# Effects of Bond Liquidity on the Nondefault Component of Corporate Bond Spreads: Evidence from Intraday Transactions Data*

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**Abstract**

We examine the relationship between the nondefault component of corporate bond spreads and bond liquidity measures constructed from intraday transactions data, with the default component controlled by the term structure of credit default swaps (CDS) spreads. In doing so, we address both maturity mismatch and coupon effects in the nondefault spreads estimation, and explicitly control for the unobservable firm heterogeneity to identify the liquidity effects through variations both over time and across bonds issued by the same firm. We find a clear positive significant relationship between bond illiquidity and nondefault bond spreads. These liquidity effects identify a unique component of nondefault bond spreads that is uncorrelated with conventional liquidity proxy variables, particularly for higher-rated investment-grade bonds. Furthermore, nondefault bond spreads are relatively high at the short end of the maturity and increase with bond age. The effects of transaction-based bond liquidity measures are robust to alternative model specifications and samplings, and to whether swap or Treasury yield is used as risk-free rate.

JEL Classifications: G12, G13, G14
Key words: Corporate bond spreads, credit default swaps, liquidity

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We examine the relationship between the nondefault component of corporate bond spreads and bond liquidity measures constructed from intraday transactions data, with the default component controlled by the term structure of credit default swaps (CDS) spreads. In doing so, we address both maturity mismatch and coupon effects in the nondefault spreads estimation, and explicitly control for the unobservable firm heterogeneity to identify the liquidity effects through variations both over time and across bonds issued by the same firm. We find a clear positive significant relationship between bond illiquidity and nondefault bond spreads. These liquidity effects identify a unique component of nondefault bond spreads that is uncorrelated with conventional liquidity proxy variables, particularly for higher-rated investment-grade bonds. Furthermore, nondefault bond spreads are relatively high at the short end of the maturity and increase with bond age. The effects of transaction-based bond liquidity measures are robust to alternative model specifications and samplings, and to whether swap or Treasury yield is used as risk-free rate.

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# 1 Introduction

Recent studies suggest that a sizable component of corporate bond spreads cannot be explained by credit risk (Jones, Mason and Rosenfeld, 1984; Elton, Gruber, Agrawal and Mann, 2001; Eom, Helwege and Huang, 2004), especially for higher rated investment grade bonds at the short maturity (Huang and Huang, 2003). Existing empirical work links such nondefault component of the spreads to various measures of bond liquidity (Longstaff, Mithal and Neis, 2005; Ericsson, Reneby and Wang, 2006; Nashikkar and Subrahmanyam, 2006)[1] and suggests that liquidity risk factors may be priced in bond expected returns (see Chacko (2005), de Jong and Driessen (2004), and Downing, Underwood and Xing (2005), among others). In addition, theorists start to incorporate liquidity risk, which may be correlated with credit risk, as one of the driving factors in bond pricing models (see Liu, Longstaff and Mandell (2004) for a reduced-form model and Ericsson and Renault (2006) for a structural model).[2] In this paper, we develop a new methodology to estimate the nondefault component of bond spreads and link it to direct bond liquidity measures constructed from intraday bond transactions data. In doing so, we appropriately control for the unobservable firm heterogeneity that may have biased previous studies.

Most existing empirical studies on bond liquidity effects use bond characteristics such as coupon, size, maturity, and age as indirect proxies for bond liquidity measures. Interpreting the relation between bond spreads and these proxies may be complicated by their correlations with the issuer's credit risk. More importantly, while these proxies may vary across bonds, they are either constant or changing deterministically with the passage of time. Thus, this approach may not identify the effects of stochastic variations in bond liquidity on the nondefault bond spreads. In contrast, we measure bond liquidity using corporate bond intraday transactions data from NASD's Trading Reporting and Compliance Engine, or TRACE. We consider one measure for each of the three types of definitions of liquidity: a measure of price impact of trades based on Amihud (2002), estimated bid-ask spread based on Roll (1984) as a measure of transaction cost, and turnover

[1] See also Chen, Lesmond and Wei (2005), Houweling, Mentink and Vorst (2005), and Perraudin and Taylor (2003) for direct evidence that total bond spreads are partly explained by the cross-sectional proxies for individual bond liquidity.

[2] Alternative explanations of the large nondefault spreads include tax differential, market risk premiums, and jump risk premiums, etc. (Elton et al., 2001; Delianedis and Geske, 2001; Collin-Dufresne, Goldstein and Helwege, 2003; Cremers, Driessen, Maenhout and Weinbaum, 2005), although the magnitudes of these components are still subject to debate.

rate as a measure of trading frequency.[3] Although these measures have been frequently used in studies on stock market liquidity (see, e.g, Amihud and Mendelson (1986), Brennan, Chordia and Subrahmanyam (1998), Hasbrouck and Seppi (2001), Amihud (2002) and Hasbrouck (2005), among others), they only become available more recently for the corporate bond market with the introduction of TRACE in 2001. The TRACE data have already fostered a rapid growth in the research on liquidity issues in the corporate bond market (Downing et al., 2005; Edwards, Harris and Piwowar, 2004; Bessembinder, Maxwell and Venkataraman, 2006; Goldstein, Hotchkiss and Sirri, 2007). We complement the existing literature by examining the effect of *observed* bond trading illiquidity on the nondefault component of bond spreads and provide clear evidence that such an effect is positive and statistically significant.[4]

Following Longstaff et al. (2005), Ericsson et al. (2006), and Nashikkar and Subrahmanyam (2006), we use data on the credit default swap (CDS) spreads to estimate the default component of bond spreads. In a nutshell, a CDS is an insurance contract on credit risk, where the protection seller promises to buy the reference bond at its par value when a pre-defined credit event occurs. In return, the protection buyer makes periodic payments or premiums to the seller until the maturity date of the contract or until the credit event occurs. This periodic payment, usually expressed as a percentage of the notional value of protection, is called "CDS spread". Compared with corporate bond spreads, CDS spreads are a relatively pure pricing of default risk of the underlying entity, abstracting from numerous bond characteristics, such as seniority, coupon rates, embedded options, and guarantees. Thus, using CDS spreads to control for the default component of bond spreads avoids the actual estimation of default probability and recovery rate and associated risk premium, which would typically suffer from potential model misspecification problems. Also, unlike corporate bond spreads, CDS contracts are unfunded and do not face short-sale restrictions, reducing much the liquidity concerns in the CDS market.[5]

[3]We also consider additional measures for each of these three types of liquidity definitions, such as modified Amihud measure, volatility impact of trades, number of days with trades, and number of trades. The general results are similar to what we present here and are available upon request. Earlier papers have also studied bond liquidity effects based on rather limited transaction data sets (Alexander, Edwards and Ferri, 2004; Hong and Warga, 2000; Schultz, 2001; Hotchkiss and Ronen, 2002; Hotchkiss, Warga and Jostova, 2002; Chakravarty and Sarkar, 2003).

[4]Recent studies by Chacko (2005), Chacko, Mahanti and Mallik (2005) and Nashikkar and Subrahmanyam (2006) have advocated an approach of "latent liquidity"—the weighted average turnover of investors who hold a particular bond by their fractional holdings of the amount outstanding—to measure the accessibility of bond to market participants.

[5]Tang and Yan (2007) examines the liquidity effects on CDS premium, arguing that CDS liquidity effects are statistically significant. See also Nashikkar and Subrahmanyam (2006). As discussed later, we use certain proxies,

Our new methodology, however, improves the estimation of nondefault bond spreads in two dimensions. First, unlike previous studies which used only 5-year CDS spreads, we utilize the entire term structure of CDS spreads provided by Markit. Thus, we are able to match exactly the maturities of all bonds and avoid using the conventional "bracket" method in approximating bond yields. Second, we use a nonparametric approach to remove the "coupon effect" that may have biased the existing estimations of nondefault bond spreads. Specifically, based on Duffie (1999) and Duffie and Liu (2001), we approximate the par yield curve for fixed rate coupon bonds using the sum of the CDS term structure and a risk-free term structure.[6] From that, we bootstrap the firm's discount rate curve, which is then used to price the cash flows of all of the firm's senior unsecured bonds. Providing the CDS term structure reflects solely market expectations on credit risk and associated risk premium, the resulting bond yield–or the "CDS implied yield"–equals to the default component of the bond yield with an appropriate adjustment for the bond's cash flow. Thus, this approach removes the well-known coupon effect in yield computations that may have biased previous estimates in an unknown direction.

More importantly, our methodology allows us to better control for the unobservable firm heterogeneity that may have biased previous estimates. In theory, bond liquidity can be intimately related to the issuer's credit risk, firm-wide funding risk, or systematic risks in the economy. These variables may also affect the nondefault bond spreads.[7] Thus when unobservable, they may cause omitted variable biases in the estimation. Contrasting with many existing approaches that select only one bond for each firm at any time, our estimation method allows multiple bonds for each firm at any time. This gives us enough degrees of freedom to apply a fixed-effect approach to control for the cross-firm variations attributed to the unobservable permanent firm characteristics and for the time-series variations caused by macroeconomic conditions. Effectively, the fixed-effect approach uses the variations in our liquidity measures across different bonds issued by the *same firm* to identify the effects of bond liquidity on the nondefault bond spreads.

We find a positive and statistically significant relationship between the illiquidity of intraday trading and the nondefault bond spread. Such an estimated relationship becomes weaker if the

such as the number of CDS quotes and lagged CDS spreads, to explicitly control for CDS liquidity.

[6] Duffie (1999) and Duffie and Liu (2001) show that using CDS spread as a direct measure of the default component may result in a small bias. Longstaff et al. (2005) use an intensity-based model to correct such a bias.

[7] The empirical evidence on the relationship between credit risk and liquidity effect can be mixed (Chen et al., 2005)—some positive (Alexander et al., 2004) and others non-existent (Schultz, 2001).

unobservable firm heterogeneity is not controlled for by the fixed effects, suggesting the existence of unobserved firm heterogeneity which may be correlated with bond liquidity. The point estimates of the liquidity effects are uniformly significant across rating groups for the price impact and trading frequency measures, but those on transaction cost measures are only significant for higher rated investment-grade bonds (rated A- or higher).

Controlling for the conventional proxy variables of bond liquidity, all of our transaction-based liquidity measures remain statistically significant for higher rated investment-grade bonds, though the magnitude on the trading frequency measure becomes smaller; for low rung investment-grade bonds (rated BBB-, BBB, or BBB+), only the price impact and transaction costs measures are significant; for speculative-grade bonds (rated BB+ or lower), none of our transaction-based liquidity measure is significant. This is consistent with our findings that the trading frequency measure is highly collinear with bond characteristics, especially for speculative-grade bonds.

These results suggest that conditional on the predictable changes in bond liquidity associated with bond characteristics, our trading liquidity measures identify a unique component of nondefault bond spreads associated with the stochastic variations in bond liquidity, especially for higher rated investment-grade bonds. In addition, we find that the nondefault component of bond spreads is increasing in bond age and decreasing in remaining bond maturity except for speculative-grade bonds. This result is consistent with the findings of some previous studies that while credit risk can explain most of the yield spread for speculative-grade bonds, a larger fraction (percentage-wise) of investment-grade bond spreads cannot be accounted for by credit risk, especially at the short maturities—the so-called "credit premium puzzle" (e.g., Huang and Huang (2003)).

Finally, we find that the estimated effects of our transaction-based liquidity measures are robust to a number of alternative model specifications, basis estimation methods, and samplings. However, the estimated effects of conventional liquidity proxy variables, especially those of coupon rate, change notably with different risk-free rate measures and whether coupon effect is appropriately adjusted for. Thus, one important implication is that our transaction-based liquidity measures are uncorrelated with the differences in the estimated nondefault bond spreads induced by tax differentials in alternative risk-free rates or by coupon effect (Longstaff et al., 2005). On the other hand, the effects of conventional liquidity proxies may not be separately identifiable from the differential tax effects or coupon effect.

The pronounced positive effects of illiquidity on the nondefault bond spread are consistent with recent studies showing that liquidity is an important pricing factor for corporate bonds (Chen et al., 2005; Downing et al., 2005; Bessembinder et al., 2006; Goldstein et al., 2007; Chacko et al., 2005). It is also consistent with the finding that CDS market usually leads bond market in the short-run price discovery process (Blanco, Brennan and Marsh, 2005; Zhu, 2005).[8] One explanation that the lead-lag studies put forth for such a finding is that the bond market is more illiquid–possibly due to short sale constraints, clientele effects, and higher transaction costs–than the CDS market, thus reacts more slowly to news. Our evidence suggests that this statistical lead-lag relationship has its economic interpretation in that bond trading liquidity does explain the dynamics of the difference between bond spread and CDS premium, or the so-called "basis spread".[9]

The rest of the paper is organized as follows: Section 2 describes data sources and and sampling schemes; Section 3 presents our methodology of estimating the nondefault bond spread and constructing our transaction-based liquidity measures; Section 4 discusses summary statistics; Section 5 presents our main empirical findings; and Section 6 concludes.

## 2 Data Description and Sampling

The key step of our analysis is to estimate the nondefault component of corporate bond spreads and transaction-based bond liquidity measures. This requires data on corporate bond yields, CDS premiums, secondary market bond trades, and risk-free rates. In addition, data on bond characteristics are necessary for such estimations and for appropriate sampling. We obtain these data from a number of sources and merge them using bond CUSIPs and date. Below we describe briefly these data and our sampling method.

### 2.1 Merrill Lynch Bond Price Data

We obtain daily secondary market yields on corporate bonds in the Merrill Lynch Global Bond Index universe. Merrill Lynch provides an effective or option-adjusted yield measure in that the implied values of options written in the debt contracts, such as call or put, are removed in the yield

[8] Although in the long-run, CDS and bond spreads are in line with each other, as predicted by the no-arbitrage relationship (Duffie, 1999).

[9] Note that most existing studies define basis spread as the difference between CDS premium and bond spread–opposite to our definition. Readers should keep this in mind when comparing our results to the literature.

calculations. The prices are bid-side quotes, either indicative or "live" ones, collected from dealers at the close of business days. In addition, the database has limited information on bond characteristics such as bond CUSIP, the amount of face value outstanding, maturity date, a composite rating based on S&P and Moody's ratings, and issuer location.

The composition of the Merrill Lynch database is rebalanced at the end of every month to add new bonds that meet certain criteria and remove those becoming ineligible. Among these criteria, a bond has to have a remaining maturity greater than one year throughout incoming month and have face values outstanding larger than certain limits. Moreover, Merrill's composite bond ratings may only change at the rebalancing at the end of each month.

## 2.2 Markit CDS Premium Data

Data on CDS premiums are obtained from the Markit Partners. Markit provides daily composite quotes, one for each of the four types of restructuring clauses, on CDS contracts with maturities at 6 month, 1, 2, 3, 5, 7, 10, 20, and 30 years. These composite quotes represent the average of the midpoint of bid and ask quotes from a number of major dealers. Markit calculates daily values only for contracts that have quotes from at least three different contributors after outliers and stale quotes are filtered out. We use only quotes corresponding to the modified restructuring clause, which reportedly is the most widely used in the U.S.. Among other information provided by Markit, the data include a variable on the number of contributors that provide quotes on the 5-year CDS contract–the one that is widely believed as the most liquid among all maturities.

## 2.3 TRACE Bond Transaction Data

To compute transaction-based liquidity measures for corporate bonds, we use intraday transactions data provided by NASD's TRACE reporting system. TRACE started to disseminate corporate bond transactions data on July 1, 2002 for a small number of selected bonds; but it gradually expanded to cover almost entire over-the-counter secondary market transactions in corporate bonds. The data contain bond CUSIPs and trading information such as transaction price, trading size, settlement date and time. Appendix A provides more details on the TRACE data.

