(Il)liquidity Premium in Credit Markets: A Myth?

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March 29, 2018

Abstract

Across multiple measures of "liquidity" and a variety of methods to control for correlated characteristics of more (less) liquid bonds, we find only limited evidence of a liquidity premium in the cross section of corporate bonds. Specifically, while illiquid bonds have slightly higher credit spreads and directionally higher average returns, portfolios that tilt toward (away from) less (more) liquid bonds exhibit considerably higher levels of volatility. Economically, the low Sharpe ratios of illiquidity-factor-mimicking portfolios are hard to justify for an investor. This is puzzling, as theory suggests investors should demand a risk premium for holding less-liquid assets.

JEL classification: G12; G14; M41
Key words: corporate bonds, liquidity, risk premium

We thank Attakrit Asvanunt, Andrea Eisfeldt, Tony Gould, Antti Ilmanen, Ronen Israel, Nils Ladefoged, Toby Moskowitz, Chris Palazollo, and Lasse Pedersen for helpful discussion and comments. We acknowledge the research assistance of Peter Diep and Atul Tiwary. AQR Capital Management is a global investment management firm, which may or may not apply similar investment techniques or methods of analysis as described herein. The views expressed here are those of the authors and not necessarily those of AQR.

1. Introduction

Liquidity risk is an important determinant of security prices. The perceived liquidity profile of an asset should affect security prices directly as investors demand protection for the future challenge to exit that position in a cost-effective and timely manner. Amihud, Mendelson, and Pedersen (2012) provide a thorough summary of the theoretical and empirical evidence supporting the notion that higher illiquidity reduces security prices and raises expected returns for less-liquid assets. Our objective is to test this notion in corporate bond markets. Corporate bonds are an attractive setting to examine whether, and to what extent liquidity risk is priced in secondary markets. First, the market for corporate bonds is very large, amounting to nearly $12 trillion outstanding across investment-grade and high-yield issuers globally. Second, there is a very large cross section of both issuers and issues. Unlike equity markets, where there is typically only one instrument per issuer traded in secondary markets, credit markets provide a rich experimental setting where we can hold issuer effects fixed and focus on differences in liquidity across bonds issued by the same issuer. This allows for a strong identification strategy to link liquidity characteristics to credit-excess returns. Third, the corporate bond market is characterized by relatively low liquidity. In contrast to stocks, bonds trade far less frequently and typically have a much higher bid-offer spread relative to underlying volatility (Israel, Palhares, and Richardson, 2018). Collectively, this makes corporate bonds a rich setting to explore the pricing of liquidity risk.

To date, the empirical finance literature has documented that illiquid bonds tend to have higher spreads than liquid bonds (e.g., Bao, Pan, and Wang, 2011; Dick-Nielsen, Feldhutter, and Lando, 2012; and Chen, Lesmond, and Wei, 2007) and label that difference in average spreads a liquidity premium. This result, while interesting, does not translate into a meaningful portfolio implication for a credit investor. Knowing that illiquid bonds have higher spreads than liquid bonds suggests that an illiquidity-factor portfolio (i.e., a portfolio long the most illiquid bonds and short the most liquid bonds) will have a positive carry. However, while credit spreads adjusted for default risk may be informative about hold-to-maturity returns, they do not tell us the experience an investor would face from holding such a portfolio. For that we need to examine both future excess returns and the associated volatility of those excess returns. Our focus is to assess whether an illiquidity factor portfolio is compensated with a positive risk-adjusted excess return: a necessary condition for an investor to actively seek exposure to less-liquid corporate bonds.

Our empirical setup is to investigate whether illiquid bonds do indeed have higher spreads and then assess whether those higher spreads translate into higher average credit excess returns. To test this assertion we use a comprehensive set of US corporate bonds between January 1997 and December 2016. Our dataset includes constituents of the Bank of America Merrill Lynch ("BAML") investment-grade ("US Corporate Master Index") and high-yield ("US High Yield Master Index") indices. We use a variety of measures that should reflect the underlying liquidity of each bond including measures related to the bid-ask spread, average daily trading volumes, turnover, issue size, price impact, and frequency of zero trading days. A more liquid bond is one with a tighter bid-ask spread, greater trading volume, greater turnover, larger issue size, smaller price impact, and lower frequency of zero trading days. These bond-specific liquidity characteristics directly capture the idea of liquidity risk: how easy will it be for an investor to exit a position at a later date in a cost-effective and timely manner? For example, if the bid-ask spread is wide and/or there is little evidence of actual trading, then all else being equal, such a bond would be harder to exit at a later date. Hence, bonds with these characteristics should be priced lower to compensate for that risk, increasing their expected returns. It is important to note that our empirical analysis focuses on liquidity as a characteristic as opposed to a "liquidity beta." This is a deliberate choice that is consistent with a lot of past research, but most importantly it is of direct relevance from an investor's perspective: how easily can I sell my bond, and how is that risk priced? While it may be interesting to assess whether corporate bonds that realize low pay-offs when overall market liquidity is low receive higher risk-adjusted returns, this is not our focus. We discuss related work on the covariance (liquidity beta) dimension in section 4.3.7.

The correlation structure across the measures of liquidity is largely expected. First, measures of bid-ask spread and price impact are positively correlated, reflecting the direct costs of trading. Second, daily trading volume, issue size, and frequency of zero trading days are all strongly positively correlated, reflecting the ability to trade. While there is a strong positive correlation within these two types of measures (cost of trading and ability to trade), they are lowly correlated with each other. We therefore look at our measures of liquidity individually and jointly in our empirical analyses, as these measures could be capturing different aspects of the ease of trading.

For both our investment-grade and high-yield universes, we find some evidence that spreads are positively correlated with liquidity measures. Specifically, we find that there is a positive correlation between our measures of the cost to trade (i.e., bid-ask spreads and market impact) and credit spreads for both investment-grade and high-yield markets. We find a weaker correlation between our measures of the ability to trade (daily trading volume, issue size, and frequency of zero trading days) and credit spreads for both investment-grade and high-yield markets. Overall the results are consistent with the positive relation between spreads and illiquidity found in previous work (e.g., Bao, Pan, and Wang, 2011; Dick-Nielsen, Feldhutter, and Lando, 2012; and Chen, Lesmond, and Wei, 2007). While this evidence may be suggestive of investor demands for a risk premia due to taking liquidity risk, it is far from conclusive. Ilmanen (2011) notes that credit spreads do not map directly into the return that a credit investor ultimately experiences. For that, we must assess whether an illiquidity-factor portfolio is compensated with a positive risk-adjusted excess return.

To assess whether the higher spreads of less-liquid bonds translate into higher future credit-excess returns we examine academic style long/short portfolios. Each month we sort our universe of corporate bonds into quintiles based on each liquidity measure and compute a long/short portfolio return by buying the least liquid bonds (i.e., smaller issue sizes, higher bid-ask spreads, lower trading volume, higher price impact, or higher frequency of zero trading days) and selling the most liquid bonds (i.e., larger issues sizes, smaller bid-ask spreads, higher trading volume, lower price impact, or lower frequency of zero trading days). We find that most of those portfolios earned positive average returns and that the magnitude of those returns was in line with the spread advantage of illiquid bonds. The most surprising result, however, is that these positive average returns are indistinguishable from zero. Further, the various long/short illiquidity portfolios experienced sufficiently volatile returns such that the small credit spread advantage and positive average returns of less-liquid bonds did not translate into economically or statistically significant Sharpe ratios. As a consequence, illiquidity factors would receive close to a zero allocation in typical investor portfolios, and this conclusion comes *before* considering the impact of higher expected transaction costs for less-liquid bonds. As a point of comparison, both Houweling and van Zundert (2017) and Israel, Palhares, and Richardson (2018) report Sharpe ratios well in excess of 1.0 for academic long/short corporate bond portfolios and information ratios above 0.8 for long-only corporate bond portfolios. Put another way, while liquidity risk affects price a little, consistent with theory and past empirical research, the effect is very small, and importantly, liquidity risk is not a key driver of credit-excess returns.

