50 | 1.00 | |
| | (<.0001) | | |
| $ILLIQ^3$ | 0.52 | 0.99 | 1.00 |
| | (<.0001) | (<.0001) | |
| **Panel B : Cross-sectional average, followed by time-series average** | | | |
| $ILLIQ^1$ | 1.00 | | |
| $ILLIQ^2$ | 0.47 | 1.00 | |
| | (<.0001) | | |
| $ILLIQ^3$ | 0.50 | 0.98 | 1.00 |
| | (<.0001) | (<.0001) | |

# Table V
# Portfolio Characteristics Sorted on Illiquidity

We report characteristics of equal-weighted portfolios formed each trading week during January 1, 2003 to December 31, 2006, sorted using our three illiquidity measures. Panel A consists of five portfolios sorted on $ILLIQ^1$, panel B of five portfolios sorted on $ILLIQ^2$, and panel C of five portfolios sorted on $ILLIQ^3$. Our main measure of return consists of our proxy of expected excess bond returns, where an expected default loss rate and an expected tax compensation rate are subtracted from the traditional yield spread. The numbers in parentheses refer to our second measure of expected excess bond returns, the traditional yield spread. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

| **Panel A : Portf. Sorted on $ILLIQ^1$** | | | | | **Panel B : Portf. Sorted on $ILLIQ^2$** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sort Order** | **Quintile** | **Mean** | **Std. Dev.** | **Autocorr.** | **Sort Order** | **Quintile** | **Mean** | **Std. Dev.** | **Autocorr.** |
| **Illiquidity** | **1** | 91.54 | 37.00 | 0.91 | **Illiquidity** | **1** | 83.32 | 33.31 | 0.88 |
| **Increasing** | | (132.27) | (48.58) | (0.90) | **Increasing** | | (121.16) | (44.68) | (0.86) |
| | **2** | 80.76 | 22.83 | 0.89 | | **2** | 100.03 | 40.49 | 0.80 |
| | | (117.93) | (32.64) | (0.86) | | | (148.80) | (56.00) | (0.79) |
| | **3** | 85.01 | 26.74 | 0.86 | | **3** | 105.66 | 40.08 | 0.90 |
| | | (123.06) | (41.74) | (0.80) | | | (155.13) | (58.16) | (0.90) |
| | **4** | 110.04 | 45.98 | 0.81 | | **4** | 107.21 | 38.60 | 0.85 |
| | | (155.84) | (69.00) | (0.78) | | | (152.61) | (60.53) | (0.82) |
| | **5** | 146.52 | 51.07 | 0.89 | | **5** | 128.88 | 40.62 | 0.87 |
| | | (194.98) | (67.85) | (0.86) | | | (170.08) | (57.88) | (0.84) |
| **High - Low** | | 54.98 | | | **High - Low** | | 45.56 | | |
| | | (62.71) | | | | | (48.93) | | |
| **t-stat.** | | 36.17*** | | | **t-stat.** | | 27.85*** | | |
| | | (29.58)*** | | | | | (20.46)*** | | |

| **Panel C : Portf. Sorted on $ILLIQ^3$** | | | | |
|---|---|---|---|---|
| **Sort Order** | **Quintile** | **Mean** | **Std. Dev.** | **Autocorr.** |
| **Illiquidity** | **1** | 78.59 | 23.96 | 0.85 |
| **Increasing** | | (113.16) | (29.77) | (0.82) |
| | **2** | 94.69 | 32.44 | 0.73 |
| | | (139.88) | (44.92) | (0.67) |
| | **3** | 106.73 | 44.16 | 0.87 |
| | | (157.51) | (64.95) | (0.85) |
| | **4** | 111.64 | 48.39 | 0.85 |
| | | (160.43) | (78.45) | (0.81) |
| | **5** | 133.38 | 45.34 | 0.84 |
| | | (176.76) | (65.19) | (0.83) |
| **High - Low** | | 54.79 | | |
| | | (63.60) | | |
| **t-stat.** | | 26.41*** | | |
| | | (19.47)*** | | |

# Table VI
# Portfolio Characteristics Sorted on Maturity, Credit Rating, and Illiquidity

We report characteristics of equal-weighted portfolios formed each trading week during January 1, 2003 to December 31, 2006, sorted on maturity, credit rating, and illiquidity. Panel A consists of five portfolios sorted on maturity, panel B of five portfolios sorted on credit rating class, panel C of 25 portfolios sorted on maturity and then on $ILLIQ^1$, and panel D of 25 portfolios sorted on credit rating class and then on $ILLIQ^1$; for panels A and B, the numbers in parentheses represent the results for our second proxy of expected excess bond returns, the traditional yield spread; for panels C and D, the numbers in parentheses represent the standard deviations of the portfolios. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