### 2.4 Data on Bond Characteristics

We combine Bloomberg and Moody's DRS databases to obtain descriptive information on the Merrill Lynch bonds. Information on bond characteristics is crucial for three reasons. First, it allows us to sample only senior unsecured bonds, as most CDS contracts specify that only those bonds can be delivered to the protection-buyer when a credit event occurs. Second, we use bond characteristics such as coupon, issue date, and outstanding when estimating such key variables as CDS implied yields and liquidity measures. Third, previous literature has used certain bond characteristics, such as bond size, age, and remaining maturity, as proxy for bond liquidity. So they will be additional controls in our regression analysis.

Moody's DRS database contains detailed information on the characteristics of corporate bonds ever rated by Moody's, including bond seniority, security, coupon frequency, issue date, and currency denomination. The database, though, has less detailed information on option features written in the bond contracts, with which we use information searched on Bloomberg to complement.

### 2.5 Risk-Free Rates and Macroeconomic Variables

Our main risk-free rate measure is swap rate. While still in debate, it is widely believed that swap rate is the preferred risk-free rate measure for the studies using CDS spreads data (e.g., Houweling and Vorst (2005); Longstaff et al. (2005); Blanco et al. (2005); Zhu (2005)). While Treasury securities are almost truly default free, the Treasury yields may be affected by a number of factors, such as specialness of Treasury securities and taxation.[10] On the other hand, swaps don't have any special tax or regulatory treatment.[11]

For robustness, however, we compare the results with Treasury rate as the risk-free rate to those with swap rate. We are able to calculate both rates for any maturity at any date using the Nelson-Sigel-Svenson coefficients estimated by the Federal Reserve Board (available publicly. See Gurkaynak, Sack, and Wright, 2006).

We use the following conventional variables to measure macroeconomic conditions: the level

[10]For example, lower capital requirements for financial institutions to hold Treasury securities and higher demand for holding Treasury securities to fulfill regulatory requirements may give additional values to Treasuries beyond a pure risk-free instrument (Duffee, 1996; Reinhart and Sack, 2001). In addition, interests earned on Treasury securities are not taxed at the state level, but those on corporate bonds are.

[11]Nonetheless, swap rate may be still a distorted risk-free rate measure because of counterparty credit risk and credit risk in LIBOR rate.

and the slope of Treasury term structure, the return, realized and implied volatility on the S&P 500 index, and Treasury on-the-run premium. These variables are collected from Bloomberg and the Board's public website.

### 2.6 Additional Sampling Criteria

Our sample period is from July 2002 to April 2007. In addition to the sampling restrictions mentioned above, namely using only CDS quotes corresponding to the modified restructuring clause and only senior unsecured bonds, we further impose the following restrictions.

- We keep only U.S. dollar-denominated bonds issued by U.S. firms that pay semi-annual coupons with remaining maturity less than 15 years.
- We delete bonds that are puttable, convertible, defaulted, with floating rate and sink fund features, but keep callable bonds because otherwise, it will reduce the sample by about 60 percent (in bond-months. See Table 1 Line 11).[12]
- To include a reference entity, its CDS quotes must be non-missing at 1- and 10-year maturities and be non-missing at additional two of the four maturities in between (ie., 2-, 3-, 5-, and 7-year).[13] In addition, all CDS quotes are for U.S. dollar-denominated notional values.
- In estimating transaction-based liquidity measures, we follow the practice of existing TRACE-related studies to remove trades with "price errors" (see, e.g., Downing et al. (2005); **?**).[14]

We merge the above datasets using bond CUSIP and date and impose these sampling restrictions. We first compute daily values on all time series variables for each CUSIP and then calculate their monthly average values to form a bond CUSIP-month panel dataset (unbalanced). We choose monthly frequency for our empirical analysis largely because transaction-based liquidity measures may exhibit more extreme variations at higher frequencies as bond tradings are generally sparse.

[12]As mentioned above, Merrill's effective yields are option-adjusted, which mitigates the impact of optionality. Also, we use callability as a control variable in our analysis. Moreover, as shown in Table 13, excluding callable bonds does not change our main conclusions.

[13]Only a small fraction (less than 6 percent) of our final sample have missing values at the 15-year maturity. Excluding them (tables are available upon request) does not affect our results.

[14]Specifically, we delete a trade if the trade size is missing or zero, or if its price is less than $1 or greater than $500, or if price is more than 20 percent away from median price in a day, or if price is more than 20 percent away from previous trading price.

As shown in Panel A of Table 1, our final sample consists of 431 firms–identified by unique Merrill Lynch ticker–with total 1894 bonds–identified by bond CUSIPs, that is, about 4 bonds per firm. On average, each bond appears about 21 months during the total 58 months of our sampling period. In addition, as shown in Panel B of Table 1, the number of available bonds varies significantly by bond rating and, due to the phasing-in approach of TRACE dissemination (discussed in Appendix A), by time periods. Specifically, investment-grade bonds rated BBB and A are by far the most available, and AA and BB-rated bonds come next, with the fewest bonds in the both tails of the rating distribution (i.e., AAA and CCC/below). Still, the number of bonds, especially for the speculative-grade ones, is far greater than those in any of the existing studies. Finally, the number of bonds rated BBB or lower increased substantially since Phase III of TRACE dissemination (which started from October 1, 2004). Overall, comparing to the rating distribution of the entire corporate bond market (not shown), our sample slightly tilts more towards the investment-grade bonds. Two factors contribute this pattern. First, as discussed in Appendix A, TRACE only disseminated transaction data on mostly highly rated investment-grade bonds before the full dissemination phase. Second, there are fewer speculative-grade firms for which the number of CDS quotes on each day meets our sampling restrictions.

# 3 Empirical Methodology

In this section, we describe our new methodology of using the CDS term-structure to estimate the nondefault component of bond spreads. In doing so, we address both maturity mismatch and coupon effect issues. We also describe how we construct transaction-based bond liquidity measures using intraday transactions data.

## 3.1 Estimating Nondefault Bond Spread

Obviously, the key issue of estimating nondefault component of bond spread is to estimate appropriately the default component. Broadly speaking, there are two approaches on the default component estimation: model-based or parametric approach and CDS-based or non-parametric approach. A typical model-based analysis, such as Huang and Huang (2003), first derives some estimates of expected default probability and expected loss given default using historical default and loss data. These estimates are then used as inputs to a corporate bond pricing model, either structural or reduced-form. The bond spread implied by the model is the estimate of the default component of bond spread. The main drawbacks of the model-based approach are that the model may be misspecified and/or that statistical errors in estimating expected default probability and loss given default may be large as historically default events are often sparse and clustered.

The CDS-based approach avoids these potential problems because CDS premiums reflect both market expectations on default probability and loss given default and the associated risk premiums. As shown in Duffie (1999)), under certain conditions, CDS premiums roughly equal to the yield spread on a bond with and only with the same credit risk exposure. Most existing studies use only 5-year CDS premium data, due to both data limitations and the believe that the 5-year CDS contracts are the most liquid (eg., Longstaff et al. (2005); Blanco et al. (2005); Zhu (2005)). Typically, it is rare for a reference entity to have a bond maturing in exactly 5 years. As a result, researchers rely on pricing information on the bonds straddling the 5-year maturity to estimate the yield spread on a hypothetical bond at the 5-year maturity. This may induce an estimation error because the reference entity might have issued a 5-year bond with different terms and the price on the 5-year hypothetical bond might have been different if it were actually traded. In addition, the method does not address the well-known coupon effect in bond yield computations.

We also use CDS data to estimate the default component of bond spread, and our approach addresses both maturity mismatch and coupon effect issues.[15] Our estimation has three steps. First, for each firm on each day, we estimate a CDS implied yield curve by adding swap rates to CDS premiums at observed maturity points and interpolating across maturities. Under certain conditions laid out in Duffie (1999) and assuming swap rate is the appropriate measure of risk-free rate, the resulting curve equals to the par yield curve for floating-rate bonds with the same credit profile. Duffie and Liu (2001) further show that par yields on floating-rate and fixed-rate bonds by the same issuer would differ only very slightly for the usual range of interest rate term structures and term-to-maturities. Thus, we use the resulting curve as a reasonable approximation for the par-yield curve for fixed-rate bonds with the same credit profile. Such approximation is necessary

[15]Other factors such as counterparty credit risk in CDS may also result in biased estimates of the default component of bond spread. The effect of counterparty credit risk on CDS pricing is believed to be small because only highly-rated agents are able to sell default protections and margin requirements are imposed for the issues. We leave more quantitative estimations on this for future research.

because all bonds in our sample pay fixed-rate coupons.

A note on the interpolation is worthwhile. We use the piecewise cubic Hermite interpolating polynomial (PCHIP) algorithm, available in Matlab, to fit the CDS implied yield curve. Importantly, the PCHIP algorithm differs from a regular spline method in that it preserves the shape of the data and respects monotonicity. That is, on intervals where the data are monotonic, so is the interpolated curve; at points where the data have a local extremum, so does the interpolated curve. Therefore, PCHIP does not introduce artificial oscillations between points, which a regular spline algorithm may often do.

Second, we apply the standard bootstrap method to back out a discount rate curve on each day from each firm's CDS implied yield curve. We use the resulting curve to discount cash flows on the firm's senior unsecured fixed-rated bonds. The yield implied by the resulting estimated price is our estimate of the default component of bond yield. Importantly, the actual bond yield and the CDS-implied yield have identical cash flows, so we remove both maturity mismatch and coupon effects. Moreover, our approach implies that on any given period when a firm has multiple bonds meeting our sampling criteria, they are all kept in our final sample. These extra degrees of freedom allow us to apply a fixed effect approach to control for the unobservable firm heterogeneity, which effectively identifies the liquidity effect using variations across bonds by the same issuer.

Finally, the nondefault component of bond spreads are the difference between the actual bond yield and the CDS-implied yield, a term that is also often called "basis spread". Later we compare our basis estimates with those without correcting coupon effects, that is, those with default component read directly from the CDS implied yield curve at the first step. We also compare basis estimates using Treasury rate as the risk-free rate measure.

## 3.2 Constructing Trading Liquidity Measures

Using intraday transactions data, we consider one bond liquidity measure for each of the following three types of liquidity definitions: price impact of trades, transaction cost, and trading frequency.

### 3.2.1 Amihud Measure as Price Impact of Trades

Bond liquidity may manifest through price impact of trades or market depth (Kyle, 1985). One of the frequently-used price impact measures is proposed by Amihud (2002) for stock markets. To adopt this measure for corporate bonds, we defined the Amihud measure as the ratio of the absolute percentage change in bond price to the dollar size of a trade (in million dollars). That is, for each day $t$ and bond $i$, we define

$$\text{Amihud}_t^i = \frac{1}{N_t^i} \sum_{j=1}^{N_t^i} \frac{\frac{|p_{j,t}^i - p_{j-1,t}^i|}{p_{j-1,t}^i}}{Q_{j,t}^i},$$

where $p_{j,t}^i$ (in \$ per \$100 par) and $Q_{j,t}^i$ (in \$ million) are the transaction price and the size of the trade, respectively.

Amihud measure is an illiquidity measure in that larger values suggest more illiquid bonds, as it indicates a trade of a given size would move prices more. By construction, daily Amihud measures are nonmissing only for bonds traded at least twice on the day.

### 3.2.2 Estimated Bid-Ask Spread as Transaction Cost

Liquidity is also often defined by transaction costs (eg., Acharya and Pedersen (2005)). A commonly-used transaction costs measure is bid-ask spreads. Unfortunately, our data do not have information on bid-ask quotes or on the side of a transaction initiating the trade–which potentially could be used to trace out effective bid-ask spreads. Instead, we estimate bid-ask spreads using the well-known Roll (1984) model. Under certain assumptions, Roll showed that the effective bid-ask spread equals to the square root of the negative covariance of adjacent price changes. That is,

$$\text{BidAsk}_t^i = 2\sqrt{-\text{Cov}(\tilde{p}_{j,t}^i - \tilde{p}_{j-1,t}^i, \tilde{p}_{j-1,t}^i - \tilde{p}_{j-2,t}^i)},$$

where $\tilde{p}_{j,t}^i = \log p_{j,t}^i$.

The intuition of the Roll model is the following. Assuming informational efficiency and no news on a bond's fundamental values, bond prices should bounce back and forth within the band formed by bid-ask spreads. The price changes for adjacent trades should be negatively correlated because a current bid (ask) is more likely followed by an ask (bid). The extent of this negative correlation depends on the the width of the band. By construction, daily bid-ask spread estimates are nonmissing only for bonds traded at least three times on the day.

### 3.2.3 Turnover Rate as A Measure of Trading Frequency

Bond liquidity may also be reflected in trading frequency. Intuitively, all else equal, bonds that are more illiquid would trade less frequently. Trading frequency measures have been widely used as indicators for asset liquidity (see, e.g., Vayanos (1998) and Lo, Mamaysky and Wang (2004), among others). We consider monthly turnover rate as our trading frequency measure, which is the ratio of total trading volume in a month to the amount of face value outstanding.

# 4 Summary Statistics

Table 2 presents summary statistics of key variables used in this paper. As shown on Line 1, the mean of basis spreads when using swap rate as risk-free rate is $-11$ basis points for the overall sample, but the median is just about $-0.6$ basis point, with an interquartile range of 22 basis points and the 95th-5th percentile range of about 1 percent. The relatively wide range with the small median value suggests that while on average basis spreads don't deviate much from zero, there exist large temporary and/or cross-sectional variations away from zero. As shown in Line 2, such variations are also evident when basis spreads are computed using Treasury rate as risk-free rate, though not surprisingly both mean (28bps) and median (26bps) become positive as Treasury rates are generally lower (on average by about 40 basis points) than swap rates at comparable maturities. Our main goal is to understand whether and to what extent liquidity is a driving force of these variations.

The variations in basis spreads exist both across bonds and over time. Cross-sectionally, we show a selected set of summary statistics by three broad bond rating groups. As indicated by the numbers of bond-months, bonds rated A- or higher account for nearly half of our sample, BBBs for about one third, and speculative-grade for about one sixth. Perhaps surprisingly, BBB bonds have the largest median basis spreads while speculative-grade bonds the lowest. Over time, Figure 1 plots monthly median basis spreads by rating groups with swap rate as the risk-free rate over the sample period. All three series show significant time variations, although the interpretation before Phase III (October 2004) is tricky due to the small sample sizes, especially for speculative-grade bonds (see Panel B of Table 1). Even so, since then, basis spreads for speculative grade bonds lingered just below zero, but basis spreads for investment grade bonds trended above zero.

For comparison, Lines 3 and 4 also show the statistics of basis spreads without correcting coupon effects. On average, correcting coupon effects raises the median basis spreads by slightly over 1 basis point for the overall sample as well as for the A- or higher rated bonds, but less than 1 basis point for BBB-rated bonds, and only a touch for speculative-grade bonds.

The summary statistics on three liquidity measures are reported on Lines 5-7 Table 2. For the overall sample, the median Amihud measure, Line 5, is 0.27, suggesting that a median trade, at about $\$50,000$ (Line 15), would move price by roughly \$1.4 percent. The median estimated bid-ask spread, Line 6, is \$0.86 on a par bond, costly comparing to stock trades. Corporate bonds are traded sparsely as the median monthly turnover rate, Line 7, is merely 0.04, meaning that for the average bonds in our sample, it takes about 25 months to turn over once. In addition, the median number of traded days, Line 13, is 13 days, the median number of trades in a month, Line 14, is 32, and the median monthly trading volume, Line 16, is about \$15 million.

By rating, it appears that BBB bonds are the most liquid by all measures. All rating groups have similar median turnover rates. However, comparison between A- or higher rated and speculative-grade bonds along other two dimensions is mixed, with the former having higher Amihud illiquidity values but lower bid-ask spreads than the latter. Later we will shed lights on these comparisons by associating these liquidity measures to bond characteristics.