Our conclusion that less-liquid bonds appear to be insufficiently compensated to be included in investor portfolios is robust to alternative measures of risk-adjusted returns. A common criticism is that expected returns are too noisy to be estimated from realized excess returns, especially with limited time series data. This is valid criticism, as we have access to only twenty years of corporate bond return data. In lieu of using realized full-sample excess returns when computing Sharpe ratios of the various liquidity portfolios, we can also use the ex-ante credit spread difference across the long and short leg of the liquidity long/short portfolios. Our inferences are unaffected by this ex-ante Sharpe ratio computation: illiquidity factors would still receive close to a zero allocation in typical investor portfolios.

A potential limitation of the academic long/short portfolios is that sorting on bond liquidity may be simultaneously sorting on another compensated characteristic (e.g., duration, spread, or credit risk itself) that affects average returns and/or risk. To address this issue, we run two additional sets of analyses.

First, we run cross-sectional regressions, which allows us to consider the liquidity measures both individually and in combination, as well as control for the bond systematic risk as measured by DTS (spread duration times spread) of the bond (see e.g., Ben Dor et al., 2007). Dollar-neutral long/short portfolios that are common in academic research may be beta imbalanced, and as such, inherit exposures to market risk premia. This can confound inferences for liquidity long/short portfolio returns: is it due to liquidity or standard beta? We use cross-sectional regressions to control for the effect of "beta" and find that for both investment-grade and high-yield corporate bond markets, all liquidity characteristics have no significant association with future credit excess returns.

Second, in an attempt to produce a strategy free of extraneous exposures, we examine the link between liquidity and future credit excess returns using a difference-in-difference design. Specifically, for issuers that have multiple bonds outstanding, we select pairs of bonds for an issuer that are sufficiently different along each liquidity dimension but similar in terms of the remaining maturity. This allows us to create a "pair" asset where we long the least liquid bond from a given issuer and short the more liquid bond. These "pairs" can be dollar neutral or risk neutral. Across both investment-grade and high-yield corporate bond markets, we continue to find some evidence of a credit-spread advantage for the less-liquid bonds, especially in the dollar-neutral pair construction. We also find that this pair portfolio construction substantially reduces the risk of the long/short portfolio, especially for the beta-neutral pair construction. However, despite the continued spread advantage and lower volatility, we do not find evidence of economically or statistically significant Sharpe ratios. Across the twenty specifications (five liquidity measures, dollar/risk neutral choice, IG/HY), there is not one pair asset that has a significantly positive return.

Separate from our direct measures of liquidity we also examine one other bond characteristic that past research has suggested could be indicative of lower levels of liquidity: time since issuance. There is a lengthy literature documenting that government bonds with almost identical cash flows trade at different prices (see e.g., Cornell and Shapiro, 1990; Krishnamurthy, 2002; Goyenko, Subrahmanyam, and Ukhov, 2011; and Boudoukh, Brooks, Richardson, and Xu, 2017). The standard explanation offered for this positive-yield spread between newly issued and previously issued bonds is the premium investors are willing to pay for immediacy. We repeat all of our analyses using time since issuance as the relevant bond characteristic and find that while older bonds are not associated with wider credit spreads, they are associated with higher future credit-excess returns. This pattern is robust for investment-grade and high-yield corporate bonds and is evident in academic long/short quintile portfolios, cross-sectional regressions controlling for direct liquidity measures and risk, as well as our difference-in-difference design. The interpretation of this result is not that it supports the existence of a liquidity risk premium in the cross section of corporate bonds. This is because the more direct measures of liquidity such as trading volume, price impact, turnover, bid-ask spreads, and frequency of zero trading days show no relation to future excess-credit returns. Instead, it must be either (i) a bond characteristic that investors either neglect or shy away from, or (ii) time since issuance captures some unobservable component of liquidity. We are unable to find evidence that time since issuance is either associated with contemporaneous or future measures of liquidity, so our interpretation is akin to Merton (1987) investor recognition, in which investors on average neglect/avoid older off-the-run bonds, not because they are less liquid per se (as we control for that directly in our analysis) but for some other non-observable reason.

The remainder of the paper proceeds as follows. Section 2 briefly summarizes the past theoretical and empirical literature documenting a liquidity risk premium. Section 3 explains our data sources, sample-selection criteria, liquidity measures, and research design. Section 4 describes our empirical analyses, and section 5 concludes.

2. Literature Review

Our paper relates to a growing literature on illiquidity risk premiums. Ilmanen (2011) and Ang (2014) both summarize a vast literature (theoretical and empirical) suggesting that there should be a premium for investors who are willing to bear illiquidity risk. If liquidity is a valued characteristic, then cross-sectional variation in that characteristic should be associated with future excess returns. Our objective is to test this theory using a comprehensive set of data for corporate bonds. As discussed in the introduction, both the size of the corporate bond market and the fact that we can track liquidity differences across assets linked back to the same issuer makes the corporate bond market a rich setting to explore the pricing of liquidity risk.

There are two broad types of literature relevant to our empirical analysis. The first stream of research has focused on fixed income securities with an emphasis on how liquidity measures correlate with ex-ante prices (e.g., yields and spreads). These papers typically correlate measures of corporate bond liquidity (e.g., serial correlation in daily returns or fraction of zero trading days) with corporate bond yields and corporate bond spreads and find that more liquid bonds have lower yields and/or spreads (see e.g., Bao, Pan, and Wang, 2011; Dick-Nielsen, Feldhutter, and Lando, 2012; and Chen, Lesmond, and Wei, 2007). Other examples of empirical research examining the pricing of liquidity risk in fixed income markets include (i) Longstaff (2004), who documents a positive difference in zero coupon yields between Resolution Funding Corporation bonds and US Treasury bonds and attributes this to a flight-to-liquidity (or flight-to-quality) sentiment of investors, and (ii) Schuster and Uhrig-Homburg (2014), who analyse the term structure of illiquidity premiums for German government bonds and Kreditanstalt fur Wiederaufbau (KfW) bonds guaranteed by the German government, and they likewise find evidence of this premium varying with investor liquidity preferences. These examples are “clean” in the sense that the cash flows of the bonds are directly comparable, allowing for strong inferences to be drawn from any difference in security prices. However, these settings are “not clean” in the sense that direct measures of liquidity across these bond types (e.g., bid-ask spreads, depth, volumes) are not linked to the observed difference in yields. Indeed, Longstaff (2004) notes that differences in bid-ask spreads across US Treasury bonds and RefCorp bonds are not large enough to explain the observed difference in yields, suggesting that the pricing difference may be due to something other than liquidity per se. In our setting of corporate bonds, we are able to sample multiple bonds from the same issuer and thereby control for issuer-specific credit risk when we compare the pricing implications of differences in corporate bond liquidity. Any difference in pricing or future credit-excess returns we can then attempt to link back to direct liquidity measures of the underlying bonds.