**Panel A : Portf. Sorted on Maturity**

| Sort Order | Quintile | Mean | Std. Dev. | Autocorr. |
|---|---|---|---|---|
| Maturity | 1 | 131.84 | 38.29 | 0.90 |
| Increasing | | (94.37) | (27.98) | (0.90) |
| | 2 | 123.28 | 57.16 | 0.90 |
| | | (79.93) | (38.02) | (0.90) |
| | 3 | 157.49 | 89.09 | 0.86 |
| | | (105.28) | (62.01) | (0.84) |
| | 4 | 154.36 | 49.75 | 0.91 |
| | | (112.35) | (43.38) | (0.90) |
| | 5 | 162.05 | 37.53 | 0.98 |
| | | (125.78) | (32.93) | (0.90) |
| High - Low | | 31.41 | | |
| | | (30.21) | | |
| t-stat. | | 20.24*** | | |
| | | (14.98)*** | | |

**Panel B : Portf. Sorted on Credit Rating**

| Sort Order | Quintile | Mean | Std. Dev. | Autocorr. |
|---|---|---|---|---|
| Rating | AAA | 57.54 | 23.30 | 0.60 |
| | | (80.04) | (23.49) | (0.60) |
| | AA | 62.84 | 13.64 | 0.62 |
| | | (86.08) | (13.83) | (0.63) |
| | A | 70.55 | 11.88 | 0.92 |
| | | (95.21) | (12.70) | (0.93) |
| | BBB | 110.60 | 36.94 | 0.94 |
| | | (146.91) | (41.48) | (0.94) |
| | JUNK | 273.62 | 101.01 | 0.91 |
| | | (447.94) | (184.56) | (0.94) |
| High - Low | | 216.07 | | |
| | | (367.90) | | |
| t-stat. | | 34.25*** | | |
| | | (30.52)*** | | |

**Panel C : Portf. Sorted on Maturity and $ILLIQ^1$**

| | | Illiquidity Increasing 1 | 2 | 3 | 4 | 5 | Portf. 5 - 1 | t-stat. |
|---|---|---|---|---|---|---|---|---|
| Maturity | 1 | 76.72 | 67.70 | 74.55 | 94.09 | 143.14 | 66.41 | 24.99*** |
| Increasing | | (37.57) | (29.31) | (18.16) | (31.22) | (48.03) | (38.42) | |
| | 2 | 73.89 | 57.17 | 66.31 | 85.64 | 118.29 | 44.39 | 17.99*** |
| | | (45.85) | (31.54) | (46.12) | (61.33) | (49.64) | (35.68) | |
| | 3 | 103.40 | 98.27 | 88.27 | 106.21 | 140.41 | 37.01 | 8.44*** |
| | | (72.41) | (87.59) | (67.07) | (84.51) | (102.66) | (63.40) | |
| | 4 | 105.59 | 106.71 | 101.09 | 117.11 | 143.27 | 37.68 | 7.54*** |
| | | (40.56) | (33.55) | (40.78) | (71.48) | (99.49) | (72.21) | |
| | 5 | 105.34 | 108.05 | 126.78 | 148.48 | 157.49 | 52.16 | 25.57** |
| | | (29.64) | (29.20) | (35.68) | (48.50) | (48.31) | (29.48) | |

**Panel D : Portf. Sorted on Credit Rating and $ILLIQ^1$**

| Rating | Illiquidity Increasing 1 | 2 | 3 | 4 | 5 | Portf. 5 - 1 | t-stat. |
|---|---|---|---|---|---|---|---|
| AAA | 51.42 | 48.52 | 49.87 | 54.53 | 71.80 | 20.39 | 7.33*** |
| | (33.80) | (55.47) | (46.87) | (18.21) | (22.66) | (39.44) | |
| AA | 60.40 | 51.02 | 52.00 | 61.60 | 77.65 | 17.43 | 7.88*** |
| | (26.53) | (20.94) | (19.11) | (17.88) | (21.44) | (31.89) | |
| A | 61.52 | 56.67 | 61.67 | 71.56 | 95.68 | 34.16 | 42.10*** |
| | (14.50) | (12.59) | (13.12) | (15.09) | (11.86) | (11.73) | |
| BBB | 91.67 | 86.13 | 101.28 | 121.97 | 144.82 | 53.15 | 24.24*** |
| | (40.03) | (24.25) | (33.44) | (42.84) | (36.66) | (31.70) | |
| JUNK | 235.40 | 234.31 | 246.76 | 295.15 | 351.29 | 115.89 | 9.78*** |
| | (78.79) | (80.02) | (120.33) | (154.57) | (197.29) | (171.25) | |