Average bond characteristics are shown in Lines 8 to 12 Table 2. For the overall sample, the median bond in a typical month has a coupon rate of 6.2 percent, is just over 3 years since issuance, has slightly over 5 years remaining to maturity, and has \$400 million dollars outstanding. About 60 percent of bonds are callable. Not surprisingly, median coupon rate increases in bond rating. In addition, speculative-grade bonds tend to be smaller, older, and more likely callable, but remaining maturity on BBB bonds is the longest and on A- or higher rated bonds the shortest.

Figure 2 shows the overall sample distributions of bond age, remaining maturity, and maturity at issuance. The number of bonds decreases quickly for those older than 9 years or those with more than 10 years of remaining maturity. These distributions suggest that in interpreting results related to age and remaining term-to-maturity, we have to be cautious about the reliability over the range greater than 10 years. In addition, while there are wide variations in the maturity at issuance, about half of the bonds are issued at around 10 years, with other mass points at 3, 5, 7, 15, 20, and 30 years.

It is interesting to examine unconditionally how basis spreads and our liquidity measures are related to each other and to bond characteristics. Figure 3 plots basis spreads and liquidity measures by 7 finer bond rating groups. Interestingly, median basis spreads appear to be constant for bonds rated A or higher, and then become higher for BBB- and BB-rated bonds and sharply lower for B or lower rated bonds. While basis spreads appear to be negatively correlated with bond turnover rate, as conjectured, they also appear to be negatively correlated with other illiquidity measures, as opposite to common views. In addition, these correlations are mostly driven by observations at deep junk rating groups, where as alerted above, the number of bonds is small.

Figures 4 plots basis spreads and our liquidity measures by bond age. It shows that basis spreads increase very much linearly in age up to 10 years, so does the Amihud measure. The estimated bid-ask spread appears to be uncorrelated with age up to 10 years, but turnover rates decrease in bond age, especially sharply at the short end of the age range. These results suggest that for the most part of the sample (with age less than 10 years), the age-driven correlation between basis spreads and Amihud illiquidity, bid-ask spread, and turnover rate, is positive, zero, and negative, respectively, largely consistent with common views,

Figure 5 plots basis spreads and our liquidity measures by remaining maturity. Interestingly, basis spreads decrease quickly at the short term-to-maturity and remain roughly flat until reaching the tail of the maturity distribution. The pattern at the short maturity confirms unconditionally the findings by previous studies such as Huang and Huang (2003) that credit risk accounts smaller fraction of bond spreads when approaching the shorter end of maturity. Both Amihud measure and the estimated bid-ask spread increase in remaining maturity, while turnover rate does so only up to 10 years and then fell sharply. These results suggest that only the negative maturity-deriven correlation between basis spreads and turnover rate is roughly consistent with common views.

# 5 Regression Results

We now report regression results on the Effects of bond liquidity on the nondefault component of bond spreads. First, we demonstrate the importance of controlling for unobservable firm heterogeneity in obtaining unbiased estimates of the liquidity effect. Second, we show that controlling for liquidity conditions in CDS increases significantly both the model fit and the economic significance of liquidity effects. Third, we test whether our key results are affected by controlling for bond characteristics that are often used in the literature as proxies for bond liquidity. Finally, we present results from a number of analysis for robustness. Unless specified otherwise, basis spreads are the difference between bond yield and the corresponding CDS implied yield with swap rates as risk-free rates. Also note that to reduce the impact of outliers, we windsorize the sample at 5 percent of both basis spreads and liquidity measures used in each regression. In addition, we convert all liquidity measures to log scale in all regressions.

### 5.1 Controlling for Unobservable Firm Heterogeneity

Table 3 reports the results from OLS regressions of basis spreads for samples with all observations (Columns 1-4) and with each of the three broad rating categories (Columns 5-16). For each sample, we first regress basis spreads on each of our three transaction-based liquidity measures, and then on all three measures together. For each regression, we also include dummy variables indicating the month of each observation as controls for macroeconomic conditions. Standard errors of the estimated coefficients are computed using the Huber/White robust method assuming that regression residual terms may be correlated across bonds issued by the same firm but uncorrelated across firms.

The results lend limited support for the liquidity effect on the nondefault bond spreads. Specifically, consistent with the common view, all coefficients on turnover rates are negative and statistically significant at the 95 percent confidence level. However, the Amihud illiquidity measure is positive and marginal significant only for the overall sample when other liquidity measures are also included. Moreover, contrary to the common view, almost all coefficients on the bid-ask spread estimate are negative, though mostly statistically insignificant. The $R^2$ statistics for all regressions appear to be modest: $R^2$ is at most 15 percent for A- or higher rated bonds, 16 percent for BBB bonds, and 9 percent for speculative-grade bonds.

Intuitively, after removing time series variation common to all bonds using time fixed effects, these OLS regressions use total variation–across bonds, firms, and over time–in the liquidity measures to identify the liquidity effect. These estimates may be flawed if there are unobservable firm characteristics that are correlated with both trading liquidity measures and basis spreads. For example, clientele effects among institutional investors associated with different firms may generate liquidity impacts on bond spreads (see, e.g., Chacko et al. (2005)). These unobservable heterogeneity may bias the above OLS estimates in an unpredictable direction.

To address this issue, we add firm fixed effects to each of the above models, where a firm is represented by a unique Merrill Lynch ticker. We now effectively identify the liquidity effect using variations across bonds issued by the same firm. The richness of our data, especially the full term structure of CDS spreads that allows multiple bonds by the same firm at any given time, gives us enough degrees of freedom to estimate these fixed effect models. The results are shown in Table 4.

Overall, controlling for the unobservable firm heterogeneity leads to somewhat stronger support for the liquidity effect on the nondefault bond spread, especially for investment-grade bonds. Specifically, comparing to Table 3, the main change is that the coefficients on the Amihud illiquidity measure become positive and statistically significant at the 95 percent confidence level for the overall sample and the two investment-grade samples. All coefficients on the bid-ask spread estimate and on turnover rate remained negative and statistically significant. The $R^2$ statistics increase about 2 percentage points for the overall sample and the A- or higher rated sample, but decrease somewhat for both BBB and speculative-grade samples.

## 5.2 Controlling for CDS Liquidity

An implicit assumption in using the CDS term structure to estimate the default component of bond spread is that CDS pricing reflects solely credit risk and the associated risk premium. In particular, this requires that the CDS market is perfectly liquid and that CDS pricing is not affected by any liquidity difference between bond and CDS markets. Either condition may not hold in the reality. First, while the CDS market has grown rapidly over the past decade, it is still evolving and its liquidity has been varying over time. Recent studies suggest that the effect of CDS liquidity on CDS spreads may be significant, both statistically and economically (Tang and Yan, 2007). This implies that our CDS-based method may have underestimated the nondefault component of bond spread in the presence of CDS illiquidity. Put it differently, our nondefault bond spread measure would be negatively (positively) correlated with a CDS illiquidity (liquidity) measure. Empirically, this implies that if liquidity conditions in bond and CDS markets are correlated, not controlling for CDS liquidity results in biased estimates on the bond liquidity effects.

Second, any liquidity difference between bond and CDS markets may push CDS pricing away from the pure credit risk pricing. For example, due to the short-selling constraint or higher transaction cost on corporate bonds, investors may rely more on CDS to hedge their exposures. In particular, when the issuer's credit quality deteriorates. investors may put excess buying pressures on CDS in order to insure against possible default, resulting in a CDS spread higher, and our nondefault bond spread measure lower, than what it should be in the absence of any liquidity difference between bond and CDS markets. The opposite holds when the issuer's credit quality improves. In other words, our nondefault bond spread measure would be increasing in the issuer's credit quality. Empirically, this implies that in the presence of liquidity difference between bond and CDS markets, not controlling for credit conditions may lead to omitted variable biases because bond liquidity may be correlated with credit quality.

These discussions suggest that when CDS may be illiquid or the liquidity conditions of bonds and CDS differ, we should control for CDS liquidity and the issuer's credit condition in order to achieve an unbiased estimate on the effect of bond liquidity on the nondefault component of bond spread. In the absence of direct CDS liquidity measures, e.g., CDS bid-ask spreads, we use two variables to help control for the CDS liquidity effect. The first variable is the number of quotes on 5-year CDS contracts. Presumably, a larger number of quotes indicates more dealers making the market, thus improving the CDS liquidity. Thus, our discussion above implies the coefficient on the number of quotes is expected to be positive. The potential drawback of this variable is that market participants observe that the number of available quotes often increases when the issuer's credit quality changes.

We also include the one-period lagged CDS spread as a control for the issuer's credit condition. This variable is read at the corresponding bond's maturity from the CDS term structure fitted using the PCHIP algorithm described above. The lagged variable is used to avoid the complication of simultaneity issues. This variable also helps reduce the drawbacks mentioned above in using the number of CDS quotes as a proxy for CDS liquidity. Our discussions above suggest that, all else equal, the coefficients on the lagged CDS spread should be negative.

The results with these two additional controls are shown in Table 5. Overall, controlling for CDS liquidity results in firmer support, in terms of coefficient signs, statistical significance, and model fit, for the liquidity effect on the nondefault bond spreads, especially for higher-rated investment-grade bonds. Specifically, first, now almost all coefficients on the bond liquidity measures have expected signs and statistically significant at the 95 percent confidence level. The exceptions are the results on the bid-ask spread estimate for the speculative-grade bond sample and for the models including all three bond liquidity measures as regressors for all samples. Second, all coefficients on the lagged CDS spread are negative as expected and statistically significant, suggesting that, all else quality, the nondefault component of bond spread increases with the improvement in the issuer's credit quality. Third, almost all coefficients of the number of CDS quotes are positive as expected but only statistically significant for the overall sample and the A- or higher rated sample when turnover rate is used as the only liquidity regressor. Fourth, notably, the $R^2$ statistics increase significantly across all specifications but most dramatically for the speculative-grade bond sample.

To get a sense of the economic magnitude of the liquidity effect, we use the point estimates in Table 5 to calculate how the nondefault bond spreads change when the liquidity measures changes at both intensive and extensive margins. Intensive margin simply refers to the estimated coefficient (i.e., the first order derivative), and the extensive margin is defined as that a liquidity measure increases from its median by the size of its interquartile range. The results are stated in Table 6.

Our calculations suggest that generally speaking, the magnitude of the liquidity effect is, at least in relative terms, the largest for A- or higher rated bonds and the smallest for speculative-grade bonds, and that overall the liquidity effect appears to be quantitatively modest but nontrivial. Specifically, for the Amihud measure, Line 1, the absolute values are the largest for speculative-grade bonds and the smallest for A- or higher rated bonds for both intensive and extensive margins. However, relative to the medians of their full spreads, Line 4, or to the absolute value of basis spreads, Line 5, the order reverses. For the bid-ask spread measure, Line 2, the magnitudes for A- or higher rated bonds are higher, in both absolute and relative terms, than for BBB bonds, while the point estimates for speculative-grade bonds are not statistically significantly different from zero. For the turnover rate measure, Line 3, the absolute values for A- or higher rated bonds and for speculative-grade bonds are close, and both are larger than for BBB bonds, at both intensive and extensive margins. However, relative to their full spreads, the absolute values are the largest for A- or higher rated bonds and the smallest for speculative-grade bonds. Overall, all these estimates are rather small in absolute values, generally no larger than 1 basis point. However, they are nontrivial both relative to the near-zero basis spreads and even to their full spreads.

It is worth emphasizing that to reach the above conclusions, our study differs from previous work in two key areas. First, we use the full term structure of CDS spreads and a new methodology to better control the default component of bond spreads and, more importantly, to better control for unobservable firm heterogeneity. Second, we use transaction-based measures for bond liquidity while previous work mostly used bond characteristics as proxies. Since bond characteristics are predictable, previous work relies mainly on cross bond variation to identify the liquidity effect, while our transaction-based liquidity measures vary both across bonds and over time stochastically. We next study the additional explanatory power of our transaction-based liquidity measures after controlling for the commonly-used liquidity proxies.

### 5.3 Controlling for Bond Characteristics as Liquidity Proxies

Bond characteristics that were commonly used in previous studies as proxies for bond liquidity measures include coupon rate, bond age, remaining maturity, and the size of bonds (e.g., Longstaff et al. (2005)). While we could recite the various theories that were proposed in the literature on why these proxies may be reasonable, we opt instead to just test the relationship between our transaction-based liquidity measures and these bond liquidity proxies. The results are shown in Table 7. Note that to allow for more flexible and potentially nonlinear functional forms, we use a 4-th order polynomials for bond age and remaining maturity.[16] Also, in addition to the above variables, we also include a dummy variable indicating whether a bond is callable.

First, we find that the turnover rate measure is more strongly correlated with the liquidity proxies than the Amihud and bid-ask spread measures are. In particular, $R^2$s for the turnover rate measure range from 11 to 20 percent, while $R^2$s for the Amihud measure are no more than 10 percent. $R^2$ for the bid-ask spread measure is highest for the A- or higher rated bonds, but is only 6 percent for BBB and speculative-grade bonds. Second, interestingly, for all samples, larger coupon bonds have lower Amihud illiquidity and bid-ask spread measures, but they also turn over more slowly. Relationships between our transaction-based liquidity measures and bond size and callability are in general mixed. As for bond age and remaining maturity, coefficients on their polynomials are jointly statistically significant at the 95 percent confidence level in all specifications. Their functional forms, plotted in Figure 6, suggest that bonds become more illiquid

[16] We have also experimented using dummy variables to indicate each year (up to 15) of bond age and remaining maturity and using dummy variables to indicate brackets of bond age and remaining maturity using conventional cutoff points at 1, 3, 5, 7, and 10 years. The results, as well as those on the basis spread regressions, are similar to what we report here.

as they are older and that bonds with longer terms to maturity are more illiquid except that turnover rate increases with term-to-maturity for speculative-grade bonds. While our results on the Amihud and bid-ask spread measures are new, those on the turnover rate measure are in general consistent with the existing literature (Alexander et al., 2004; Hotchkiss and Ronen, 2002; Edwards et al., 2004; Downing et al., 2005).

Note that with these bond characteristics as additional regressors, controlling unobservable firm heterogeneity may become even more important for testing liquidity effects on the nondefault bond spreads. This is because these liquidity proxies may be correlated with credit risk, which in turn may be correlated with the unobservable factors affecting basis spreads. For example, coupon is obviously correlated with credit risk as lower credit quality issuers have to price higher yields to compensate investors for taking extra risks. Bond size may also be correlated with credit risk because riskier firms often have difficulty issuing larger bonds. Thus, to the extent that the unobservable firm characteristics may be correlated with credit risk, our estimates may be biased if such unobservables are not appropriately controlled for.

The results with bond characteristics added to our basis spreads regressions are shown in Table 8. Comparing to our benchmark result in Table 5, the main difference is that the point estimates on the turnover rate measure become notably smaller in absolute values and become statistically insignificant for BBB and speculative-grade bonds. These changes are consistent with the high correlation we found above between the turnover rate measure and the liquidity proxies. The point estimates on the bid-ask spread measure and the Amihud measure are, however, largely unchanged except for speculative-grade bonds where the coefficients, though still positive, are not statistically significant. Coefficients on the number of CDS quotes and lagged CDS spreads are largely unchanged. These findings suggest that first, for speculative-grade bonds, most of the correlation between basis spreads and our transaction-based liquidity measures are closely associated with bond characteristics; and second, our transaction-based liquidity measures identify a unique component of basis spreads that is orthogonal to the conventional liquidity proxies for investment-grade bonds, especially those rated A- or higher.