The second stream of related research is mostly from the equity markets and has focused on establishing a relationship between liquidity as a characteristic or a liquidity beta and future stock-excess returns. Perhaps the closest paper from this literature is Ang, Shtauber, and Tetlock (2013), who examine the cross section of returns of OTC stocks. They find strong evidence of illiquidity premiums. For measures of the percentage of zero trading days (designed to capture whether investors want to trade) and trading volumes (designed to capture the extent of trading), associated-factor-mimicking portfolios exhibit Sharpe ratios close to 1.0. Cross-sectional regressions also show that these liquidity characteristics are strongly related to future excess returns, with test statistics in excess of 4.0. However, such results are not evident in exchange-listed stocks, even for sub-samples based on similar-size listed securities. Indeed, Hou, Xue, and Zhang (2017) find that illiquidity-related measures are some of the least reliable characteristics to explain future equity-excess returns. Further analysis in Ang, Shtauber, and Tetlock (2013) finds that the return spread is attributable to the more liquid stocks (who have significantly negative returns) rather than the less liquid stocks (whose returns are not significantly different from zero). So even though this setting finds evidence of a priced liquidity factor, it is hard to link it back to expected difficulties in trading, which is why that premium should exist.

While this past research is clearly related to our paper, past authors typically examine only one dimension of liquidity and only examine the ex-ante pricing implications of their measure. Our objective is broader, to (i) consider multiple measures of liquidity (covering both the ability to trade and expected costs to trade) and (ii) consider both ex-ante and ex-post pricing implications of liquidity. Ascertaining whether illiquid corporate bonds have higher credit spreads should only be an intermediate goal for both researchers and investors. The ultimate objective is to assess whether liquidity risk is sufficiently compensated. That means our empirical analysis will look at both the relation between liquidity measures of credit spreads as well as future credit-excess returns.

A general criticism of all empirical research work seeking to document evidence of liquidity premia, our analysis included, is that the liquidity characteristics can be correlated with other compensated risk premia, including traditional market exposures (e.g., betas to equity or credit-risk premia) or more alternative risk premia (e.g., exposure to volatility risk premia or another compensated issuer characteristic). Our empirical analysis attempts to control for this by including issuer- and issue-specific measures of risk as well as the within issuer research design mentioned above. Of course, these are not perfect solutions, and to the extent we find any evidence of priced liquidity risk, the interpretation of why it exists may be hard to attribute.

3. Data and Methodology

3.1 Corporate Bond Data

We use corporate bond monthly returns and analytics (such as spread duration, option-adjusted spread, etc.) from Bank of America Merrill Lynch (BAML). Monthly returns are computed based on daily end-of-day prices from Interactive Data Corporation (IDC). These returns are inclusive of default events. Bond analytics are computed using industry-standard methodology. A key benefit of returns from index providers such as BAML is that they are all aligned in calendar time, allowing for clean cross-sectional analysis. A potential shortcoming is that month-end prices may not be based on actual trades and instead on interpolated data from trades of similar securities. This data limitation is expected to be greatest for bonds that are less liquid, and as such may affect our inferences. We do not expect interpolated prices to be directionally biased, but we do expect them to be less precise. Given our analysis is designed to look for a liquidity premium (i.e., less-liquid bonds should have higher future credit-excess returns), for stale prices to affect an inference it would have to be the case that less-liquid bonds were systematically marked too low. We see no reason for this directional bias. Attempts to compute bid-to-bid or ask-to-ask returns from transaction prices and still ensure cross-sectional comparability in return intervals would drastically limit the sample to only the most liquid and actively traded bonds. Clearly, this would not be an interesting sample to look for evidence of an illiquidity premium. However, insofar as we do find any evidence of an illiquidity premium, the extent to which it could be captured by an investor is not addressed by our analysis, as it is all gross of any trading costs.

Our universe is comprised of the constituents of the BAML US Corporate Index (C0A0) and the BAML US High Yield Index (H0A0). These two indices represent the investable universe of US-dollar-denominated investment-grade and high-yield corporate bonds publicly issued in the US domestic market.[1] Our resulting sample includes 1,121,799 unique bond-month observations, corresponding to 27,983 bonds issued by 5,310 unique firms. Table 2 reports details of the composition of our sample over time. The average month in the sample consists of 3,539 (1,116) bonds representing $2,137 ($486) billion of total notional outstanding, of which 81 percent (18 percent) corresponds to investment-grade (high-yield) issues.

For many of the liquidity measures, we rely on TRACE data. We use two distinct databases: the enhanced database from July 2002 to June 2014 and the conventional database thereafter. The enhanced database contains complete information about trade sizes. The conventional database discloses capped trade sizes, i.e., investment-grade bond trade sizes up to $5 million are fully disclosed, but for trades above that threshold, just the average trade size of all trades that met the cap in the previous month is reported. For high-yield corporate bonds, the cap is smaller: $1 million rather than $5 million.

3.2 Liquidity Measures

[1] We exclude non-corporates that used to be included in these indices in the early time period.

A liquid asset is one that can be bought or sold at a reasonable size, in a relatively short period of time, at a reasonable cost, without significant impact on its value. In this section, we define the various liquidity measures for corporate bonds. With the exception of age, we chose measures that are directly related to the liquidity definition above.

3.2.1 Bid-Ask (BA) Spread

This is a measure of how much it costs to trade a bond (excluding price impact). We estimate bid-ask spreads using institutional trades in TRACE. We focus on institutional trades, defined as trades with face values $100,000 or larger (see e.g., Edwards, Harris, and Piwowar, 2007). For a given bond on a given day, we compute the bid price as the volume-weighted average of the price for all trades in which dealers bought from customers. Similarly, we compute the ask price as the volume-weighted price for all trades in which dealers sold to customers as reported in TRACE. The bid-ask spread is the difference between those two prices. Note that we need at least two trades in opposite directions in a given day to be able to compute the bid-ask spread for that day. A consequence of this choice is that we are measuring bid-ask spread from transaction prices, not quotes, for a relatively liquid subset of corporate bonds that investors have endogenously chosen to trade. As such, our bid-ask spreads are expected to be smaller than past research (e.g., Table 1 of Chen, Lesmond, and Wei, 2007, report bid-ask spreads from quotes of between 30 to 70 basis points for a set of high-yield bonds). What is key, however, is cross-sectional variation in bid-ask spreads, not the level per se. Our final measure is the three-month median of the daily values. Table 1 reports the bid-ask spread for investment-grade (panel A) and high-yield (panel B). The average bid-ask spread is 29 cents (per $100 par value) for both investment-grade and high-yield bonds. As expected given the data requirement for multiple trades per day, we are only able to compute bid-ask spreads for about 46 (60) percent of the investment-grade (high-yield) sample for the period 2005–2016 when TRACE data was available (these percentages are computed from data contained in Table 2).

3.2.2 Daily Trading Volume (DTV)

This is a measure of how much a bond has been traded. We compute exponentially weighted average daily trading volume (including dealer-to-client and dealer-to-dealer transactions) using three-month center-of-mass over a twelve-month window. Turnover is an alternative measure closely related to liquidity, but in the case of fixed income markets, unlike equity, the size of the issues tends to be much smaller and especially so for larger issuers with multiple bonds outstanding. As such, observing that a higher fraction of outstanding has been traded recently is not sufficient to indicate liquidity for a large institutional investor. These investors typically have large capital allocations to invest from, so more direct measures of potential dollars to be traded (including issue size) are better indicators of liquidity. That said, we do discuss turnover as an alternative measure of liquidity in section 4.3.3. Table 1 shows that the average DTV is \$2.2 million (\$2.5 million) for investment-grade (high-yield) corporate bonds. We are able to compute DTV for about 87 (82) percent of the investment-grade (high-yield) sample for the period 2005–2016 when TRACE data was available.

3.2.3 Issue Size

This is a measure of a bond’s availability for trading. We compute the face value of the total amount outstanding. We have 100 percent coverage of this characteristic across our investment-grade and high-yield bonds. As shown in Table 1, the average size of investment-grade (high-yield) bonds is \$566 million (\$403 million).