# Table VI…Continued

Panel E consists of 25 portfolios sorted on maturity and then on $ILLIQ^2$, panel F of 25 portfolios sorted on credit rating class and then on $ILLIQ^2$, Panel G consists of 25 portfolios sorted on maturity and then on $ILLIQ^3$, panel H of 25 portfolios sorted on credit rating class and then on $ILLIQ^3$; standard deviations of the portfolios are reported in parentheses. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

**Panel E : Portf. Sorted on Maturity and $ILLIQ^2$**

| | | Illiquidity Increasing | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Portf. 5 - 1 | t-stat. |
| Maturity | 1 | 59.55 | 68.46 | 84.20 | 90.07 | 129.57 | 70.03 | 24.10*** |
| Increasing | | (33.49) | (27.12) | (33.18) | (29.29) | (44.37) | (42.01) | |
| | 2 | 65.58 | 85.02 | 83.57 | 82.23 | 94.06 | 28.48 | 6.46*** |
| | | (58.05) | (70.84) | (50.99) | (49.38) | (51.01) | (63.78) | |
| | 3 | 103.82 | 104.63 | 105.60 | 116.16 | 122.10 | 18.27 | 2.69*** |
| | | (121.54) | (64.13) | (46.56) | (111.87) | (113.49) | (98.25) | |
| | 4 | 114.76 | 121.73 | 129.03 | 117.48 | 118.51 | 3.75 | 0.71 |
| | | (74.36) | (54.28) | (64.64) | (58.66) | (47.51) | (76.73) | |
| | 5 | 116.50 | 141.09 | 151.45 | 146.87 | 145.30 | 28.80 | 14.58*** |
| | | (40.92) | (63.07) | (63.01) | (45.62) | (32.61) | (28.55) | |

**Panel F : Portf. Sorted on Credit Rating and $ILLIQ^2$**

| | Illiquidity Increasing | | | | | | |
|---|---|---|---|---|---|---|---|
| Rating | 1 | 2 | 3 | 4 | 5 | Portf. 5 - 1 | t-stat. |
| AAA | 41.30 | 45.40 | 42.97 | 55.18 | 68.08 | 26.78 | 10.30*** |
| | (31.98) | (53.70) | (21.69) | (52.16) | (21.55) | (36.77) | |
| AA | 45.67 | 47.87 | 50.88 | 56.37 | 80.12 | 35.52 | 17.51*** |
| | (21.49) | (17.10) | (19.51) | (19.87) | (25.19) | (28.90) | |
| A | 54.37 | 56.41 | 60.99 | 68.32 | 94.51 | 40.15 | 45.40*** |
| | (14.03) | (12.59) | (13.42) | (14.52) | (13.67) | (12.78) | |
| BBB | 94.01 | 97.38 | 106.91 | 115.91 | 140.69 | 46.68 | 21.77*** |
| | (35.52) | (38.37) | (37.36) | (28.62) | (26.92) | (31.00) | |
| JUNK | 279.59 | 270.18 | 277.40 | 273.64 | 287.99 | 8.40 | 0.99 |
| | (173.35) | (116.82) | (111.72) | (107.08) | (133.34) | (122.59) | |

**Panel G : Portf. Sorted on Maturity and $ILLIQ^3$**

| | | Illiquidity Increasing | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Portf. 5 - 1 | t-stat. |
| Maturity | 1 | 58.12 | 67.10 | 82.68 | 94.70 | 129.44 | 71.32 | 25.79*** |
| Increasing | | (32.78) | (30.39) | (32.10) | (35.85) | (41.40) | (39.98) | |
| | 2 | 58.03 | 79.84 | 91.20 | 81.74 | 98.76 | 40.73 | 13.57*** |
| | | (30.40) | (61.14) | (82.20) | (38.22) | (57.16) | (43.40) | |
| | 3 | 93.31 | 100.86 | 113.44 | 113.31 | 129.96 | 36.65 | 5.17*** |
| | | (86.72) | (71.25) | (70.03) | (90.49) | (125.67) | (102.48) | |
| | 4 | 102.30 | 119.71 | 128.99 | 127.04 | 122.59 | 20.30 | 5.43*** |
| | | (27.33) | (33.40) | (82.24) | (82.10) | (62.56) | (54.04) | |
| | 5 | 108.10 | 132.66 | 156.93 | 152.34 | 151.09 | 42.99 | 22.16*** |
| | | (32.44) | (57.08) | (66.38) | (51.31) | (36.87) | (28.05) | |