As for the liquidity proxies, basis spreads are positively associated with coupon rate but uncorrelated with bond size for all rating groups, and are negatively correlated with call option only for A- or higher rated bonds. Basis spreads are also statistically significantly related to bond age and remaining maturity. As plotted in the top panel of Figure 7, for investment-grade bonds, basis spreads are lower for younger bonds; but for speculative-grade bonds. basis spreads first decrease as bonds get older within about the first four years but then increase in age. As shown in the bottom panel, for investment-grade bonds, basis spreads are higher for those maturing sooner; but for speculative-grade bonds. basis spreads first increase for near maturing bonds but then decrease in remaining maturity.

Our findings on remaining maturity are consistent with previous studies suggesting that a large fraction of investment-grade bond spreads, especially at the short end of the maturity range, cannot be accounted for by credit risk (e.g., Huang and Huang 2003). In addition, our findings on bond age suggest that credit risk may not account for the bond spreads of young speculative-grade bonds either.

It is worth pointing out that some of our results are opposite to what have been found in the literature. For example, unlikely our results, basis spreads were found to be negatively related to bond size and positively with remaining maturity (e.g., Longstaff et al. (2005)). While our sample is much more representative, another possible reason for these differences may be due to our control for unobservable firm heterogeneity. In particular, previous studies may have picked up the correlation between bond characteristics and basis spreads effectively by comparing, say large or long-term, bonds issued by one firm to, respectively small or short-term, bonds issued by another firm. If credit quality and unobservable firm heterogeneity are not well controlled for, those findings may just reflect the correlation between bond size or term-to-maturity and credit risk.

### 5.4 Robustness Analysis

This section presents a number of exercises that check for the robustness of our results. These include: (1) explicitly controlling for macroeconomic conditions instead of using time dummies; (2) constructing our transaction-based liquidity measures using trades that occurred in the time window less subject to news; (3) using Treasury rate as the risk-free rate measure in estimating basis spreads; (4) using basis spreads estimated without adjusting for coupon effects; and (5) excluding callable bonds from our sample. Overall, our results are robust to these alternative model specifications, estimation methods, and samplings.

### 5.4.1 Explicitly Controlling for Macroeconomic Conditions

While using time dummy variables completely control for macroeconomic conditions, their coefficients may not be easily interpreted. To get a sense how the nondefault bond spread is associated with macroeconomic conditions, we instead use the following commonly-used macroeconomic variables as explicit controls: Treasury term structure, including 6-month T-bill rate and term spread between 10-year Treasury rate and 6-month T-bill rate, returns, realized, and implied volatilities on the S&P 500 index, and the on-the-run premium for 10-year Treasury securities.

The results are shown in Table 9. Comparing to Table 8, the results on our transaction-based liquidity measures are largely unchanged, so are those on CDS liquidity proxies and bond characteristics (not shown). On the macro variables, basis spreads are negatively associated with Treasury term structure. Since Treasury term structures often increase on strong outlook for economic growth, this result suggests nondefault bond spreads decrease on better economic perspectives. This is consistent with the negative correlation between basis spreads and S&P 500 stock returns (when they are statistically significant). However, this interpretation should be taken with a salt, considering the behavior in Treasury term structure in recent years, especially its inverting yield curve,is still not well understood.

Basis spreads are found to increase in S&P implied volatility but decrease in the realized volatility. Results on Treasury liquidity variables are also mixed.

### 5.4.2 Liquidity Measures Computed Using "Non-News" Driven Trades

Since the variation in transaction price, trade size, and trading frequency reflect not only bond liquidity but also bond valuations, our transaction-based liquidity measures may contain variation caused by changes in bond valuations, especially when news arrives. To reduce the potential impact of news, we now use only transactions occurring between 10:30AM and 3:30PM each day to exclude possibly news-driven trades. We choose this time window because company news usually arrives in the after-market hours and major economic data are generally released no later than 10AM.

The results are shown in Table 10. Comparing to Table 8, the results on investment-grade bonds are roughly unchanged, although the magnitudes appear to be a touch smaller. Changes for speculative-grade bonds are mixed: while the coefficient on the Amihud measure now becomes marginally significant, the coefficient on the turnover rate measure becomes positive and statistically significant.

### 5.4.3 Treasury Rate as Risk-Free Rate

Swap rate has been regarded as the appropriate risk-free rate measure for studying liquidity impacts on basis spreads, as it offers better control for tax effects. Nonetheless, as mentioned early, using swap rate has its own drawbacks. For example, swap rate has a component compensating for counterparty default risks and the benchmark LIBOR rate also has a credit risk component. For robustness, we repeat our regressions with basis spreads estimated using Treasury rate as the risk-free rate measure.

The results are shown in Table 11. Comparing to Table 8, the results are roughly unchanged for investment-grade bonds and slightly stronger for speculative-grade bonds as the coefficient on the bid-ask spread variable becomes statistically significant. These suggest strongly that the difference in estimated basis spreads resulting from using alternative risk-free rate measures, which are possibly due to such effects as differential tax treatment, is uncorrelated with our transaction based liquidity measures.

Among other regressors, notable changes occur to the coefficients on coupon rate: They become slightly smaller in absolute terms for investment-grade bonds but slightly larger for speculative-grade bonds. On a related note, Longstaff et al. (2005) argued that one can use the difference in the estimated coefficients on coupon rate between using Treasury rate and using swap rate as a measure of tax effect on bond spread. Based on our estimates, this would would result a negative tax effect for investment-grade bonds but a positive tax effect for speculative-grade bonds! Our results thus suggest that the said method of identifying tax effect may not be robust to the controlling of trading based liquidity effect or unobservable firm heterogeneity. Clearly, more research questions remain regarding the tax effect.

### 5.4.4 No Correction for Coupon Effects

We have argued that we improve the nondefault bond spread estimation by correcting coupon effect in bond yield calculations. What is the implication of not adjusting coupon effects for our study? We reestimate our models using basis spreads equal to bond spreads minus the CDS spread that is read at the comparable-maturity from the fitted CDS term structure (i.e., Line 3 in Table 2) where swap rate is used as the risk-free rate measure.

The results are shown in Table 12. Comparing to Table 8, the results are roughly unchanged for investment-grade bonds and somewhat stronger for speculative-grade bonds as the coefficients on both the Amihud measure and the the bid-ask spread measure become statistically significant, suggesting coupon effects are largely orthogonal to our transaction-based liquidity measures.

Not surprisingly, failing to adjust coupon effect has significant impact on the coefficients on coupon rates. Indeed, they decrease across all specifications by about 0.5, implying that for each percentage of coupon rate, using Treasury rate would underestimate the nondefault bond spreads by 0.5 basis points.

### 5.4.5 Excluding Callable Bonds

To construct our main sample, we remove bonds with any option feature except those with call option, because over 60 percent of the bond-month observations are callable. We reestimate our models by further excluding those callable bonds.

The results are shown in Table 13. While the sample size shrinks significantly, the results on our transaction-based liquidity measures are roughly unchanged for speculative-grade bonds, but are slightly stronger for investment-grade bonds in that the coefficient on the turnover rate measure becomes significant for BBB bonds and the coefficients on the bid-ask spread measure are somewhat larger for both A- or higher and BBB bonds. For other variables, the results are largely unchanged.

## 6 Conclusion

In this paper we examine the relationship between the nondefault component of corporate bond spreads and bond liquidity. We control for the default component of bond spreads using a rich term-structure of CDS spreads, addressing both maturity mismatch and coupon effects issues that may have biased existing estimations. In addition, we measure bond liquidity using newly available intraday bond transaction data. We construct three types of transaction based liquidity measures: price impact of trades, estimated transaction costs, and trading frequency variables. The richness of our data set allow us to use fixed effect models to control for the unobservable firm and economic factors that may be correlated with both the nondefault components of bond spreads and bond liquidity. Moreover, we control for the conventional liquidity proxy variables such as coupon rate, issue size, time-to-maturity, and bond age. We also use available CDS data to explicitly control for CDS liquidity.

We find a clear positive and significant relationship between nondefault bond spreads and illiquidity of intraday trading. We show that such estimated relationship would appear weaker if the unobservables firm and economic factors were not well controlled for. We also find that the trading liquidity effect is not correlated with conventional liquidity proxy variables for the higher rated investment-grade bonds, but weakly correlated for BBB-rated bonds, and highly correlated for the speculative-grade bonds. These results are consistent with previous bond pricing studies that, while credit risk can explain most of the yield spread for speculative-grade bonds, a larger fraction of investment-grade bond spreads cannot be accounted by credit risk.

Since changes in the conventional liquidity proxies are predictable, most existing studies rely on cross-sectional variations to identify the liquidity effects. Our transaction based liquidity measures vary stochastically both over time and across bonds. Empirically, we find that our measures identify a distinct component of basis spreads due to the stochastic variations in bond liquidity. We also find that the estimated liquidity effects of our transaction based liquidity measures are robust to using either Treasury yield or swap yield as the alternative measure of risk-free rate.

For future research, the strong statistical evidence of the positive relationship between the nondefault bond spreads and trading liquidity suggests that it is important to incorporate price impact of trades and transaction costs into the bond pricing models, at least in the studies of temporal variations in bond spreads. In addition, our results call for careful reevaluations on the impact of tax on bond spreads.

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# Appendix

## A Bond Trading Data

We create liquidity measures using the intraday transaction data on corporate bond tradings. The data are from NASD's Trading Reporting and Compliance Engine, or TRACE, reporting system. As an effort to increase the transparency of corporate bond market, the NASD now requires its members to report OTC secondary market transactions in eligible fixed income securities to the NASD through TRACE. In addition, the NASD adopted three phases to incrementally disseminate these trade reports to the public.

- Phase I: July 1, 2002, only about 500 bonds were subject to dissemination to the public. These included all investment-grade bonds with an original issue size of $1 billion or more and the 50 high-yield bonds that were rolled over from the Fixed Income Pricing System (FIPS). While small in number, these bonds reportedly accounted for about 50 percent of total trading volume at the time.

- Phase II: March 3, 2003, the NASD disseminated all investment-grade bonds with original issue size of $100 million or more and rating A3/A- or higher. Subsequently, an additional 120 BBB-rated bonds (40 each for BBB-, BBB, BBB+) were added on April 14, 2003. Total number of bonds subjected to dissemination reached about 5000 in this phase.

- Phase III: two stages leading to complete dissemination. On October 1, 2004, about 17,000 bonds were added to the dissemination list, bringing the total number of disseminated bonds to about 21,600. Later on February 7, 2005, all bonds, except the TRACE-eligible Rule 144A bonds which account for about one-sixth of all eligible bonds, became subject to dissemination, bringing the total number of disseminated bonds to about 29,300.

More details on TRACE rules can be found in NASD (2004). We obtain the publicly disseminated intraday transaction data through MarketAccess. The data include transaction price (including the effect of any dealer commission), trade size, settlement time, bond CUSIP, and other trade related variables. Our data, however, do not have some critical transaction information such as whether the trade was initiated by the buyer or by the seller. An additional limitation is that the trade size in our data is capped at $1 million for high-yield bonds and $5 million for investment-grade bonds.

Table 1: **Sample Description**

Our sample is constructed as follows. Our sampling period is from July 2002 to April 2007. We keep only senior unsecured bonds issued by U.S. firms with remaining maturity at any time in the range of 1 to 15 years. Also, bonds that are puttable, convertible, defaulted, or have floating rate or sinking fund features are deleted, but bonds with call options are kept. In addition, monthly values of all variables are means of daily values, where on each day we restrict to the firms that have nonmissing values on both 1- and 10-year CDS quotes and at least two additional nonmissing values among 2-, 3-, 5-, and 7-year CDS quotes. For bond transaction data, we remove trades with "price errors" as in Downing et al. (2005) and Edwards et al. (2004). Finally, firms are identified by unique issuer tickers in the Merrill Lynch Global Bond Indexes database.

Panel A: Overall Sample Accounting

| Variable | Mean | Std. Dev. | Min | Median | Max | N |
|---|---|---|---|---|---|---|
| N. of months per bond | 21 | 15 | 1 | 20 | 58 | 1894 (bonds) |
| N. of bonds per firm | 4 | 5 | 1 | 3 | 44 | 431 (firms) |

Panel B: Sample Accounting by Bond Rating and TRACE Dissemination Phases

| | Average number of bonds | | | | N. of | |
|---|---|---|---|---|---|---|
| | Phase I | Phase II | Phase III.1 | Phase III.2 | bonds | firms |
| Bond rating | Jul02-Feb03 | Mar03-Sep04 | Oct04-Jan05 | Feb05-Apr07 | Jul02-Apr07 | |
| AAA | 0 | 6 | 8 | 5 | 14 | 4 |
| AA | 26 | 57 | 60 | 73 | 210 | 25 |
| A | 53 | 363 | 351 | 267 | 689 | 128 |
| BBB | 32 | 78 | 447 | 339 | 786 | 219 |
| BB | 4 | 7 | 92 | 152 | 379 | 119 |
| B | 2 | 4 | 41 | 69 | 171 | 71 |
| CCC/lower | 1 | 1 | 32 | 23 | 82 | 27 |
| Total | 118 | 516 | 1031 | 928 | 2331 | 596 |

Data sources: Merill Lynch, Markit, NASD TRACE, and Moody's.

Table 2: **Summary Statistics for Monthly Data Sample from July 2002 to April 2007.**

Our sampling method is described in Table 1. We calculate basis spread variables and trading liquidity variables for each bond on each date and then use their means over each month as their monthly values. All summary statistics here are for the resulting bond-month data. Brief definitions of key variables are the following with details shown in the main text. Rows 1-4 are four alternative measures for basis spreads. In Rows 1 and 2, basis spreads are the difference between bond yield and CDS implied yield with swap and Treasury rates, respectively, as the risk-free rate. In Rows 3 and 4, basis spreads are the difference between bond spread and CDS premium at the comparable maturity with swap and Treasury rates, respectively, as the risk-free rate. Let $p^i_{j,t}$ and $Q^i_{j,t}$ be the price and the size of the $j$th trade of bond $i$ on date $t$. Amihud measure of the $j$th trade is $\frac{|p^i_{j,t}-p^i_{j-1,t}|}{p^i_{j-1,t}}/Q^i_{j,t}$. Using Roll's Model (1984), estimated effective bid-ask spread is $2\sqrt{-\mathrm{Cov}(r^i_{j+1,t}, r^i_{j,t})}$ with $r^i_{j,t} = \log p^i_{j,t}/p^i_{j-1,t}$. Turnover rate is the ratio of total trading volume in a month to the amount of face value outstanding. Other variables are self-explanatory.