3.2.4 Market Impact (Amihud)

This is a measure of transaction price impact on a bond (see e.g., Amihud and Mendelson, 1986). We use the ratio between absolute return and volume, which is a modified version of Dick-Nielsen, Feldhutter, and Lando (2012). For a given bond on a given day, we compute the average ratio between the absolute return and trade size. Note that we require multiple non inter-dealer trades in the same direction (e.g., clients buying from dealers or clients selling to dealers) in a given day to compute return. The final measure is the six-month median of the daily values. Table 1 shows that the average market impact is 29 bps (39 bps) per $1 million traded for investment-grade (high-yield) corporate bonds. Similar to the stringent data requirements for bid-ask spread, we are only able to measure market impact for a subset of bonds over the 2005–2016 period. Specifically, we can compute market impact for about 29 (38) percent of the investment-grade (high-yield) sample.

3.2.5 Percent of No Trading Days (PNT)

This is a measure of how frequently a bond has been traded. We compute the fraction of days over the last six months in which there were no institutional-size trades. Similar to the data requirements for DTV, we have a reasonably comprehensive data coverage for the 2005–2016 time period when TRACE was live. Specifically, we can compute PNT for about 88 (82) percent of the investment-grade (high-yield) sample. Table 1 shows that the average investment-grade (high-yield) bond trades on less than 32 (36) percent of days over the past six months. Liquidity in corporate bonds is considerably lower than traditional listed equity markets and even OTC markets. Ang, Shtauber, and Tetlock (2013) note that a PNT measure for OTC stocks (comparable listed equities) averages 55 (20) percent, indicating a higher frequency of trading in OTC stocks than what we see in the corporate bond market.

3.2.6 Time since issuance (Age)

This is not a direct measure of liquidity. However, it is widely believed that more recently issued bonds are more liquid than older bonds. We measure "age" as the number of years since the issuance of the bond. We include this variable in our analysis, as it has often been used in past fixed income empirical research comparing yields and spreads of off-the-run versus on-the-run bonds. As discussed in the introduction, we do not believe that this variable captures liquidity directly (we have direct measures for that described above), but it is possible "age" may reflect a characteristic of bonds that certain investors do not like and hence avoid.

As noted in the introduction, the correlation structure across the measures of liquidity is largely expected. Table 3 reports the average pairwise correlation across our liquidity measures. For ease of interpretation we flip the sign of BA Spread, Amihud, PNT, and Age to ensure that all six liquidity measures are increasing in liquidity. We therefore expect to see positive correlations in Table 3. There are two clusters of liquidity variables. First, measures of bid-ask spread and price impact are positively correlated, reflecting the direct costs of trading. Second, daily trading volume, issue size, and frequency of zero trading days are all strongly positively correlated, reflecting the ability to trade. While there is a strong positive correlation within these two types of measures (cost of trading and ability to trade), they are lowly correlated with each other. We therefore look at our measures of liquidity individually and jointly in our empirical analyses, as these measures could be capturing different aspects of the ease of trading.

4. Results

4.1 Ex-ante

Table 4 reports average spread duration, spread, and duration-times-spread (DTS)[2] for quintile portfolios sorted by the various liquidity measures. Each month, we sort the cross section of corporate bonds (investment grade and high yield separately) into five quintiles. Q5 (Q1) is the quintile containing the least (most) liquid corporate bonds. We do this for each of our liquidity measures and report summary statistics across the six panels in Table 4. We also report a test of the difference in spread duration, spread, and DTS across the top and bottom quintiles (Q5–Q1) for each liquidity variable.

In panel A, we find that BA Spread sorts bonds on credit spreads as well (i.e., the least liquid bonds in Q5 with highest BA spreads tend to have wider credit spreads than the most liquid bonds in Q1 with tightest BA spreads). While this may give the appearance of priced liquidity risk,[3] the more natural interpretation of this relation is that high credit spreads cause higher bid-ask spreads through standard market-making behavior. Kyle (1985) notes that in a dealer-intermediated market, inventory holding risk and adverse selection are primary drivers of price protection by market makers. Both inventory holding risk and, especially, adverse selection is expected to be higher for the riskier corporate bonds. Credit spreads scale proportionately with return volatility, so it is not surprising to see a positive association between credit spreads and bid-ask spreads (credit risk, as reflected in credit spreads, tends to drive bid-ask spreads wider). Labeling this as an ex-ante pricing of liquidity

[2] DTS is widely used as a proxy for risk. See Ben Dor et al. (2007) for details.

[3] Credit spread is often used as an ex-ante measure of credit-excess return, albeit imprecise, as it is does not account for default losses and/or bad selling practices from investors (see e.g., Ilmanen, 2011).

risk is not clear, as it can simply reflect underlying credit risk. We return to this issue later in section 4.2.2, when we use Fama-Macbeth–style regressions to control for risk, and in 4.2.3, when we look at return differences across bonds from the same issuer. This analysis allows us to cleanly hold issuer credit risk fixed and isolate any pricing effects of bond-specific liquidity characteristics.

We find that other liquidity measures generally sort on spreads as well. However, remember that credit spreads are fundamentally linked to default risk. So to the extent that bonds issued by safer issuers are more liquid, we will observe significant relationship between liquidity measures and spreads, but it does not imply that less-liquid bonds will generate higher returns. We will show in later sections that the spread differences between liquid and illiquid bonds are insignificant within the same issuers.

4.2 Ex-post

4.2.1 Long/short quintile portfolios

Our first set of analyses use a simple portfolio-sort methodology. At the beginning of each month, we construct quintile portfolios based on a cross-sectional rank using each liquidity measure. The portfolio can be either equal weighted or market-value weighted. Table 5 reports average monthly credit excess returns of these quintile portfolios over time as well as the difference between the top and bottom quintile portfolios and associated test statistics. Across the twenty-four sets of long/short portfolios (six liquidity measures, two rating categories, and two weighting schemes), we only find a significant relation for the Age characteristic. This is interesting given that Age does not have an explicit link to liquidity, as discussed in Section 3.2.6.

The observed return differences in Table 5 generally correspond in terms of direction and magnitude to the credit spread differences reported in Table 4. However, the most striking aspect of the results in Table 5 is that despite the directional consistency in the credit spread advantage and the future credit-excess returns of less-liquid bonds, this does not manifest itself in a significant risk-adjusted return. The volatility of the excess returns of the long/short portfolios makes these returns relatively unattractive to an investor (with the exception of Age, the Sharpe ratios in Table 5 are typically less than 0.30). For the sake of comparison, Sharpe ratios for academic corporate bond long/short portfolios are usually greater than 1.0 (see e.g., Correia, Richardson, and Tuna, 2012; and Israel, Palhares, and Richardson, 2018). And these returns are gross of expected transaction costs, which are expected to be greater for the least liquid bonds, which are the focal point of the portfolios in Table 5.

The bottom three rows of each panel in Table 5 contain additional information for the various liquidity portfolios. We report formal measures of skewness and kurtosis to shed light on any tail risk, embedded in these long/short portfolios. Finally, we also report an ex-ante Sharpe ratio in the last row. Our sample is comprehensive in its coverage of the cross-section of corporate bond returns (we have the returns for every index constituent). However, our sample is limited in the time series covered: we only have monthly return data back to January 1997. Thus, a limitation of our data is that the time series may be too short to draw reliable inferences from realized excess returns as a measure of expected returns. To help address this limitation, we use the credit spread advantage (without any adjustment for default losses) reported in Table 4 (equal weighted and value weighted appropriately) in lieu of realized average excess returns. If default rates and losses are the same for the liquid and illiquid bonds, the spread advantage serves as a proxy for expected returns. Even with this alternative measure, we are still unable to find any evidence of economically significant Sharpe ratios.