**Panel H : Portf. Sorted on Credit Rating and $ILLIQ^3$**

| | Illiquidity Increasing | | | | | | |
|---|---|---|---|---|---|---|---|
| Rating | 1 | 2 | 3 | 4 | 5 | Portf. 5 - 1 | t-stat. |
| AAA | 41.54 | 43.56 | 45.25 | 54.76 | 68.08 | 26.54 | 10.12*** |
| | (31.61) | (33.51) | (47.98) | (51.96) | (21.94) | (37.10) | |
| AA | 46.11 | 48.12 | 50.74 | 56.12 | 79.81 | 34.77 | 16.78*** |
| | (22.51) | (17.97) | (18.35) | (19.46) | (25.23) | (29.52) | |
| A | 54.09 | 56.82 | 60.75 | 68.12 | 129.96 | 40.75 | 48.15*** |
| | (13.31) | (12.58) | (14.03) | (14.77) | (125.67) | (12.23) | |
| BBB | 89.75 | 96.23 | 106.50 | 119.23 | 143.12 | 53.37 | 26.33*** |
| | (31.41) | (36.96) | (38.84) | (33.31) | (27.49) | (29.31) | |
| JUNK | 245.74 | 265.67 | 285.65 | 279.22 | 311.13 | 65.39 | 7.08*** |
| | (109.32) | (127.47) | (155.52) | (98.44) | (158.64) | (133.54) | |

## Table VII
## Descriptive Statistics of Test Portfolios

We report descriptive statistics of the five portfolios sorted on illiquidity (using our three illiquidity measures), as well as for a selected group from the portfolios sorted on maturity and illiquidity and credit rating and illiquidity (for example, in Panel B, portfolio 1, 1 represents the portfolio with the lowest maturity and lowest liquidity/illiquidity level; in Panel C, portfolio AAA, 1 represents the portfolio with a AAA credit rating level and lowest liquidity/illiquidity level). The market beta is represented by $\beta$, while the three liquidity betas are represented by $\beta^{L1}$, $\beta^{L2}$, and $\beta^{L3}$, respectively. All betas are scaled to facilitate presentational purposes. $E(c^P)$ represents the average weekly illiquidity of the test portfolios.