| | Entire Sample | | | | | | | A- or higher | | | | BBB | | | | High-yield | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | N | Mean | P5 | P25 | P50 | P75 | P95 | N | P25 | P50 | P75 | N | P25 | P50 | P75 | N | P25 | P50 | P75 |
| *Basis spreads (in bps):* | | | | | | | | | | | | | | | | | | | |
| 1. Bond yld-CDS implied yld w. swap | 39967 | -11.03 | -65.65 | -10.89 | -0.55 | 10.84 | 34.46 | 19735 | -9.19 | -2.26 | 6.75 | 12688 | -5.54 | 5.05 | 14.48 | 7544 | -61.68 | -12.04 | 15.39 |
| 2. Bond yld-CDS implied yld w. Treas | 39967 | 28.34 | -23.67 | 26.36 | 39.41 | 52.23 | 73.07 | 19735 | 26.93 | 36.27 | 46.58 | 12688 | 35.23 | 46.90 | 57.21 | 7544 | -18.14 | 30.42 | 57.72 |
| 3. Bond yld-swap-CDS | 39967 | -12.32 | -63.90 | -11.96 | -1.64 | 9.52 | 31.80 | 19735 | -10.40 | -3.50 | 5.15 | 12688 | -6.39 | 4.17 | 13.52 | 7544 | -59.80 | -12.26 | 14.50 |
| 4. Bond yld-Treas-CDS | 39967 | 26.78 | -23.69 | 24.70 | 37.66 | 51.01 | 71.46 | 19735 | 25.13 | 34.44 | 45.00 | 12688 | 33.71 | 45.66 | 56.38 | 7544 | -17.85 | 29.73 | 56.61 |
| *Price impact of trades:* | | | | | | | | | | | | | | | | | | | |
| 5. Amihud illiq. (abs(ret)/$M) | 38059 | 0.48 | 0.00 | 0.08 | 0.27 | 0.59 | 1.53 | 19256 | 0.14 | 0.31 | 0.61 | 11582 | 0.02 | 0.18 | 0.49 | 7221 | 0.04 | 0.28 | 0.66 |
| *Transaction costs:* | | | | | | | | | | | | | | | | | | | |
| 6. Estimated bid-ask spread (%) | 30493 | 1.06 | 0.16 | 0.49 | 0.86 | 1.40 | 2.60 | 16589 | 0.52 | 0.84 | 1.30 | 8122 | 0.35 | 0.75 | 1.34 | 5782 | 0.56 | 1.10 | 1.80 |
| *Trading frequency:* | | | | | | | | | | | | | | | | | | | |
| 7. Turnover rate | 39967 | 0.06 | 0.00 | 0.02 | 0.04 | 0.07 | 0.19 | 19735 | 0.01 | 0.03 | 0.06 | 12688 | 0.02 | 0.04 | 0.08 | 7544 | 0.02 | 0.04 | 0.07 |
| *Bond characteristics:* | | | | | | | | | | | | | | | | | | | |
| 8. Coupon (%) | 39967 | 6.25 | 3.88 | 5.20 | 6.25 | 7.19 | 8.75 | 19735 | 4.80 | 5.75 | 6.75 | 12688 | 5.35 | 6.25 | 7.10 | 7544 | 6.65 | 7.50 | 8.50 |
| 9. Age (year) | 39967 | 3.86 | 0.39 | 1.63 | 3.11 | 5.25 | 9.22 | 19735 | 1.50 | 3.05 | 5.33 | 12688 | 1.62 | 2.96 | 4.71 | 7544 | 1.97 | 3.60 | 5.99 |
| 10. Term-to-maturity (year) | 39967 | 5.70 | 1.45 | 3.20 | 5.34 | 7.92 | 11.13 | 19735 | 2.88 | 4.87 | 7.79 | 12688 | 3.54 | 5.88 | 8.13 | 7544 | 3.50 | 5.67 | 7.84 |
| 11. Callable (1 if yes) | 39967 | 0.61 | 0 | 0 | 1 | 1 | 1 | 19735 | 0 | 0 | 1 | 12688 | 1 | 1 | 1 | 7544 | 0 | 1 | 1 |
| 12. Bond size ($100mm) | 39967 | 5.65 | 1.50 | 2.50 | 4.00 | 6.50 | 15.00 | 19735 | 2.74 | 5.00 | 8.00 | 12688 | 2.75 | 3.75 | 5.40 | 7544 | 2.00 | 3.48 | 5.00 |
| *Memo items:* | | | | | | | | | | | | | | | | | | | |
| 13. Number of traded days | 39967 | 12.67 | 2 | 7 | 13 | 19 | 22 | 19735 | 9 | 16 | 20 | 12688 | 5 | 9 | 15 | 7544 | 7 | 13 | 18 |
| 14. Number of trades | 39967 | 87.55 | 3 | 13 | 32 | 92 | 341 | 19735 | 20 | 48 | 123 | 12688 | 8 | 18 | 45 | 7544 | 15 | 34 | 79 |
| 15. Median trade size ($MM) | 39967 | 0.36 | 0.01 | 0.03 | 0.05 | 0.25 | 2.00 | 19735 | 0.02 | 0.03 | 0.06 | 12688 | 0.03 | 0.10 | 0.73 | 7544 | 0.03 | 0.15 | 0.95 |
| 16. Monthly trading vol ($MM) | 39967 | 39.34 | 0.40 | 5.00 | 15.41 | 41.33 | 152.42 | 19735 | 5.00 | 16.37 | 44.69 | 12688 | 5.24 | 15.58 | 43.25 | 7544 | 4.35 | 12.92 | 30.90 |

Data sources: Merill Lynch, Markit, TRACE, Federal Reserve Board.

Table 3: **Results of OLS Regressions of Nondefault Bond Spreads on Bond Liquidity Measures with Time Fixed Effects**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \log(\text{bond [il]liquidity measures}) + \text{time fixed effects} + \epsilon.$$

(3) Figures in parentheses are robust standard errors with clustering at the firm level. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| Dependent variable = Bond yield − CDS implied yield with swap rate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | -0.23 | | | 0.58* | 0.12 | | | 0.41 | -0.28 | | | -0.08 | -0.03 | | | 0.85 |
| | (0.27) | | | (0.30) | (0.24) | | | (0.28) | (0.50) | | | (0.46) | (0.54) | | | (0.63) |
| Log(Bid-ask sprds) | | -1.39* | | -1.96** | | 0.37 | | -0.21 | | -2.36 | | -2.26* | | -0.72 | | -1.11 |
| | | (0.80) | | (0.63) | | (0.63) | | (0.53) | | (1.63) | | (1.17) | | (1.61) | | (1.56) |
| Log(Turnover rate) | | | -1.96** | -2.18** | | | -1.36** | -1.28** | | | -1.53** | -2.13** | | | -5.59** | -7.21** |
| | | | (0.35) | (0.45) | | | (0.30) | (0.32) | | | (0.55) | (0.71) | | | (1.08) | (1.06) |
| Constant | -8.49 | -8.97 | -11.47* | -12.17 | -9.85 | -11.00 | -10.29 | -12.18 | -1.02 | -2.93 | -11.49* | -5.99 | -38.07** | -42.40** | -36.89** | -58.44** |
| | (6.11) | (5.68) | (6.54) | (7.52) | (7.00) | (6.69) | (7.23) | (7.82) | (4.57) | (4.44) | (6.42) | (5.98) | (3.63) | (1.57) | (6.77) | (8.04) |
| Observations | 30891 | 24874 | 32666 | 21941 | 17269 | 15037 | 17683 | 13610 | 9311 | 6600 | 10407 | 5379 | 4311 | 3237 | 4576 | 2952 |
| $R^2$ | 0.06 | 0.06 | 0.07 | 0.07 | 0.14 | 0.14 | 0.15 | 0.15 | 0.12 | 0.13 | 0.14 | 0.16 | 0.02 | 0.03 | 0.06 | 0.09 |

Table 4: **Results of OLS Regressions of Nondefault Bond Spreads on Bond Liquidity Measures with Both Firm and Time Fixed Effects**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \log(\text{bond [il]liquidity measures}) + \text{firm and time fixed effects} + \epsilon.$$

(3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| Dependent variable = Bond yield − CDS implied yield with swap rate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.14** | | | 0.34** | 0.30** | | | 0.41** | 0.20** | | | 0.15 | -0.21 | | | 0.54 |
| | (0.06) | | | (0.11) | (0.08) | | | (0.11) | (0.08) | | | (0.15) | (0.22) | | | (0.35) |
| Log(Bid-ask sprds) | | -0.48** | | -1.05** | | 0.12 | | -0.44** | | -0.78** | | -1.23** | | -2.21** | | -2.62** |
| | | (0.15) | | (0.18) | | (0.16) | | (0.19) | | (0.24) | | (0.30) | | (0.65) | | (0.79) |
| Log(Turnover rate) | | | -1.50** | -1.63** | | | -1.25** | -1.32** | | | -1.27** | -1.47** | | | -3.87** | -5.09** |
| | | | (0.08) | (0.11) | | | (0.09) | (0.11) | | | (0.12) | (0.19) | | | (0.41) | (0.59) |
| Constant | -3.46* | -5.02** | -5.64** | -7.14** | -3.64* | -5.39** | -4.39* | -5.94** | 3.65 | 3.53 | -5.74 | -0.28 | -16.49* | -19.21** | -7.54 | -28.64** |
| | (1.91) | (1.98) | (2.35) | (2.14) | (2.19) | (2.30) | (2.27) | (2.41) | (3.56) | (3.34) | (6.73) | (3.90) | (8.75) | (5.73) | (13.98) | (11.26) |
| Observations | 30891 | 24874 | 32666 | 21941 | 17269 | 15037 | 17683 | 13610 | 9311 | 6600 | 10407 | 5379 | 4311 | 3237 | 4576 | 2952 |
| Number of firms | 397 | 378 | 408 | 366 | 141 | 139 | 142 | 136 | 195 | 178 | 201 | 168 | 138 | 132 | 144 | 129 |
| $R^2$ | 0.08 | 0.07 | 0.09 | 0.09 | 0.15 | 0.14 | 0.17 | 0.17 | 0.13 | 0.12 | 0.13 | 0.12 | 0.03 | 0.04 | 0.05 | 0.08 |

Table 5: **The Effects of Bond Liquidity on the Nondefault Bond Spreads by Controlling for CDS Liquidity**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \log(\text{bond [il]liquidity measures}) + \text{CDS liquidity proxies} + \text{firm and time fixed effects} + \epsilon.$$

(3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| Dependent variable = Bond yield − CDS implied yield with swap rate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.46** | | | 0.46** | 0.40** | | | 0.40** | 0.52** | | | 0.35** | 0.63** | | | 0.79** |
| | (0.07) | | | (0.10) | (0.08) | | | (0.11) | (0.08) | | | (0.14) | (0.21) | | | (0.34) |
| Log(Bid-ask sprds) | | 0.72** | | 0.16 | | 0.74** | | 0.13 | | 0.42* | | -0.27 | | 0.90 | | 0.39 |
| | | (0.14) | | (0.17) | | (0.17) | | (0.19) | | (0.23) | | (0.28) | | (0.64) | | (0.76) |
| Log(Turnover rate) | | | -0.93** | -0.93** | | | -1.13** | -1.14** | | | -0.63** | -0.67** | | | -1.04** | -1.20* |
| | | | (0.08) | (0.10) | | | (0.09) | (0.11) | | | (0.12) | (0.19) | | | (0.42) | (0.61) |
| N. of CDS quotes | 0.04 | 0.02 | 0.09** | 0.09** | 0.06 | -0.03 | 0.08** | 0.03 | 0.04 | 0.12 | -0.01 | 0.15* | 0.12 | 0.02 | 0.23 | 0.07 |
| | (0.03) | (0.04) | (0.03) | (0.04) | (0.04) | (0.04) | (0.03) | (0.04) | (0.06) | (0.08) | (0.06) | (0.08) | (0.16) | (0.18) | (0.15) | (0.19) |
| Lagged CDS spread | -0.09** | -0.09** | -0.10** | -0.09** | -0.09** | -0.08** | -0.07** | -0.07** | -0.12** | -0.11** | -0.12** | -0.11** | -0.10** | -0.10** | -0.11** | -0.10** |
| | (0.01) | (0.00) | (0.00) | (0.00) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.00) | (0.01) |
| Constant | 2.09 | 8.85** | 10.67** | 9.01** | 11.62** | 10.69** | 6.07** | 7.77** | 12.93** | 9.43** | 22.30** | 21.20* | 162.73** | 59.55** | 36.99** | 63.33** |
| | (2.41) | (2.09) | (2.48) | (2.55) | (2.20) | (2.16) | (2.21) | (2.65) | (3.26) | (3.35) | (8.35) | (11.40) | (57.34) | (11.65) | (17.53) | (12.53) |
| Observations | 28380 | 22976 | 29957 | 20429 | 16125 | 14087 | 16570 | 12853 | 8630 | 6160 | 9566 | 5069 | 3625 | 2729 | 3821 | 2507 |
| Number of firms | 383 | 356 | 387 | 349 | 137 | 135 | 138 | 134 | 184 | 164 | 185 | 159 | 132 | 120 | 134 | 118 |
| $R^2$ | 0.17 | 0.16 | 0.18 | 0.17 | 0.18 | 0.17 | 0.19 | 0.19 | 0.24 | 0.21 | 0.22 | 0.20 | 0.19 | 0.20 | 0.21 | 0.21 |

Table 6: **Economic Magnitude of the Effect of Bond Liquidity on the Nondefault Bond Spreads**

This table presents the magnitude of the effects, both at intensive margin and at extensive margin, of bond liquidity on the nondefault component of bond spread based on results in Table 5. Intensive margin simply refers to the estimated coefficient (i.e., the first order derivative), and extensive margin computes the change in the nondefault bond spread when the liquidity measure increases from its median by the size of its interquartile range. Only those with statistically significant coefficients are computed. Figures in the brackets represent the 95 percent confidence intervals of the estimates.

| | Effects at intensive margin | | | Effects at extensive margin | | |
|---|---|---|---|---|---|---|
| | A-/higher | BBBs | Speculative | A-/higher | BBBs | Speculative |
| 1. Amihud illiquidity | 0.40 | 0.52 | 0.63 | 0.36 | 0.67 | 0.74 |
| | [ 0.24, 0.55] | [ 0.36, 0.67] | [ 0.22, 1.04] | [ 0.22, 0.51] | [ 0.47, 0.87] | [ 0.25, 1.22] |
| 2. Bid-ask spread | 0.74 | 0.42 | | 0.48 | 0.35 | |
| | [ 0.40, 1.07] | [-0.02, 0.86] | | [ 0.26, 0.70] | [-0.02, 0.73] | |
| 3. Turnover rate | -1.13 | -0.63 | -1.04 | -0.99 | -0.63 | -0.95 |
| | [-1.30,-0.95] | [-0.86,-0.39] | [-1.85,-0.22] | [-1.15,-0.84] | [-0.86,-0.39] | [-1.71,-0.20] |
| Memo (median, bps) | | | | | | |
| 4. Full spread[a] | 21.14 | 56.03 | 185.95 | 21.14 | 56.03 | 185.95 |
| 5. Basis spread[b] | -2.25 | 5.04 | -12.04 | -2.25 | 5.04 | -12.04 |

[a]Full spread = bond yield − swap rate.

[b]Basis spread = bond yield − CDS implied yield with swap rate as risk-free rate.