4.2.2 Cross-sectional regressions

In Table 5 we examined the expected returns of liquidity-sorted portfolios. Even though these expected returns were statistically insignificant, they might still be additive to a credit investor if they help diversify an overall portfolio. To test whether illiquidity factors are additive once we control for risk, we run Fama-Macbeth regressions of credit excess returns on the various illiquidity measures as well as a proxy for sensitivity to market risk: we use spread duration-times-spread (DTS) as suggested by Ben Dor et al. (2007). The results are reported in Table 6 with the average cross-section size (Avg Obs) and number of months (T) reported at the bottom of each panel. Panel A (B) reports regression results for investment-grade (high-yield) bonds. Across both sets of bonds, none of the illiquidity measures are individually statistically significant.[4]

Interestingly, Age is only marginally significant when controlling for DTS in column VI but becomes strongly significant once we control for the liquidity measures. In other words, the estimate price of risk for Age increases substantially when we hedge out any direct illiquidity exposure it inherits. A potential limitation to this inference is that the sample sizes across columns in Table 6 are not the same. We have chosen to report the maximum sample size for each column, and obviously column VII has the smallest cross-section size and number of months covered. We have re-run columns II–VI using the same sample size as in column VII and continue to find that Age is significantly associated with future credit-excess returns after hedging out market risk and any direct exposure to illiquidity risk. By hedging out poorly compensated liquidity exposures (remember from Table 5, the volatility of these

[4] The tabulated regressions in Table 6 are standard Fama-Macbeth OLS with equal weight assigned to each observation in a given cross section and then equally weighting each cross-sectional regression to compute test statistics. We have examined alternative weighting schemes including risk-based weighting each observation (i.e., weights are inversely proportional to DTS) and precision weighting each cross section (i.e., weighting each cross section by its sample size).

exposures were very large), an investor may be able to reduce the risk of an exposure to Age without reducing its performance.

4.2.3 Difference-in-difference

The single most important factor driving credit-excess return of corporate bonds is the credit risk of the issuer. Therefore, a potentially clean identification of the impact of liquidity on corporate bond prices/returns is to look at bonds that are issued by the same issuer but differ on the liquidity dimension. At the beginning of each month, we sort bonds into terciles according to each of our liquidity measures. Then for each bond in the top tercile, we pair it with a bond in the bottom tercile from the same issuer with similar maturities (within two years of each other). In this way we are able to identify “pairs” of bonds that are similar in remaining time to maturity but sufficiently different in terms of liquidity. We form a portfolio of long/short pairs in two ways (dollar neutral and risk neutral). First, to form a portfolio of dollar-neutral “pairs,” we assign equal dollar notional exposure to the long and short leg within a pair; we then equally weight across pairs and finally re-scale the portfolio to ensure a constant gross dollar notional exposure through time. Second, to form a portfolio of risk-neutral “pairs,” we assign an equal DTS exposure to the long and short leg within a pair; we then equally weight across pairs and finally re-scale the whole portfolio to ensure a constant gross DTS exposure through time.

Table 7 reports the return statistics of these pair portfolios, with two panels for Investment Grade and two panels for High Yield (a separate panel for dollar- or risk-neutral pair formation). In each panel we report the average returns and associated Sharpe ratios for each pair. In addition, we report the average number of pairs in each month as well as the average number of issuers in each month. For some issuers that have many bonds outstanding, it is possible to identify multiple pairs in a given month. We also report the average difference in the respective liquidity measure across the long and short leg of each pair. This is important to note, as failure to reject the null hypothesis of no liquidity premium may be due to low power tests. Thus, it is critical that we have "enough" variation in the liquidity characteristic across the short and long leg of our pair assets. Comparing the average liquidity difference across our pair assets to the difference in liquidity characteristics across the top and bottom quintile in Table 4, it is clear that we still have economically meaningful variation in liquidity across the long and short leg of our pair asset. Specifically, across the size measures, the magnitude of the liquidity differences is about two-thirds of the inter-quintile difference for the full cross section reported in Table 4.

Across each pair the difference in spread, spread duration, and DTS is very small, and by construction in the case of risk neutral pairs, the difference in DTS is zero. Similar to our earlier regression and quintile portfolio sorts, Age is the only characteristic positively associated with future credit-excess returns and then only with the risk-neutral pair construction.

To further increase the power of our tests with the pair asset methodology, we combine the Investment-Grade and High-Yield universe together. In panels A and B of Table 8 the results again confirm that only the Age characteristic is positively associated with future credit-excess returns and again only for the risk-neutral pair construction. Finally, panel C of Table 8 compares the return spread across the entire cross section of corporate bonds using any one of the size potential liquidity measures. The sample size here is much larger, increasing the power of the test, but again we find no evidence of a liquidity premium.[5]

[5] In unreported tests we also constructed pair assets requiring the difference in liquidity to be at least as large as the full cross-sectional inter-quintile difference reported in Table 4. This reduces the sample but does

4.3 Supplemental analysis/discussion

4.3.1 Sharpe ratios and portfolio implications

When judging the usefulness of liquidity as a factor, we focused on Sharpe ratios. Risk allocations among different factors are proportional to Sharpe ratios when investors are choosing among uncorrelated risk factors and have mean-variance preferences. This implies that there are several ways that liquidity may be relevant from an investor perspective, but our empirical design will fail to capture. First, liquidity may be strongly negatively correlated with other attractive factors in the investor opportunity set. We have not specified that set of factors, so it is hard to make a definitive case against this possibility. However, hoping for a yet-to-be-found risk factor that hedges the liquidity factor is a weak argument for its usefulness. Second, investors in credit markets may have preferences that extend beyond the second moment of returns. Given the left-tail nature of credit-excess returns, this is not an unreasonable assumption (see e.g., Asvanunt and Richardson, 2017, who examine Sharpe and Sortino ratios for the credit-risk premium). However, for this to change our inferences, it would need to be the case that a portfolio of illiquid bonds had either a smaller left tail and/or a left tail that realized only in better market environments. In unreported analyses our inferences of low Sharpe ratios for liquidity long/short portfolios reported in Table 5 are similarly low if we switch to Sortino ratios instead.

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increase the liquidity differences. Our inferences are exactly the same: no evidence of a positive return for these liquidity pair assets.

4.3.2 Transaction Costs

Illiquid bonds have higher transaction costs. For example, when we sorted bonds on their bid-ask prices based on dealer-to-client trades in the same day, we found that the top 20 percent most illiquid IG bonds had a bid-ask 64 basis points larger than the 20 percent most liquid. That large-bid ask is equivalent to almost two years of the spread advantage of illiquid (as measured by bid-ask) IG bonds. Furthermore, this analysis is likely to be conservative since our bid-ask data requirements tend to exclude the most illiquid bonds. These high transaction costs place an additional hard-to-overcome hurdle on the case for the relevance of liquidity premia for credit investors. Remember that the empirical analysis up to this point has been gross of any transaction costs.

4.3.3 Turnover as a measure of liquidity

As discussed in section 3.2, there are several ways to estimate trading activity in a corporate bond. For our primary analysis, we focused on a measure of average daily trading volume. We believe that the first order consideration from an investor is the actual dollars that could be traded. An alternative measure is turnover, which is the ratio of dollars traded to the issue size of the bond. We study that measure in unreported analysis. The average cross-sectional correlation between DTV and turnover for our sample of IG (HY) bonds is 0.72 (0.64), so it is not too surprising that we see similar results using turnover instead of average daily trading volume. Specifically, across long/short quintile portfolios, cross-sectional regressions, and difference-in-difference analysis, there is no evidence that differences in turnover are associated with future credit-excess returns.