| | Section A: ILLIQ[1] | | | | | Section B: ILLIQ[2] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta$ | $\beta^{L1}$ | $\beta^{L2}$ | $\beta^{L3}$ | $E(c^P)$ | $\beta$ | $\beta^{L1}$ | $\beta^{L2}$ | $\beta^{L3}$ | $E(c^P)$ |
| **Panel A: Portfolios sorted on illiquidity** | | | | | | | | | | |
| **1** | 0.61 | 0.02 | -1.87 | 0.03 | 0.39 | 0.28 | 0.03 | -2.53 | -0.01 | 0.19 |
| **2** | 0.27 | 0.37 | -0.96 | 0.19 | 4.75 | 0.36 | 0.15 | -3.96 | -0.03 | 0.79 |
| **3** | 0.28 | 1.06 | 0.82 | 0.29 | 17.55 | 0.73 | 0.5 | -5.68 | -0.09 | 2.55 |
| **4** | 0.39 | 2.19 | -0.05 | 0.57 | 44.76 | 0.47 | 1.8 | -4.35 | -0.24 | 9.75 |
| **5** | 0.69 | 13.9 | -2.39 | 0.01 | 192.53 | 0.43 | 14.9 | -3.25 | -3.53 | 99.44 |
| **Panel B: Portfolios sorted on maturity and illiquidity** | | | | | | | | | | |
| **1.1** | 0.27 | 0.01 | -0.51 | 0.01 | 0.2 | 0.41 | 0.02 | 1.72 | -0.01 | 0.14 |
| **1.5** | 0.95 | 5.49 | 2.51 | 1.11 | 109.64 | 0.85 | 7.57 | -1.02 | -2.66 | 57.6 |
| **2.1** | 0.64 | -0.01 | -1.68 | 0.06 | 0.58 | 0.87 | 0.03 | -7.35 | 0 | 0.22 |
| **2.5** | 0.88 | 12.56 | -0.35 | 1.06 | 140.49 | 0.27 | 8.5 | -1.53 | -1.91 | 71.92 |
| **3.1** | 1.11 | 0.09 | 1.5 | 0.21 | 1 | 1.09 | 0.05 | -12.16 | -0.01 | 0.23 |
| **3.5** | 1.48 | 11.65 | 0.23 | 3.4 | 165.8 | 1.34 | 9.45 | -17.6 | -1.38 | 69.09 |
| **4.1** | 0.28 | 0.01 | -2.34 | 0 | 0.4 | 0.23 | 0.03 | -3.04 | 0 | 0.15 |
| **4.5** | -0.31 | 9.96 | 1.25 | -0.61 | 167.24 | 0.75 | 8.99 | -3.92 | 0.32 | 67.71 |
| **5.1** | 0.48 | 0.1 | -2.25 | 0.17 | 0.78 | 0.97 | 0.12 | -0.3 | -0.01 | 0.39 |
| **5.5** | 0.65 | 26.25 | -5.62 | -2.09 | 337.02 | 0.52 | 34.05 | 0.47 | -6.62 | 214.3 |
| **Panel C: Portfolios sorted on credit rating and illiquidity** | | | | | | | | | | |
| **AAA,1** | 0.02 | 0.07 | 0.49 | -0.06 | 0.8 | -0.06 | 0.06 | 0.42 | -0.01 | 0.26 |
| **AAA,5** | -0.04 | 25.17 | 2.08 | 5.44 | 201.15 | -0.17 | 15.13 | 2.48 | 4.99 | 135.73 |
| **AA,1** | 0.22 | 0.36 | 1.08 | 5.19 | 0.5 | 0.2 | 0.03 | 2.3 | -0.01 | 0.19 |
| **AA,5** | -0.25 | 3.51 | 1.98 | -3.48 | 163.45 | -0.36 | 19.66 | 4.42 | -7.02 | 95.11 |
| **A,1** | 0.1 | -0.03 | -0.43 | 2.58 | 0.58 | 0.16 | 0.03 | 6.31 | -0.01 | 0.21 |
| **A,5** | 0.1 | 14.06 | 1.81 | -2.05 | 190.11 | -0.1 | 13.34 | 0.66 | -3.18 | 97.47 |
| **BBB,1** | 0.06 | 0.39 | 2.11 | -1.3 | 0.31 | -0.24 | 0.03 | 1.42 | 0 | 0.11 |
| **BBB,5** | 0.24 | 12.68 | 6.91 | 0.86 | 188.38 | -0.04 | 21.46 | 3.16 | -7.07 | 95.38 |
| **JUNK,1** | -0.36 | -0.32 | 3.48 | 0.79 | 0.64 | -0.91 | 0.06 | -8.14 | 0 | 0.27 |
| **JUNK,5** | -0.74 | 13.29 | 26.2 | 2.25 | 172 | -0.77 | 5.12 | -7.86 | 3.57 | 54.73 |

**Table VII…Continued**

**Section C: ILLIQ[3]**

| | $\beta$ | $\beta^{L1}$ | $\beta^{L2}$ | $\beta^{L3}$ | $E(c^p)$ |
|---|---|---|---|---|---|
| **1** | 0.13 | 0.08 | -0.83 | -0.01 | 0.63 |
| **2** | 0.15 | 0.4 | -2.26 | -0.03 | 2.52 |
| **3** | 0.15 | 1.28 | -4.29 | -0.08 | 7.81 |
| **4** | 0.22 | 4.34 | -5.55 | -0.21 | 28.22 |
| **5** | 0.16 | 29.67 | -2.96 | -2.73 | 248.61 |
| **Panel B: Portfolios sorted on maturity and illiquidity** | | | | | |
| **1.1** | 0.26 | 0.04 | 0.69 | -0.01 | 0.43 |
| **1.5** | 0.34 | 13.89 | -0.14 | -1.68 | 142.42 |
| **2.1** | 0.07 | 0.08 | -3.07 | 0.01 | 0.77 |
| **2.5** | 0.26 | 16.6 | -3.38 | -1.25 | 179.88 |
| **3.1** | 0.07 | 0.14 | -4.92 | -0.02 | 0.82 |
| **3.5** | 0.04 | 19.29 | -17.46 | -1.13 | 174.22 |
| **4.1** | -0.07 | 0.1 | 0.28 | 0 | 0.52 |
| **4.5** | 0.34 | 18.32 | -5.53 | 0.26 | 170.33 |
| **5.1** | 0.42 | 0.34 | -1.26 | -0.01 | 1.21 |
| **5.5** | 0.35 | 67.61 | 1.23 | -5.12 | 528.21 |
| **Panel C: Portfolios sorted on credit rating and illiquidity** | | | | | |
| **AAA,1** | -0.02 | 0.12 | 0.37 | -0.01 | 0.88 |
| **AAA,5** | -0.06 | 19.83 | 2.06 | 2.76 | 307.48 |
| **AA,1** | 0.07 | 0.08 | 2.09 | -0.01 | 0.65 |
| **AA,5** | -0.13 | 34.81 | 3.85 | -6.37 | 223.73 |
| **A,1** | 0.05 | 0.07 | 5.3 | -0.01 | 0.7 |
| **A,5** | -0.03 | 26.29 | 0.45 | -2.62 | 240.64 |
| **BBB,1** | -0.09 | 0.07 | 0.99 | 0 | 0.36 |
| **BBB,5** | -0.01 | 39.37 | 2.96 | -4.33 | 238.79 |
| **JUNK,1** | -0.33 | 0.16 | -2.89 | 0 | 0.99 |
| **JUNK,5** | -0.3 | 15.64 | -7.63 | 3.84 | 154.81 |