Table 7: **Relationship between Transaction Based Liquidity Measures and Liquidity Proxies**

(1) Liquidity variables are defined as shown in Table 2. (2) Each column is a regression model of the form:

$$\log(\text{Bond [il]liquidity}) = \alpha + \beta\,\text{liq. proxies} + \text{firm and time fixed effects} + \epsilon,$$

where [il]liquidity measure used for the corresponding model is indicated in the row under the column numbers. Polynomials of order 4 are used for bond age and remaining maturity in each model. The results of tests of joint significance of the age coefficients and the remaining maturity coefficients are shown here, and their functional forms are plotted in Figure 6. (3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and the 95 percent confidence levels, respectively.

| | Dependent variable = log (Bond [il]liquidity measure ) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | A- or higher | | | BBB-, BBB, BBB+ | | | Speculative-grade | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| | Amihud | Bid-ask | Turnover | Amihud | Bid-ask | Turnover | Amihud | Bid-ask | Turnover | Amihud | Bid-ask | Turnover |
| Coupon | -0.17** | -0.06** | -0.05** | -0.12** | -0.04** | -0.04** | -0.25** | -0.08** | -0.03** | -0.20** | -0.08** | -0.07** |
| | (0.01) | (0.00) | (0.01) | (0.01) | (0.01) | (0.01) | (0.03) | (0.01) | (0.01) | (0.03) | (0.01) | (0.02) |
| Log(Bond size) | 0.33** | -0.04** | 0.33** | 0.34** | -0.06** | 0.33** | 0.31** | 0.00 | 0.33** | 0.10 | 0.04 | 0.19** |
| | (0.02) | (0.01) | (0.01) | (0.02) | (0.01) | (0.02) | (0.05) | (0.02) | (0.03) | (0.07) | (0.03) | (0.04) |
| Callable | -0.04 | 0.04** | 0.02 | 0.01 | 0.04** | 0.07** | -0.13** | 0.01 | 0.02 | -0.11 | 0.00 | -0.15** |
| | (0.03) | (0.01) | (0.02) | (0.03) | (0.02) | (0.02) | (0.06) | (0.03) | (0.04) | (0.09) | (0.04) | (0.05) |
| Constant | -3.87** | -0.18** | -3.94** | -3.87** | -0.01 | -3.58** | -4.07** | -0.88** | -4.30** | -1.80** | -0.17 | -4.90** |
| | (0.16) | (0.08) | (0.11) | (0.17) | (0.09) | (0.14) | (0.44) | (0.23) | (0.25) | (0.68) | (0.39) | (0.41) |
| Bond age polyn (4) | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** |
| Rem. mat polyn (4) | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** |
| Observations | 30891 | 24874 | 32666 | 17269 | 15037 | 17683 | 9311 | 6600 | 10407 | 4311 | 3237 | 4576 |
| Number of firms | 397 | 378 | 408 | 141 | 139 | 142 | 195 | 178 | 201 | 138 | 132 | 144 |
| $R^2$ | 0.05 | 0.14 | 0.15 | 0.09 | 0.23 | 0.20 | 0.05 | 0.07 | 0.11 | 0.06 | 0.06 | 0.20 |

Table 8: **Estimating Liquidity Effects with Both Transaction Based Liquidity Measures and Liquidity Proxies**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \text{ log(bond [il]liquidity measures)} + \text{bond characteristics} + \text{CDS liquidity proxies} + \text{firm and time fixed effects} + \epsilon.$$

Polynomials of order 4 are used for bond age and remaining maturity in each model. The results of tests of joint significance of the age coefficients and the remaining maturity coefficients are shown here, and their functional forms are plotted in Figure 7. (3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| Dependent variable = Bond yield − CDS implied yield with swap rate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.45** | | | 0.28** | 0.32** | | | 0.16 | 0.41** | | | 0.22 | 0.29 | | | 0.53* |
| | (0.06) | | | (0.10) | (0.07) | | | (0.11) | (0.08) | | | (0.14) | (0.20) | | | (0.31) |
| Log(Bid-ask sprd) | | 1.21** | | 1.00** | | 0.82** | | 0.59** | | 0.78** | | 0.51* | | 0.94 | | 1.00 |
| | | (0.14) | | (0.17) | | (0.16) | | (0.19) | | (0.22) | | (0.27) | | (0.61) | | (0.71) |
| Log(Turnover rate) | | | -0.17** | -0.07 | | | -0.38** | -0.31** | | | 0.05 | 0.10 | | | 0.61 | 0.96 |
| | | | (0.08) | (0.11) | | | (0.09) | (0.12) | | | (0.12) | (0.19) | | | (0.43) | (0.63) |
| Coupon | 1.72** | 1.62** | 1.59** | 1.57** | 1.55** | 1.43** | 1.50** | 1.33** | 1.51** | 1.64** | 1.29** | 1.39** | 3.09** | 3.56** | 2.82** | 4.05** |
| | (0.11) | (0.12) | (0.11) | (0.13) | (0.11) | (0.11) | (0.10) | (0.12) | (0.20) | (0.27) | (0.19) | (0.28) | (0.49) | (0.59) | (0.47) | (0.63) |
| Log(Bond size) | 0.15 | 0.29 | 0.27 | 0.16 | -0.10 | -0.06 | 0.01 | 0.02 | -0.58 | -0.55 | -0.40 | -0.57 | 0.45 | 1.41 | 0.21 | 0.81 |
| | (0.19) | (0.21) | (0.19) | (0.22) | (0.19) | (0.20) | (0.19) | (0.21) | (0.44) | (0.53) | (0.42) | (0.58) | (1.04) | (1.24) | (1.00) | (1.32) |
| Callable bond | -0.26 | -0.59* | -0.13 | -0.44 | -1.89** | -2.12** | -1.70** | -1.98** | 0.61 | 0.02 | 0.23 | -0.25 | 0.09 | 1.31 | 0.94 | 1.93 |
| | (0.28) | (0.31) | (0.27) | (0.33) | (0.30) | (0.33) | (0.29) | (0.33) | (0.49) | (0.61) | (0.48) | (0.70) | (1.08) | (1.28) | (1.05) | (1.38) |
| N. of CDS quotes | 0.05 | 0.03 | 0.09** | 0.08** | 0.09** | -0.00 | 0.10** | 0.05 | -0.01 | 0.10 | -0.06 | 0.08 | 0.12 | 0.11 | 0.23 | 0.15 |
| | (0.03) | (0.04) | (0.03) | (0.04) | (0.03) | (0.04) | (0.03) | (0.04) | (0.06) | (0.07) | (0.05) | (0.08) | (0.15) | (0.17) | (0.15) | (0.18) |
| Lagged CDS spread | -0.08** | -0.09** | -0.09** | -0.09** | -0.10** | -0.09** | -0.08** | -0.08** | -0.08** | -0.08** | -0.07** | -0.08** | -0.08** | -0.09** | -0.10** | -0.09** |
| | (0.01) | (0.00) | (0.00) | (0.00) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Constant | 4.48 | 12.37** | 13.45** | 16.95** | 19.44** | 19.90** | 16.31** | 20.55** | 25.38** | 24.20** | 32.98** | 36.57** | 97.99** | 3.16 | 9.17 | 15.64 |
| | (2.76) | (2.59) | (2.79) | (3.03) | (2.60) | (2.65) | (2.62) | (3.02) | (5.04) | (5.76) | (7.41) | (11.24) | (47.15) | (13.50) | (14.08) | (14.86) |
| Bond age polyn (4) | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** |
| Rem. mat polyn (4) | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** |
| Observations | 28380 | 22976 | 29957 | 20429 | 16125 | 14087 | 16570 | 12853 | 8630 | 6160 | 9566 | 5069 | 3625 | 2729 | 3821 | 2507 |
| Number of firms | 383 | 356 | 387 | 349 | 137 | 135 | 138 | 134 | 184 | 164 | 185 | 159 | 132 | 120 | 134 | 118 |
| $R^2$ | 0.23 | 0.22 | 0.23 | 0.22 | 0.27 | 0.27 | 0.27 | 0.27 | 0.31 | 0.28 | 0.30 | 0.27 | 0.28 | 0.29 | 0.28 | 0.30 |

Table 9: **The Effects of Liquidity on Nondefault Bond Spreads When Explicitly Controlling for Macroeconomic Conditions**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spread} = c + \alpha\ \log(\text{Bond [il]liquidity measures}) + \beta\,\text{bond char.} + \gamma\,\text{CDS liq. proxies} + \theta\,\text{macro variables} + \text{firm fixed effects} + \epsilon.$$

(3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| | Dependent variable = Bond yield − CDS implied yield with swap rate | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.48** | | | 0.31** | 0.35** | | | 0.17 | 0.39** | | | 0.25* | 0.22 | | | 0.53* |
| | (0.06) | | | (0.10) | (0.08) | | | (0.12) | (0.08) | | | (0.14) | (0.22) | | | (0.32) |
| Log(Bid-ask sprds) | | 1.34** | | 1.13** | | 0.93** | | 0.69** | | 0.76** | | 0.53* | | 0.95 | | 0.93 |
| | | (0.15) | | (0.18) | | (0.17) | | (0.20) | | (0.23) | | (0.29) | | (0.61) | | (0.72) |
| Log(Turnover rate) | | | -0.03 | 0.09 | | | -0.33** | -0.23* | | | 0.11 | 0.31 | | | 0.77* | 1.17* |
| | | | (0.08) | (0.11) | | | (0.10) | (0.12) | | | (0.12) | (0.19) | | | (0.41) | (0.62) |
| 6-Month T-bill | -6.18** | -6.28** | -5.90** | -5.89** | -6.02** | -5.91** | -5.77** | -5.81** | -6.96** | -7.28** | -5.91** | -6.50** | -8.45** | -8.90** | -6.64** | -7.89** |
| | (0.29) | (0.31) | (0.27) | (0.33) | (0.30) | (0.32) | (0.29) | (0.33) | (0.60) | (0.70) | (0.56) | (0.78) | (1.73) | (1.93) | (1.63) | (2.04) |
| Treas term sprd | -8.95** | -9.08** | -8.75** | -8.80** | -8.85** | -8.69** | -8.73** | -8.71** | -10.03** | -10.44** | -8.71** | -9.70** | -8.74** | -9.29** | -6.91** | -8.52** |
| | (0.37) | (0.40) | (0.35) | (0.41) | (0.38) | (0.40) | (0.37) | (0.42) | (0.77) | (0.90) | (0.74) | (1.00) | (2.28) | (2.52) | (2.14) | (2.67) |
| Return on S&P500 | -1.55 | -2.06 | -0.43 | -3.32** | 0.44 | -1.01 | 2.42* | -1.04 | 2.61 | 5.40 | 3.88 | 1.11 | -38.71** | -35.70** | -23.41** | -33.54** |
| | (1.34) | (1.42) | (1.29) | (1.49) | (1.35) | (1.45) | (1.34) | (1.49) | (3.34) | (3.68) | (3.29) | (4.15) | (11.58) | (12.31) | (10.80) | (12.93) |
| S&P500 real. vol. | -11.39** | -11.54** | -11.71** | -11.08** | -9.03** | -8.69** | -8.78** | -8.55** | -17.29** | -17.74** | -17.00** | -17.77** | -5.76 | -7.28 | -7.18 | -6.85 |
| | (1.42) | (1.43) | (1.25) | (1.49) | (1.43) | (1.54) | (1.43) | (1.56) | (2.37) | (2.87) | (2.23) | (3.18) | (5.84) | (6.37) | (5.12) | (6.55) |
| S&P500 impl. vol. | 0.53** | 0.51** | 0.61** | 0.53** | 0.56** | 0.44** | 0.61** | 0.47** | 0.46** | 0.60** | 0.41** | 0.52** | 0.78** | 0.66* | 0.71** | 0.70* |
| | (0.07) | (0.07) | (0.06) | (0.08) | (0.07) | (0.08) | (0.07) | (0.08) | (0.13) | (0.15) | (0.12) | (0.17) | (0.35) | (0.39) | (0.31) | (0.40) |
| Treas. liquidity | 0.06 | 0.08 | 0.10* | 0.09 | 0.06 | 0.09 | 0.10* | 0.11* | 0.31** | 0.30** | 0.18** | 0.23* | -0.50* | -0.59** | -0.67** | -0.44 |
| | (0.05) | (0.06) | (0.05) | (0.06) | (0.06) | (0.06) | (0.06) | (0.06) | (0.09) | (0.11) | (0.08) | (0.12) | (0.25) | (0.27) | (0.22) | (0.28) |
| Bond char. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| CDS liq. proxies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 28380 | 22976 | 29957 | 20429 | 16125 | 14087 | 16570 | 12853 | 8630 | 6160 | 9566 | 5069 | 3625 | 2729 | 3821 | 2507 |
| Number of firms | 383 | 356 | 387 | 349 | 137 | 135 | 138 | 134 | 184 | 164 | 185 | 159 | 132 | 120 | 134 | 118 |
| $R^2$ | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.17 | 0.19 | 0.23 | 0.20 | 0.22 | 0.20 | 0.23 | 0.24 | 0.24 | 0.24 |

Table 10: **The Effects of Liquidity on Nondefault Bond Spreads When Liquidity Measures Are Computed Using "Non-News" Driven Trades**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \ \log(\text{bond [il]liquidity measures}) + \text{bond characteristics} + \text{CDS liquidity proxies} + \text{firm and time fixed effects} + \epsilon,$$

where bond liquidity measures are computed using only transactions occurred between 10:30AM and 3:30PM on any trading days. (3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| Dependent variable = Bond yield − CDS implied yield with swap rate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.38** | | | 0.17* | 0.29** | | | 0.17 | 0.31** | | | 0.02 | 0.33* | | | 0.21 |
| | (0.06) | | | (0.10) | (0.07) | | | (0.11) | (0.07) | | | (0.15) | (0.19) | | | (0.32) |
| Log(Bid-ask sprd) | | 0.96** | | 0.79** | | 0.58** | | 0.35* | | 0.70** | | 0.64** | | 0.78 | | 1.01 |
| | | (0.15) | | (0.17) | | (0.16) | | (0.18) | | (0.24) | | (0.29) | | (0.61) | | (0.67) |
| Log(Turnover rate) | | | -0.11 | -0.14 | | | -0.37** | -0.38** | | | 0.18* | 0.07 | | | 0.84** | 1.16* |
| | | | (0.07) | (0.11) | | | (0.08) | (0.11) | | | (0.10) | (0.20) | | | (0.38) | (0.63) |
| Bond char. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| CDS liq. proxies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 27427 | 19924 | 29598 | 17674 | 15738 | 12696 | 16457 | 11543 | 8165 | 4952 | 9335 | 4028 | 3524 | 2276 | 3806 | 2103 |
| Number of firms | 376 | 345 | 386 | 335 | 136 | 133 | 138 | 130 | 180 | 155 | 185 | 151 | 130 | 116 | 133 | 112 |
| $R^2$ | 0.22 | 0.23 | 0.23 | 0.23 | 0.27 | 0.27 | 0.27 | 0.28 | 0.31 | 0.27 | 0.30 | 0.26 | 0.28 | 0.30 | 0.29 | 0.31 |

Table 11: **The Effects of Liquidity on Nondefault Bond Spreads When Treasury Rate Is Used as Risk-Free Rate**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \text{ log(bond [il]liquidity measures)} + \text{bond characteristics} + \text{CDS liquidity proxies} + \text{firm and time fixed effects} + \epsilon,$$

where CDS implied bond yields are computed using Treasury rate as risk-free rate. (3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| | Dependent variable = Bond yield − CDS implied yield with Treasury rate | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.42** | | | 0.32** | 0.29** | | | 0.26** | 0.37** | | | 0.23* | 0.23 | | | 0.51 |
| | (0.06) | | | (0.10) | (0.08) | | | (0.12) | (0.08) | | | (0.14) | (0.21) | | | (0.32) |
| Log(Bid-ask sprd) | | 1.15** | | 0.82** | | 0.68** | | 0.35* | | 0.75** | | 0.39 | | 1.13* | | 0.97 |
| | | (0.15) | | (0.18) | | (0.18) | | (0.21) | | (0.23) | | (0.28) | | (0.62) | | (0.75) |
| Log(Turnover rate) | | | -0.31** | -0.20* | | | -0.53** | -0.43** | | | 0.05 | 0.13 | | | 0.23 | 0.91 |
| | | | (0.08) | (0.11) | | | (0.10) | (0.12) | | | (0.12) | (0.19) | | | (0.44) | (0.65) |
| Coupon | 1.61** | 1.63** | 1.52** | 1.55** | 1.41** | 1.33** | 1.40** | 1.20** | 1.28** | 1.55** | 1.18** | 1.27** | 3.30** | 4.22** | 3.09** | 4.73** |
| | (0.12) | (0.13) | (0.11) | (0.13) | (0.12) | (0.12) | (0.12) | (0.13) | (0.21) | (0.27) | (0.20) | (0.29) | (0.50) | (0.60) | (0.49) | (0.64) |
| Bond char. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| CDS liq. proxies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 28359 | 22961 | 29909 | 20408 | 16311 | 14218 | 16792 | 12963 | 8512 | 6073 | 9407 | 4995 | 3536 | 2670 | 3710 | 2450 |
| Number of firms | 384 | 355 | 388 | 348 | 137 | 135 | 138 | 134 | 185 | 165 | 186 | 160 | 133 | 119 | 135 | 116 |
| $R^2$ | 0.28 | 0.29 | 0.28 | 0.28 | 0.35 | 0.36 | 0.35 | 0.37 | 0.33 | 0.30 | 0.32 | 0.29 | 0.27 | 0.28 | 0.27 | 0.28 |