4.3.4 Is this puzzle limited to the cross section of corporate bonds?

Our inability to find evidence of a liquidity premium in corporate bonds is admittedly a puzzle. But it is a very robust result evidenced across investment-grade and high-yield corporate bonds using a variety of liquidity metrics and a variety of research methods. In addition, this surprising result of an absence of a liquidity premium is not limited to the cross section of corporate credit. Prior research (e.g., Asvanunt and Richardson, 2017) has noted that credit-excess returns measured at the market level are greater for CDS indices than they are for cash bond indices, a result that is directly opposed to a liquidity premium, as liquidity in CDS indices is far greater than liquidity in cash bond indices. While a variety of explanations have been offered for that result (e.g., Desclee, Maitra, and Polbennikov, 2015, suggest that differences in seniority, maturity, quality, and sector composition across CDS indices and cash bond indices can explain some of this return difference), liquidity is not one of those explanations.

4.3.5 Why might liquidity have a low price of risk in credit markets?

The fact that there is not a positive association between credible measures of corporate bond liquidity and future credit-excess returns may be interpreted as a "puzzle." One alternative interpretation is that we have not been able to measure liquidity sufficiently well. While this is possible, we argue that it is unlikely, as we have explored a wide set of potential liquidity measures. Another alternative explanation is that the marginal investor in this market has a preference for less-liquid bonds. While conjectural, this is possible, as the typical investors in the corporate bond market are large institutional investors such as corporate and public pension plans and insurance companies. To the extent that these investors face regulatory capital constraints and/or solvency requirements that can be adversely affected by having to mark to market their asset holdings, investing in less-liquid assets provides a degree of discretion/optionality to smooth reported asset values in periods of stress.

4.3.6 Age and liquidity

The results for Age were the strongest, but we suspect that they may be driven by other explanations rather than liquidity. First, in Table 3 we noted that the correlations between direct measures of liquidity and Age were relatively low (parametric correlations between 14 percent and 27 percent). Second, in unreported tests, we also examined the relation between contemporaneous and future measures of liquidity. It is possible that Age is capturing a currently unobservable aspect of liquidity (hard to believe, as Age is known with certainty and is slow moving). If that were the case, then it is possible that Age is a better leading indicator of future measures of liquidity. We find no evidence to support this conjecture: across all liquidity measures, Age is strictly inferior to the liquidity measure itself (e.g., past DTV forecast future DTV more precisely than age).

4.3.7 Liquidity characteristic or covariance

The focus in our paper has been on liquidity as a characteristic: do bonds with lower liquidity have higher credit spreads and higher future credit-excess returns? We feel that this aspect of liquidity is most relevant from an investor perspective. However, it is important to note that an alternative approach is to treat liquidity as an exposure that has time-varying risk. The classic paper in this area is Pastor and Stambaugh (2003), who find that stocks whose prices drop when illiquidity increases earn a risk premium above and beyond their standard factor exposures. Subsequent research has isolated this return premium to the co-movement of stock liquidity with market returns: stocks that lose liquidity in times of stress are those that attract a return premium (Archarya and Pedersen, 2005). Indeed, this approach has been extended to corporate bond markets. Lin, Wang, and Wu (2011) find that bonds with high sensitivities to liquidity risk earn returns 4 percent higher than those with low sensitivity. So while we are unable to find any evidence of associations between multiple measures of liquidity and future credit-excess returns, it is possible a liquidity "beta" may resurrect the case for a liquidity premium in the corporate bond market.

5. Conclusion

We undertake a comprehensive analysis of how measures of liquidity correlate with secondary market prices in credit markets. While illiquid bonds have slightly higher credit spreads and directionally higher average returns, portfolios that tilt toward (away from) less (more) liquid bonds exhibit higher levels of volatility such that liquidity is not reliably associated with future credit-excess returns. This is a puzzling result. Despite a strong theoretical prior for the existence of a liquidity premium, whereby investors price protect for the potential future inability to close a position of a reasonable size in a relative short period of time at a reasonable cost, we are unable to find any empirical evidence of a liquidity premium in credit markets. This result, or rather lack of result, is robust to multiple measures of liquidity (capturing both the ability to trade and expected costs of trading) and a variety of research methods (long/short quintile portfolios, cross-sectional regressions, difference-in-difference).

The one "positive" result we do find is that "older" bonds are associated with higher future credit-excess returns. The interpretation of this result is not that it supports the existence of a liquidity risk premium in the cross section of corporate bonds. This is because the more direct measures of liquidity such as trading volume, price impact, turnover, bid-ask spreads, and frequency of zero trading days show no relation with future credit-excess returns. Instead, we argue that time since issuance reflects characteristics of corporate bonds that investors either neglect or shy away from. Our interpretation is akin to Merton (1987) investor recognition, in which investors on average neglect/avoid older off-the-run bonds not because they are less liquid per se (as we control for that directly in our analysis) but for some other non-observable reason.

Overall, our results are important for both academics and investors. From an academic perspective, our “puzzle” of an absence of liquidity premium is a challenge to standard theoretical models of asset pricing where investors should rationally price protect when holding less-liquid securities. From an investor perspective, our “puzzle” of an absence of a liquidity premium is important for credit asset managers: arguably portfolios holding less-liquid corporate bonds are assuming a higher level of risk (potential redemption risks from liquidity mismatch), which is insufficiently compensated ex-ante.

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Table 1
Summary statistics of U.S. corporate bond characteristics

This table reports descriptive statistics for our sample of US investment-grade and high-yield bonds. Investment-grade bonds are the constituents of the Bank of America Merrill Lynch U.S. Corporate Master Index. High-yield bonds are the constituents of the Bank of America Merrill Lynch U.S. High Yield Master Index. Spread is the difference between the corporate bond yield and a key-rate duration-matched government bond yield. Duration is the spread duration. DTS is the product of spread and duration. Bid-Ask (BA) spread is estimated for each bond using transaction data from the Trade Reporting and Compliance Engine (TRACE) and is measured in price terms. DTV is the average daily trading volume estimated from TRACE using exponential weights with three-month center-of-mass over a twelve-month window (in $ millions). Size is the par value of the bond (in $ millions). Amihud is the six-month rolling median of the ratio of the absolute value of daily returns (in basis points) to daily trading volume (in $ millions). PNT is the percentage of zero trading days over the prior six months. Age is the number of years since the bond was originally issued. Data coverage for Bid-Ask Spread and DTV are limited due to the additional data requirements of combining TRACE data with the corporate bond index data. Q1 (Q3) are the lower and upper quartile respectively.

Panel A: Investment-Grade Corporate Bonds

	N	Mean	Q1	Median	Q3
Spread	852,947	161	101	142	194
Duration	852,947	6.02	3.17	5.27	7.78
DTS	852,947	1,016	371	773	1,475
BA Spread	280,311	$0.29	$0.123	$0.223	$0.376
DTV	505,980	2.19	0.36	0.94	2.36
Size	852,947	566.02	271.78	397.71	685.05
Amihud	171,985	29.28	10.05	19.09	35.40
PNT	510,720	68.67	53.09	74.17	87.56
Age	852,756	3.89	1.34	2.99	5.53

Panel B: High-Yield Corporate Bonds

	N	Mean	Q1	Median	Q3
Spread	268,852	676	337	463	736
Duration	268,852	4.39	2.94	4.12	5.32
DTS	268,852	2,549	1,303	2,064	3,284
BA Spread	118,687	$0.284	$0.201	$0.252	$0.310
DTV	159,185	2.47	0.53	1.28	2.88
Size	268,852	402.50	201.43	302.01	482.11
Amihud	74,511	38.69	11.10	20.40	40.84
PNT	159,946	65.87	49.47	69.27	84.60
Age	268,794	3.52	1.18	2.57	4.71