## Table VIII
## GMM Estimation of LCAPM

We report results from cross-sectional regressions using a GMM framework of the LCAPM using alternative cases of the following equation:

$$E(r_t^p - r_t^f) = \alpha + \gamma E(c_t^p) + \lambda\beta^p + \lambda^{L1}\beta^{L1,p} + \lambda^{L2}\beta^{L2,p} + \lambda^{L3}\beta^{L3,p} + \lambda^{L4}\beta^{L4,p} + \lambda\beta^{NET,p},$$

where $\beta$ represents the market beta, and $\beta^{L1}$, $\beta^{L2}$, and $\beta^{L3}$ represent the three liquidity betas, respectively. $\beta^{L4,p} = \beta^{L1,p} - \beta^{L2,p} - \beta^{L3,p}$, and $\beta^{NET,p} = \beta^p + \beta^{L1,p} - \beta^{L2,p} - \beta^{L3,p}$. The betas are pre-estimated using equations (7) – (10). *t*-statistics are in parentheses. The superscripts ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

**Section A : ILLIQ[1]**

| | Intercept | $E(c^p)$ | $\beta$ | $\beta^{L1}$ | $\beta^{L2}$ | $\beta^{L3}$ | $\beta^{L4}$ | $\beta^{NET}$ | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | **Panel A : Portfolios sorted on illiquidity** | | | | | | | | |
| 1 | 84.61 | -0.03 | | | | | | 3.95 | 0.279 |
| | (57.00)*** | (0.58) | | | | | | (6.37)*** | |
| 2 | 86.05 | -0.04 | | | | | 4.1 | | 0.279 |
| | (59.31)*** | (0.68) | | | | | (6.31)*** | | |
| 3 | 48.74 | -0.41 | 57.93 | 9.32 | -2.45 | 60.89 | | | 0.345 |
| | (15.99)*** | (5.49)*** | (9.31)*** | (8.75)*** | (3.25)*** | (9.76)*** | | | |
| | **Panel B: Portfolios sorted on maturity and illiquidity** | | | | | | | | |
| 1 | 90.56 | 0.14 | | | | | | 1.37 | 0.127 |
| | (97.21)*** | (4.00)*** | | | | | | (4.03)*** | |
| 2 | 90.99 | 0.14 | | | | | 1.30 | | 0.125 |
| | (97.53)*** | (4.19)*** | | | | | (3.76)*** | | |
| 3 | 86.36 | 0.23 | 4.47 | -0.16 | -3.69 | 4.41 | | | 0.139 |
| | (68.77)*** | (3.82)*** | (2.18)** | (0.21) | (8.17)*** | (3.04)*** | | | |
| | **Panel C: Portfolios sorted on credit rating and illiquidity** | | | | | | | | |
| 1 | 60.79 | 0.70 | | | | | | -9.83 | 0.379 |
| | (29.99)*** | (20.04)*** | | | | | | (24.86)*** | |
| 2 | 60.53 | 0.14 | | | | | 1.30 | | 0.369 |
| | (29.29)*** | (19.87)*** | | | | | (24.34)*** | | |
| 3 | 59.42 | 0.11 | -45.79 | -1.58 | 11.31 | 1.21 | | | 0.482 |
| | (27.68)*** | (3.50)*** | (12.68)*** | (4.43)*** | (23.09)*** | (2.74)*** | | | |