Table 12: **The Effects of Liquidity on Nondefault Bond Spreads When Coupon Effects Are Not Removed**

(1) Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \log(\text{bond [il]liquidity measures}) + \text{bond characteristics} + \text{CDS liquidity proxies} + \text{firm and time fixed effects} + \epsilon,$$

where basis spreads equal to the difference between bond spreads and comparable-maturity CDS premiums. (3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| Dependent variable = Bond yield − Swap rate − CDS premium | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.48** | | | 0.31** | 0.36** | | | 0.17 | 0.41** | | | 0.25* | 0.37* | | | 0.64** |
| | (0.06) | | | (0.10) | (0.07) | | | (0.11) | (0.07) | | | (0.13) | (0.20) | | | (0.31) |
| Log(Bid-ask sprd) | | 1.31** | | 1.03** | | 0.99** | | 0.72** | | 0.84** | | 0.51* | | 1.03* | | 0.87 |
| | | (0.14) | | (0.17) | | (0.16) | | (0.18) | | (0.22) | | (0.27) | | (0.60) | | (0.71) |
| Log(Turnover rate) | | | -0.17** | -0.07 | | | -0.39** | -0.32** | | | 0.03 | 0.06 | | | 0.59 | 0.93 |
| | | | (0.08) | (0.11) | | | (0.09) | (0.11) | | | (0.12) | (0.19) | | | (0.42) | (0.62) |
| Coupon | 1.29** | 1.15** | 1.14** | 1.13** | 1.09** | 0.98** | 1.07** | 0.89** | 1.08** | 1.14** | 0.90** | 0.96** | 2.49** | 2.90** | 2.11** | 3.32** |
| | (0.11) | (0.12) | (0.10) | (0.12) | (0.10) | (0.11) | (0.10) | (0.11) | (0.20) | (0.26) | (0.19) | (0.28) | (0.48) | (0.58) | (0.46) | (0.62) |
| Bond char. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| CDS liq. proxies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 28362 | 22957 | 29941 | 20399 | 16196 | 14122 | 16659 | 12880 | 8597 | 6142 | 9517 | 5046 | 3569 | 2693 | 3765 | 2473 |
| Number of firms | 383 | 356 | 387 | 349 | 137 | 135 | 138 | 134 | 183 | 163 | 184 | 158 | 133 | 121 | 134 | 118 |
| $R^2$ | 0.22 | 0.21 | 0.22 | 0.22 | 0.25 | 0.25 | 0.25 | 0.26 | 0.30 | 0.27 | 0.30 | 0.27 | 0.27 | 0.28 | 0.26 | 0.29 |

Table 13: **Liquidity Effects on Nondefault Bond Spreads with Non-Callable Bonds Only**

(1) The sample consists of only straight bullet bonds. Brief variable definitions are in Table 2 with details shown in the main text. (2) Each column reports the result of the following regression:

$$\text{Basis spreads} = c + \alpha \log(\text{bond [il]liquidity measures}) + \text{bond characteristics} + \text{CDS liquidity proxies} + \text{firm and time fixed effects} + \epsilon.$$

(3) Figures in parentheses are robust standard errors. (4) * and ** indicate that the coefficient is statistically significant at the 90 and 95 percent confidence level, respectively.

| Dependent variable = Bond yield − CDS implied yield with swap rate | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Bonds | | | | A- or higher | | | | BBB-, BBB, BBB+ | | | | Speculative-grade | | | |
| Independent var. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| Log(Amihud Illiq.) | 0.38** | | | 0.17 | 0.30** | | | 0.05 | 0.42** | | | 0.17 | -0.60 | | | -0.20 |
| | (0.11) | | | (0.16) | (0.12) | | | (0.17) | (0.19) | | | (0.34) | (0.39) | | | (0.62) |
| Log(Bid-ask sprd) | | 1.25** | | 1.02** | | 0.97** | | 0.84** | | 1.11** | | 0.26 | | -0.87 | | 0.07 |
| | | (0.23) | | (0.26) | | (0.24) | | (0.27) | | (0.50) | | (0.59) | | (1.20) | | (1.38) |
| Log(Turnover rate) | | | -0.45** | -0.34** | | | -0.37** | -0.27* | | | -0.64** | -0.78** | | | 0.70 | 0.53 |
| | | | (0.13) | (0.16) | | | (0.14) | (0.16) | | | (0.25) | (0.37) | | | (0.75) | (1.12) |
| Coupon | 1.82** | 1.75** | 1.77** | 1.65** | 1.76** | 1.65** | 1.70** | 1.61** | 2.31** | 2.60** | 2.13** | 1.96** | 4.30** | 5.01** | 3.95** | 5.18** |
| | (0.14) | (0.14) | (0.13) | (0.14) | (0.13) | (0.13) | (0.13) | (0.14) | (0.48) | (0.52) | (0.46) | (0.60) | (1.11) | (1.34) | (0.96) | (1.45) |
| Log(Bond size) | -0.58** | -0.33 | -0.39 | -0.15 | -0.61** | -0.53** | -0.50** | -0.35 | -0.75 | -0.71 | 0.07 | 0.49 | -3.02 | -1.76 | -1.76 | -2.11 |
| | (0.25) | (0.26) | (0.25) | (0.27) | (0.23) | (0.24) | (0.24) | (0.25) | (1.08) | (1.11) | (1.06) | (1.16) | (2.24) | (2.69) | (1.97) | (2.85) |
| N. of CDS quotes | 0.17** | 0.18** | 0.21** | 0.23** | 0.15** | 0.13** | 0.18** | 0.15** | 0.08 | 0.42** | 0.11 | 0.64** | 0.23 | 0.06 | 0.25 | 0.29 |
| | (0.05) | (0.06) | (0.05) | (0.06) | (0.05) | (0.05) | (0.05) | (0.06) | (0.13) | (0.15) | (0.12) | (0.18) | (0.29) | (0.34) | (0.27) | (0.35) |
| Lagged CDS spread | -0.06** | -0.08** | -0.08** | -0.08** | -0.05** | -0.04** | -0.03** | -0.03** | -0.12** | -0.14** | -0.12** | -0.14** | -0.04 | -0.08** | -0.10** | -0.08** |
| | (0.02) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.02) | (0.01) | (0.02) | (0.03) | (0.01) | (0.01) | (0.01) |
| Constant | 19.40** | 18.34** | 18.46** | 18.97** | 14.03** | 13.08** | 11.64** | 12.72** | 53.69** | 56.52** | 48.57** | 51.69** | 23.33 | 16.72 | 14.97 | 20.84 |
| | (2.94) | (2.63) | (2.54) | (2.88) | (2.42) | (2.49) | (2.48) | (2.69) | (9.83) | (11.28) | (9.76) | (12.74) | (16.99) | (21.62) | (14.86) | (23.07) |
| Bond age polyn (4) | Yes** | Yes** | Yes** | Yes** | Yes | Yes** | Yes | Yes** | Yes | Yes | Yes | Yes** | Yes** | Yes** | Yes** | Yes** |
| Rem. mat polyn (4) | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** | Yes** |
| Observations | 11212 | 9639 | 11504 | 8701 | 8225 | 7426 | 8369 | 6804 | 1932 | 1461 | 1999 | 1217 | 1055 | 752 | 1136 | 680 |
| Number of firms | 205 | 191 | 206 | 181 | 90 | 87 | 89 | 84 | 86 | 76 | 87 | 69 | 57 | 52 | 59 | 52 |
| $R^2$ | 0.19 | 0.20 | 0.20 | 0.21 | 0.23 | 0.23 | 0.22 | 0.24 | 0.36 | 0.38 | 0.36 | 0.39 | 0.31 | 0.33 | 0.33 | 0.34 |

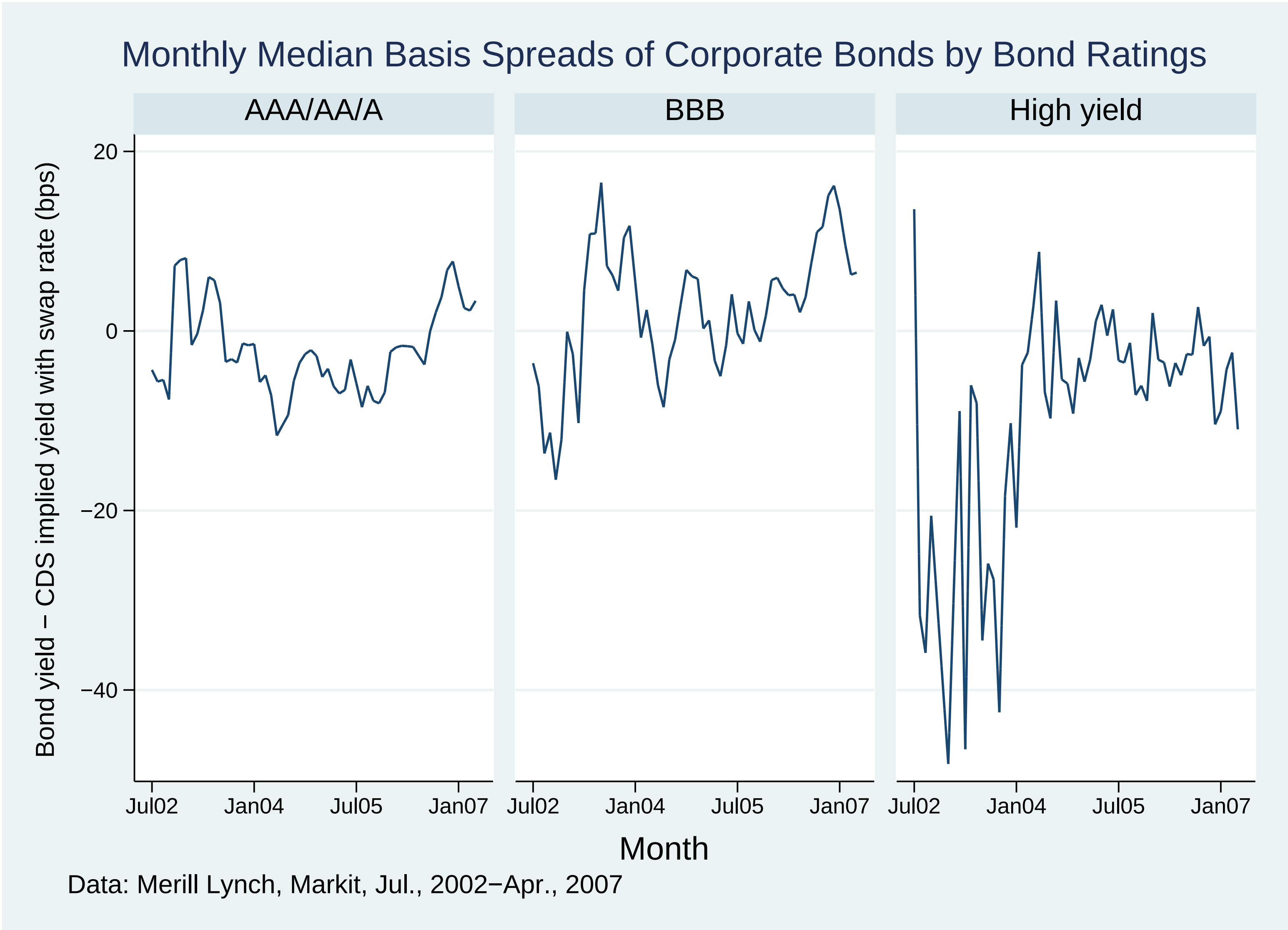
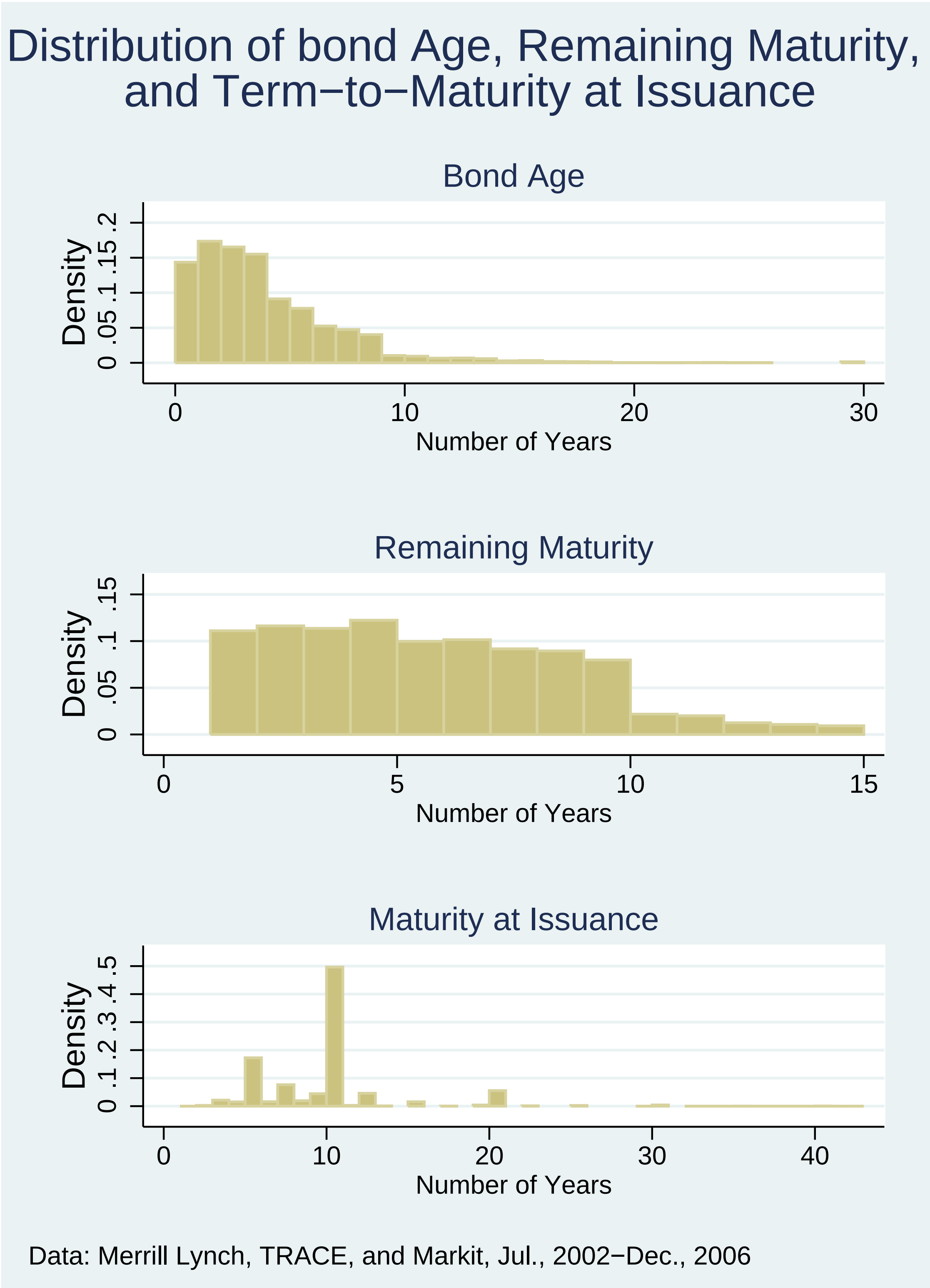



Figure 1: Time Series Plots of Basis Spreads of Corporate Bonds by Bond Ratings

Figure 2: Distributions of Bond Age, Remaining Maturity, and Maturity at Issuance