Table 2
Sample coverage for US corporate bonds

Panel A: Investment-Grade Corporate Bonds

Year	Bonds	BA Spread	DTV	Size	Amihud	PNT	Age
1997	2,607	0	0	2,607	0	0	2,607
1998	3,232	0	0	3,232	0	0	3,232
1999	3,060	0	0	3,060	0	0	3,060
2000	2,704	0	0	2,704	0	0	2,704
2001	2,801	0	0	2,801	0	0	2,801
2002	2,833	0	0	2,833	0	0	2,833
2003	2,883	0	0	2,883	0	0	2,883
2004	2,938	0	0	2,938	0	0	2,938
2005	2,442	943	2,060	2,442	587	2,057	2,442
2006	2,501	933	2,128	2,501	654	2,154	2,501
2007	2,599	902	2,215	2,599	636	2,242	2,599
2008	2,811	1,067	2,420	2,811	689	2,431	2,811
2009	3,060	1,605	2,603	3,060	1,068	2,647	3,060
2010	3,452	1,631	2,893	3,452	1,144	2,935	3,452
2011	3,953	1,844	3,281	3,953	1,320	3,311	3,953
2012	4,455	2,139	3,635	4,455	1,416	3,675	4,455
2013	5,025	2,452	4,043	5,025	1,507	4,115	5,025
2014	5,459	2,857	4,818	5,459	1,583	4,925	5,459
2015	5,908	3,489	5,908	5,908	1,801	5,908	5,908
2016	6,162	3,499	6,162	6,162	1,928	6,162	6,162

Panel B: High-Yield Corporate Bonds

Year	Bonds	BA Spread	DTV	Size	Amihud	PNT	Age
1997	475	0	0	475	0	0	475
1998	544	0	0	544	0	0	544
1999	583	0	0	583	0	0	583
2000	686	0	0	686	0	0	686
2001	765	0	0	765	0	0	765
2002	926	0	0	926	0	0	926
2003	1,123	0	0	1,123	0	0	1,123
2004	1,189	0	0	1,189	0	0	1,189
2005	1,190	550	984	1,190	337	965	1,190
2006	1,157	657	970	1,157	422	974	1,157
2007	1,165	598	961	1,165	388	963	1,165
2008	1,164	614	952	1,164	338	941	1,164
2009	1,224	678	946	1,224	359	949	1,224
2010	1,274	639	947	1,274	435	977	1,274
2011	1,403	665	1,051	1,403	439	1,029	1,403
2012	1,274	737	981	1,274	450	976	1,274
2013	1,403	781	945	1,403	492	970	1,403
2014	1,535	1,107	1,245	1,535	671	1,302	1,535
2015	1,666	1,438	1,666	1,666	932	1,666	1,666
2016	1,617	1,425	1,617	1,617	946	1,617	1,617

Table 3
Correlations of bond liquidity characteristics

This table reports results average pairwise correlations across our various liquidity measures. Pearson (Spearman) correlations are in the lower (upper) portion of each table. Bid-Ask (BA) spread is estimated for each bond using transaction data from the Trade Reporting and Compliance Engine (TRACE) and is measured in price terms. DTV is the average daily trading volume estimated from TRACE using exponential weights with three-month center-of-mass over a twelve-month window (in $ millions). Size is the par value of the bond (in $ millions). Amihud is the six-month rolling median of the ratio of the absolute value of daily returns (in basis points) to daily trading volume (in $ millions). PNT is the percentage of zero trading days over the prior six months. Age is the number of years since the bond was originally issued. All variables in this table are converted to be increasing in liquidity (i.e., DTV and Size keep their natural values, and BA Spread, Amihud, PNT and Age are multiplied by -1). This means we expect to see positive correlations in Table 3.

Panel A: Investment-Grade Corporate Bonds

	BA Spread	DTV	Size	Amihud	PNT	Age
BA Spread		0.02	0.03	0.31	-0.08	0.10
DTV	0.09		0.72	0.06	0.89	0.40
Size	0.08	0.64		-0.03	0.75	0.17
Amihud	0.33	0.06	0.04		-0.18	0.22
PNT	0.01	0.57	0.71	-0.05		0.25
Age	0.15	0.24	0.14	0.20	0.27	

Panel B: High-Yield Corporate Bonds

	BA Spread	DTV	Size	Amihud	PNT	Age
BA Spread		0.00	0.06	0.32	-0.06	0.06
DTV	0.02		0.72	0.5	0.89	0.17
Size	0.05	0.73		0.19	0.71	0.20
Amihud	0.35	0.07	0.14		-0.08	0.29
PNT	-0.06	0.65	0.63	0.05		0.09
Age	0.20	0.13	0.14	0.34	0.20	

Table 4
Characteristics of corporate bond portfolios sorted on various liquidity measures

This table reports average values of key characteristics across corporate bond portfolios sorted on our various liquidity measures. Each month we sort our respective investment-grade and high-yield bonds into five equal-size groups based on our various liquidity measures. We report equal-weighted average portfolio characteristics across each sorting variable. For each sorting variable, we first show the average value of the sorting variable, and then we show averages of duration, spread, and DTS. Bid-Ask (BA) spread is estimated for each bond using transaction data from the Trade Reporting and Compliance Engine (TRACE) and is measured in price terms. DTV is the average daily trading volume estimated from TRACE using exponential weights with three-month center-of-mass over a twelve-month window (in $ millions). Size is the par value of the bond (in $ millions). Amihud is the six-month rolling median of the ratio of the absolute value of daily returns (in basis points) to daily trading volume (in $ millions). PNT is the percentage of zero trading days over the prior six months. Age is the number of years since the bond was originally issued. Spread is the difference between the corporate bond yield and a key-rate duration-matched government bond. Duration is the spread duration. DTS is the product of spread and duration. Each liquidity measure is sorted in terms of relative illiquidity. Q1 (Q5) corresponds to the most (least) liquid bonds.

Panel A: BA Spread

	Investment-Grade				**High-Yield**			
	BA Spread	**Duration**	**Spread**	**DTS**	**BA Spread**	**Duration**	**Spread**	**DTS**
Q1	0.05	4.89	151	840	0.11	4.04	555	2,079
Q2	0.14	4.51	147	744	0.22	4.04	577	2,136
Q3	0.22	5.44	162	926	0.25	4.14	621	2,346
Q4	0.34	6.73	183	1,217	0.30	4.34	680	2,569
Q5	0.69	6.79	191	1,307	0.57	4.64	688	2,738
Q5-Q1	0.64	1.90	40	467	0.46	0.60	133	658
T-Stat		**20.59**	**13.83**	**19.12**		**24.76**	**10.99**	**20.51**

Panel B: DTV

	Investment-Grade				**High-Yield**			
	DTV	**Duration**	**Spread**	**DTS**	**DTV**	**Duration**	**Spread**	**DTS**
Q1	7.14	6.35	180	1,167	7.50	4.42	753	2,811
Q2	1.93	6.01	169	1,066	2.48	4.18	642	2,382
Q3	0.91	6.05	169	1,087	1.30	4.18	616	2,309
Q4	0.42	6.22	172	1,129	0.66	4.32	581	2,275
Q5	0.23	6.51	194	1,278	0.45	4.58	643	2,617
Q5-Q1	-6.91	0.16	14	111	-7.05	0.16	-110	-194
T-Stat		**6.31**	**5.63**	**7.07**		**4.49**	**-7.42**	**-6.09**