# Table VIII…Continued

**Section B : ILLIQ²**

| | Intercept | $E(c^p)$ | $\beta$ | $\beta^{L1}$ | $\beta^{L2}$ | $\beta^{L3}$ | $\beta^{L4}$ | $\beta^{NET}$ | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A : Portfolios sorted on illiquidity** | | | | | | | | | |
| 1 | 70.12 | -0.66 | | | | | | 5.59 | 0.176 |
| | (22.35)*** | (5.17)*** | | | | | | (8.01)*** | |
| 2 | 71.93 | -0.68 | | | | | 5.76 | | 0.176 |
| | (24.04)*** | (5.22)*** | | | | | (7.97)*** | | |
| 3 | 61.65 | -0.63 | -47.59 | 10.33 | -13.3 | 13.43 | | | 0.180 |
| | (14.98)*** | (3.95)*** | (3.65)*** | (3.00)*** | (6.15)*** | (1.01) | | | |
| **Panel B: Portfolios sorted on maturity and illiquidity** | | | | | | | | | |
| 1 | 96.33 | 0.01 | | | | | | 1.05 | 0.024 |
| | (60.34)*** | (0.30) | | | | | | (3.69)*** | |
| 2 | 97.36 | 0.03 | | | | | 0.94 | | 0.023 |
| | (63.74)*** | (0.65) | | | | | (3.37)*** | | |
| 3 | 94.47 | -0.33 | 10.34 | 4.81 | -0.27 | 5.96 | | | 0.050 |
| | (53.81)*** | (4.45)*** | (4.85)*** | (8.48)*** | (0.97) | (4.97)*** | | | |
| **Panel C: Portfolios sorted on credit rating and illiquidity** | | | | | | | | | |
| 1 | 110.02 | -0.19 | | | | | | 2.17 | 0.013 |
| | (45.50)*** | (4.76)*** | | | | | | (9.90)*** | |
| 2 | 108.11 | -0.31 | | | | | 3.37 | | 0.032 |
| | (46.31)*** | (5.74)*** | | | | | (12.67)*** | | |
| 3 | 89.93 | -0.06 | -101.11 | 1.38 | -11.11 | -2.05 | | | 0.484 |
| | (66.61)*** | (1.92)** | (36.62)*** | (4.55)*** | (20.22)*** | (3.54)*** | | | |

**Section C : ILLIQ³**

| | Intercept | $E(c^p)$ | $\beta$ | $\beta^{L1}$ | $\beta^{L2}$ | $\beta^{L3}$ | $\beta^{L4}$ | $\beta^{NET}$ | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A : Portfolios sorted on illiquidity** | | | | | | | | | |
| 1 | 101.84 | -0.11 | | | | | | 2.37 | 0.115 |
| | (30.73)*** | (1.31) | | | | | | (2.84)*** | |
| 2 | 102.14 | -0.11 | | | | | 2.34 | | 0.114 |
| | (29.81)*** | (1.27) | | | | | (2.80)*** | | |
| 3 | 32 | -0.3 | 313.83 | -13.88 | -6.97 | -188.29 | | | 0.230 |
| | (2.38)** | (3.52)*** | (2.97)*** | (3.19)*** | (6.40)*** | (4.25)*** | | | |
| **Panel B: Portfolios sorted on maturity and illiquidity** | | | | | | | | | |
| 1 | 104.53 | -0.04 | | | | | | 1.20 | 0.045 |
| | (72.25)*** | (2.58)*** | | | | | | (9.40)*** | |
| 2 | 104.74 | -0.03 | | | | | 1.18 | | 0.044 |
| | (71.80)*** | (2.38)** | | | | | (9.20)*** | | |
| 3 | 86.00 | -0.14 | 37.08 | 2.86 | -0.77 | 10.97 | | | 0.089 |
| | (52.91)*** | (3.96)*** | (9.70)*** | (8.73)*** | (2.44)*** | (5.47)*** | | | |
| **Panel C: Portfolios sorted on credit rating and illiquidity** | | | | | | | | | |
| 1 | 113.83 | 0.12 | | | | | | -1.25 | 0.008 |
| | (42.89)*** | (4.58)*** | | | | | | (5.30)*** | |
| 2 | 113.2 | 0.10 | | | | | -0.97 | | 0.006 |
| | (42.82)*** | (4.18)*** | | | | | (4.42)*** | | |
| 3 | 83.43 | -0.1 | -242.34 | 2.58 | -11.53 | 5.7 | | | 0.496 |
| | (63.05)*** | (4.40)*** | (26.32)*** | (8.59)*** | (19.25)*** | (4.81)*** | | | |