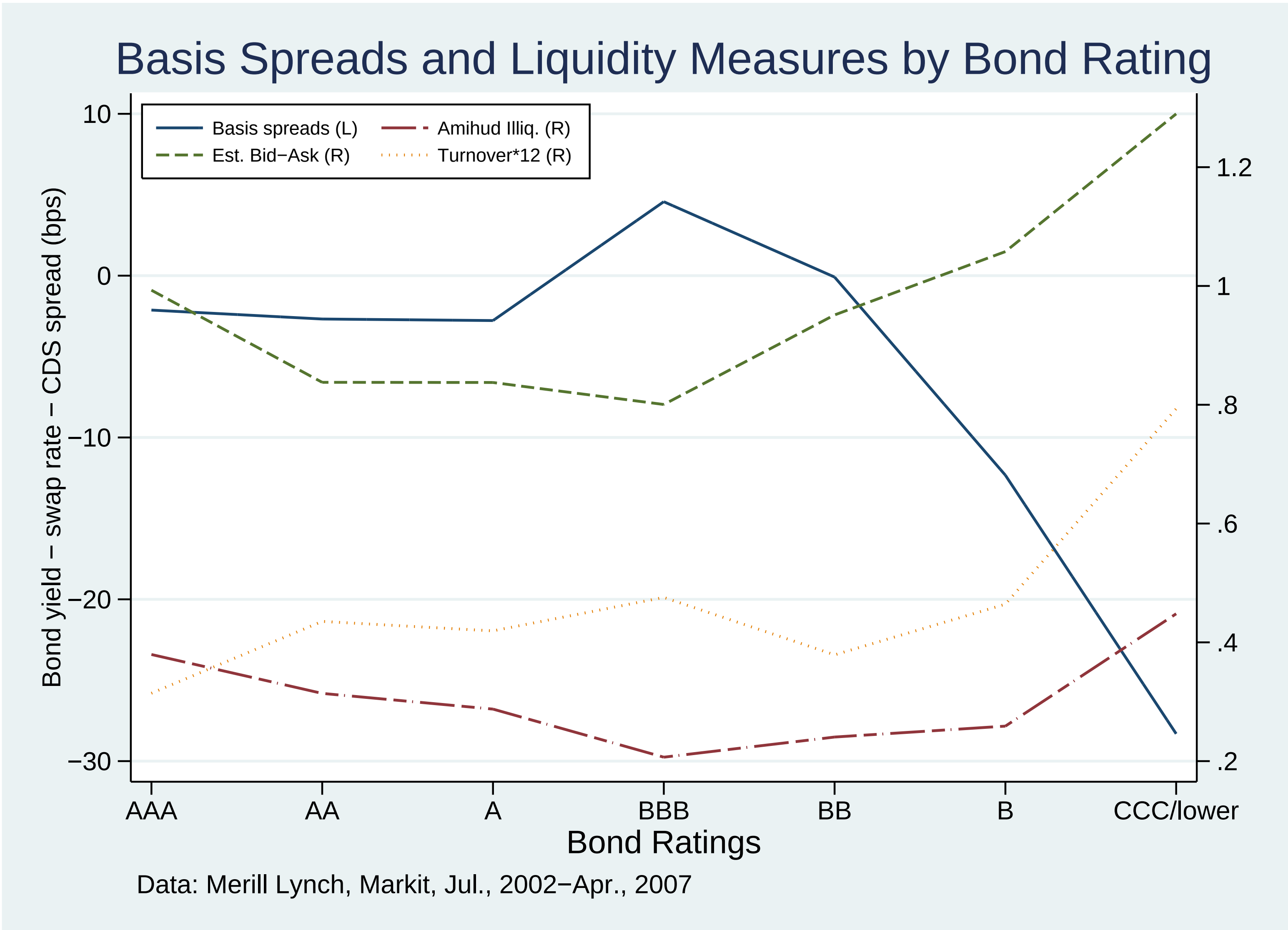



Figure 3: Basis Spreads and Liquidity Measures by Bond Ratings

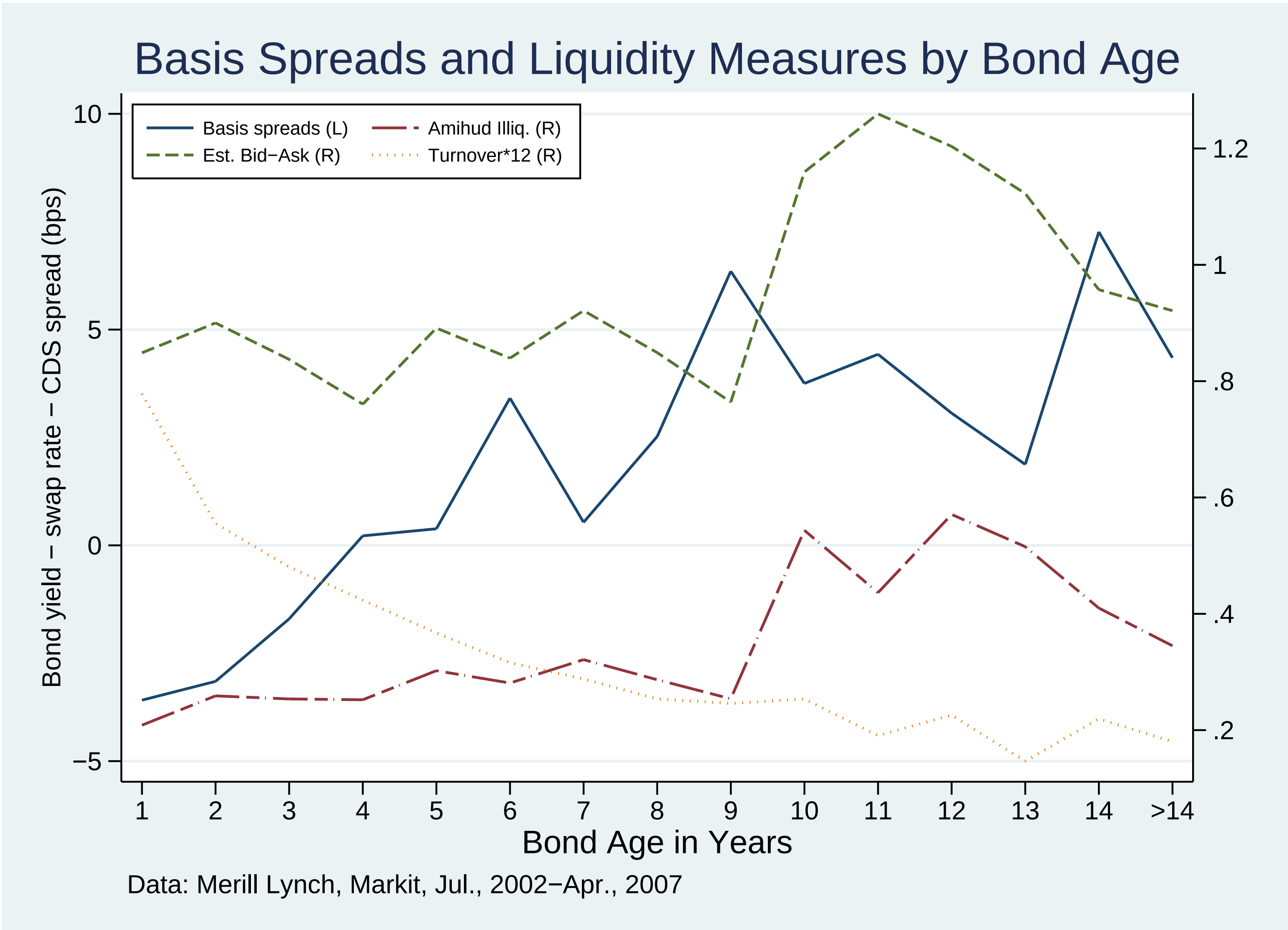



Figure 4: Basis Spreads and Liquidity Measures by Bond Age

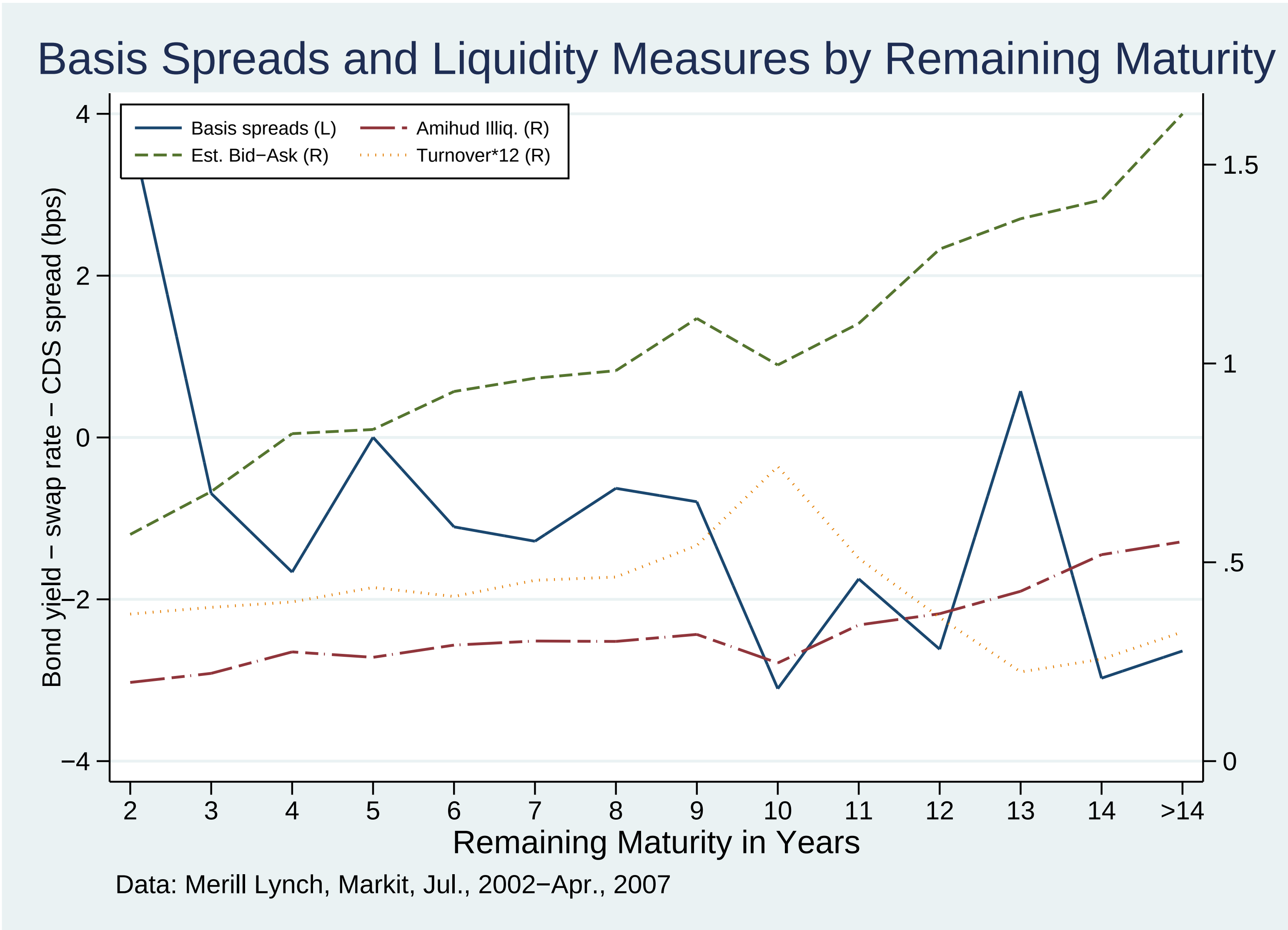



Figure 5: Basis Spreads and Liquidity Measures by Remaining Maturity

Figure 6: Relations between Trading Liquidity Measures and Bond Age and Remaining Maturity

This figure plots trading liquidity measures as 4th-order polynomials in bond age and in remaining term to maturity based on the coefficients estimated in Table 7.

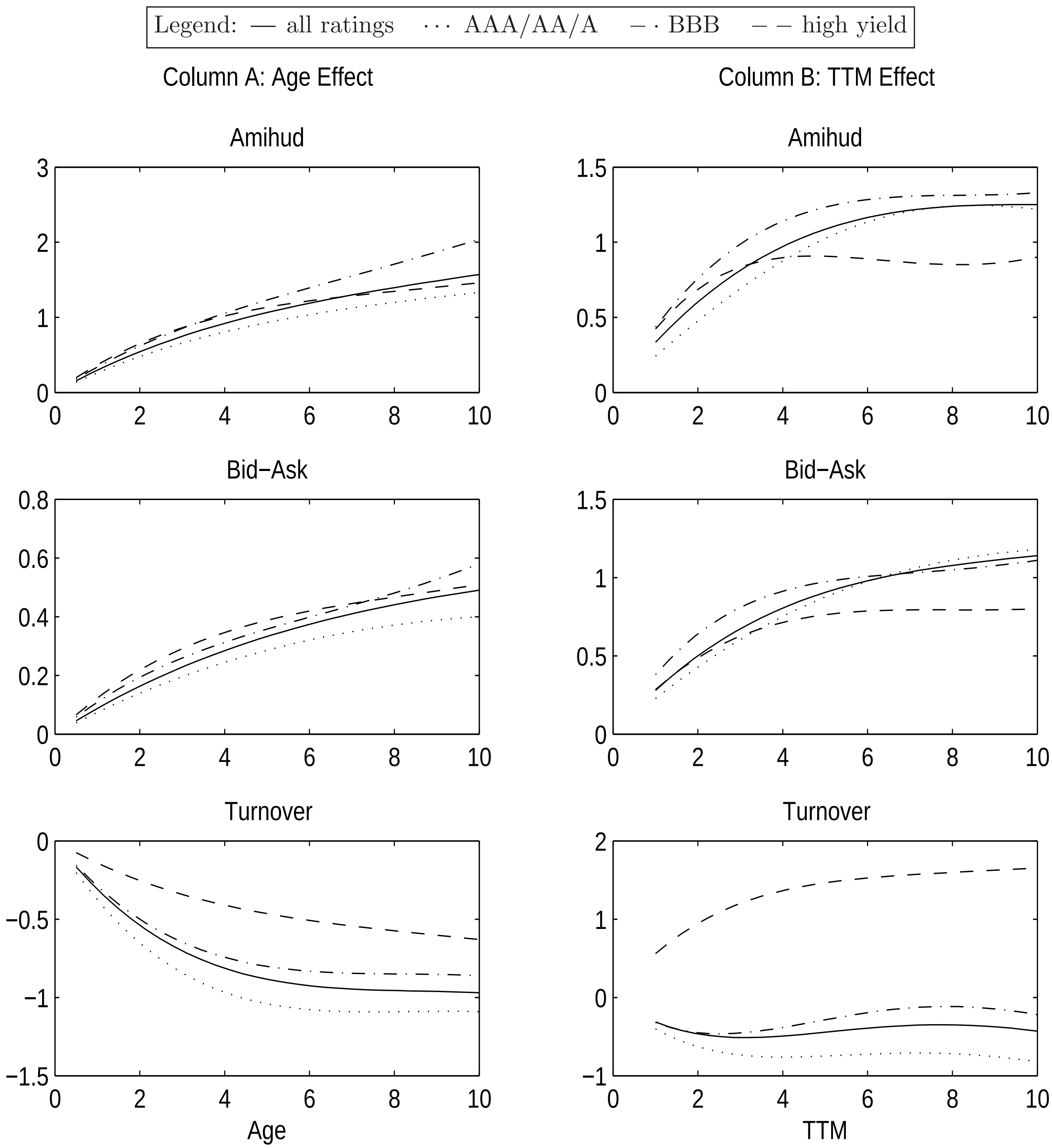


Figure 7: Relations between Basis Spreads and Bond Age and Remaining Maturity

This figure plots basis spreads as 4th-order polynomials in bond age and in remaining term to maturity based on the coefficients estimated in Table 5.

Legend: — all ratings · · · AAA/AA/A – · BBB – – high yield