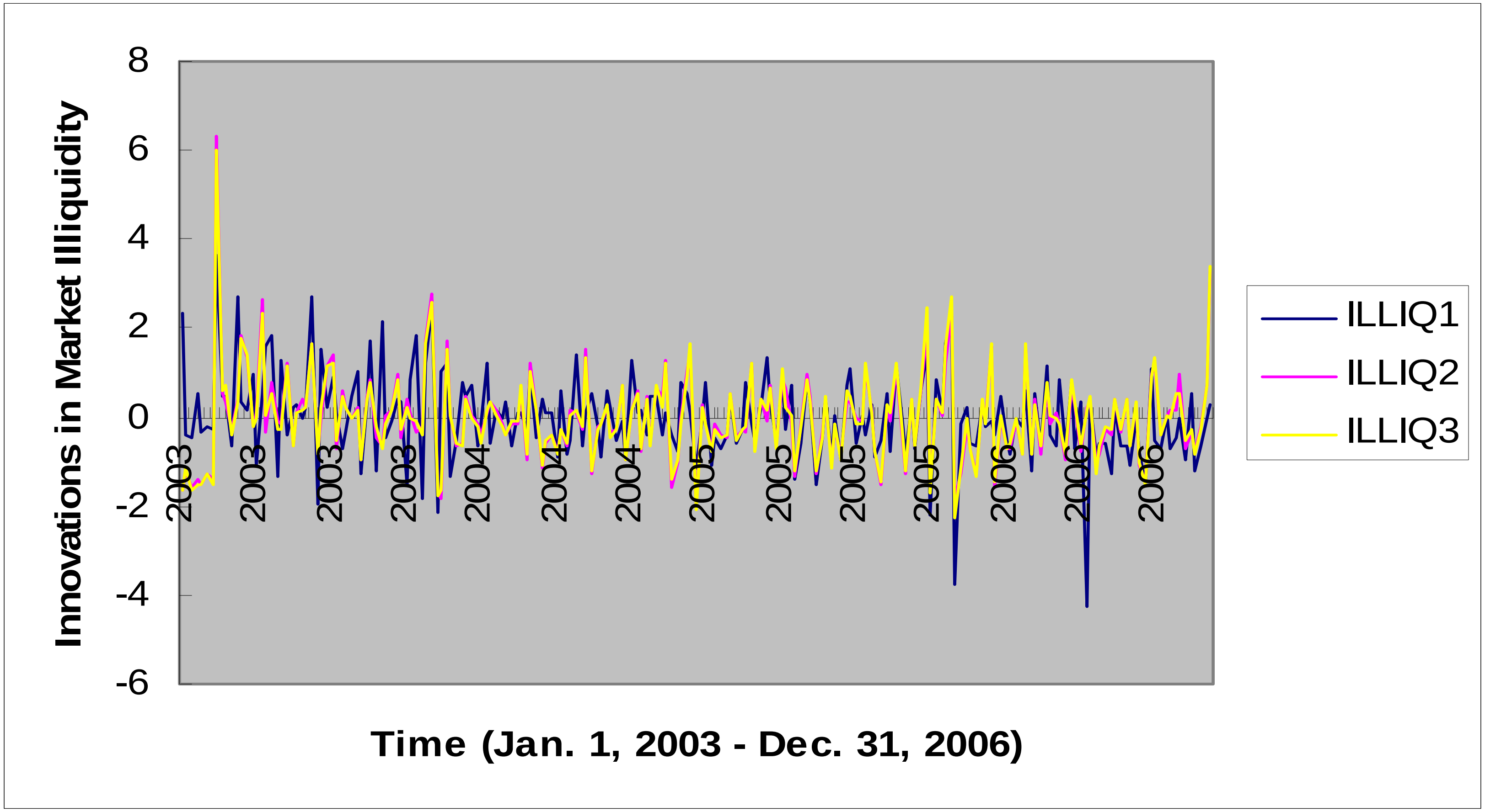


**Figure 1. Standardized innovations of market illiquidity.** This figure shows the standardized weekly innovations of market illiquidity. Illiquidity is measured using $IILIQ^1$, $IILIQ^2$ , and $IILIQ^{3.}$ The innovations are computed using an AR(2) specification.