Panel C: Size

	Investment-Grade				High-Yield			
	Size	**Duration**	**Spread**	**DTS**	**Size**	**Duration**	**Spread**	**DTS**
Q1	1,226.10	5.75	150	922	875.40	4.59	655	2,636
Q2	557.48	6.06	160	1,014	428.95	4.38	656	2,464
Q3	382.29	6.10	162	1,018	292.62	4.43	656	2,497
Q4	280.53	6.21	171	1,104	212.20	4.30	715	2,603
Q5	224.40	6.03	168	1,065	163.89	4.20	729	2,609
Q5-Q1	-1001.70	0.28	18	143	-711.51	-0.39	74	-27
T-Stat		**7.57**	**11.86**	**15.19**		**-24.24**	**6.86**	-0.74

Panel D: Amihud

	Investment-Grade				High-Yield			
	Amihud	**Duration**	**Spread**	**DTS**	**Amihud**	**Duration**	**Spread**	**DTS**
Q1	5.09	5.75	146	938	6.10	4.15	496	1,917
Q2	11.67	6.29	151	1,001	12.75	4.40	549	2,230
Q3	19.26	6.35	155	1,022	20.66	4.38	630	2,470
Q4	31.48	6.26	171	1,077	35.73	4.23	756	2,777
Q5	78.29	6.28	187	1,210	114.03	4.41	674	2,594
Q5-Q1	73.2	0.53	41	272	107.93	0.26	178	677
T-Stat		**6.31**	**13.94**	**8.17**		**9.50**	**14.03**	**23.73**

Panel E: PNT

	Investment-Grade				High-Yield			
	PNT	**Duration**	**Spread**	**DTS**	**PNT**	**Duration**	**Spread**	**DTS**
Q1	32.55	5.78	165	1,020	31.78	4.29	668	2,540
Q2	58.68	6.07	167	1,059	54.20	4.16	632	2,332
Q3	74.77	6.31	171	1,132	69.55	4.25	622	2,369
Q4	85.95	6.48	178	1,194	82.03	4.42	621	2,425
Q5	94.49	6.49	200	1,304	92.65	4.57	677	2,700
Q5-Q1	61.94	0.71	35	284	60.87	0.28	9	160
T-Stat		**19.81**	**11.26**	**12.95**		**10.46**	0.63	**4.44**

Panel F: Age

	Investment-Grade				High-Yield			
	Age	**Duration**	**Spread**	**DTS**	**Age**	**Duration**	**Spread**	**DTS**
Q1	0.53	6.49	152	1,024	0.49	4.93	600	2,641
Q2	1.64	6.03	164	1,029	1.44	4.40	712	2,720
Q3	3.01	5.65	169	991	2.59	3.90	718	2,464
Q4	4.94	5.83	164	994	4.21	3.74	735	2,335
Q5	9.32	6.08	159	1,054	8.85	4.97	624	2,609
Q5-Q1	8.79	-0.41	7	30	8.36	0.04	24	-32
T-Stat		**-10.61**	**6.37**	**2.71**		1.06	**3.00**	**2.71**

Table 5
Quintile long/short corporate bond portfolio returns across various liquidity measures

This table reports academic long/short quintile portfolio returns. Each month we sort our respective investment-grade (panels A and B) and high-yield (panels C and D) bonds into five equal-size groups based on our various liquidity measures. We report both equal-weighted (panels A and C) and value-weighted (panels B and D) credit-excess returns across each sorting variable. Credit-excess returns are the difference between total returns (cum-coupon) for the bond less the total return of a key-rate matched government bond. Bid-Ask (BA) spread is estimated for each bond using transaction data from the Trade Reporting and Compliance Engine (TRACE) and is measured in price terms. DTV is the average daily trading volume estimated from TRACE using exponential weights with three-month center-of-mass over a twelve-month window (in $ millions). Size is the par value of the bond (in $ millions). Amihud is the six-month rolling median of the ratio of the absolute value of daily returns (in basis points) to daily trading volume (in $ millions). PNT is the percentage of zero trading days over the prior six months. Age is the number of years since the bond was originally issued. Portfolio returns are reported in percentage units (i.e., 0.84 means 0.84 percent). Each liquidity measure is sorted in terms of relative illiquidity. Q1 (Q5) corresponds to the most- (least-) liquid bonds. If liquidity risk is priced positively by the market the Q5-Q1 return spread should be positive. Returns are annualized percentages in this table (i.e., 0.77 means 77 basis points annualized).

Panel A: Investment-Grade Corporate Bonds (equal weighted)

	BA Spread	DTV	Size	Amihud	PNT	Age
Q1	0.77	1.38	0.86	0.57	1.13	0.48
Q2	1.37	1.12	0.90	0.24	1.08	0.60
Q3	1.77	1.05	0.77	1.31	1.15	1.01
Q4	1.56	1.17	1.04	1.36	1.34	1.31
Q5	1.67	1.33	1.16	2.71	1.34	1.21
Q5-Q1	0.90	-0.05	0.30	2.14	0.21	0.73
T-Stat	0.86	-0.04	0.50	1.73	0.18	**2.62**
Volatility	3.57	3.71	2.74	4.26	3.94	1.23
Sharpe	0.25	-0.01	0.11	0.50	0.05	0.59
Monthly Skew	-0.96	-0.90	0.13	-0.71	-0.91	0.23
Monthly Kurtosis	6.82	10.18	16.92	12.49	12.44	3.72
Spread Sharpe	0.11	0.04	0.07	0.10	0.09	0.06

Panel B: Investment-Grade Corporate Bonds (value weighted)

	BA Spread	DTV	Size	Amihud	PNT	Age
Q1	0.46	1.08	0.75	0.61	1.08	0.39
Q2	0.93	0.92	0.75	0.01	0.82	0.48
Q3	1.56	0.81	0.67	1.16	0.93	0.78
Q4	1.12	0.95	0.85	1.09	1.15	1.11
Q5	1.36	1.24	0.95	2.29	0.97	1.09
Q5-Q1	0.90	0.16	0.20	1.68	-0.11	0.70
T-Stat	0.81	0.17	0.34	1.40	-0.12	**2.16**
Volatility	3.81	3.25	2.65	4.14	3.42	1.44
Sharpe	0.23	0.05	0.08	0.41	-0.03	0.48
Monthly Skew	-0.61	-0.30	-0.16	-0.36	-1.95	1.66
Monthly Kurtosis	4.85	15.54	16.47	7.32	17.44	14.41
Spread Sharpe	0.10	0.04	0.07	0.10	0.10	0.05

Panel C: High-Yield Corporate Bonds (equal weighted)

	BA Spread	DTV	Size	Amihud	PNT	Age
Q1	4.77	4.01	2.94	2.92	2.64	1.08
Q2	4.53	5.99	2.65	3.65	5.33	2.73
Q3	4.21	4.86	2.89	2.64	5.36	3.90
Q4	4.94	4.81	3.68	5.86	5.66	3.89
Q5	5.70	3.73	4.00	6.44	4.71	4.37
Q5-Q1	0.93	-0.28	1.06	3.52	2.07	3.29
T-Stat	0.51	-0.11	0.56	0.95	0.86	**2.62**
Volatility	6.16	9.13	8.46	12.82	8.38	5.60
Sharpe	0.15	-0.03	0.12	0.27	0.25	0.59
Monthly Skew	0.94	-2.84	-0.07	1.27	-4.07	1.26
Monthly Kurtosis	5.00	21.41	10.65	5.18	36.28	7.40
Spread Sharpe	0.22	-0.12	0.09	0.14	0.01	0.04

Panel D: High-Yield Corporate Bonds (value weighted)

	BA Spread	DTV	Size	Amihud	PNT	Age
Q1	3.88	3.95	2.47	2.93	3.36	0.66
Q2	3.87	4.58	2.18	3.07	4.32	2.55
Q3	3.74	3.83	2.43	2.76	4.58	3.16
Q4	3.73	3.98	3.04	4.37	4.68	3.59
Q5	5.78	2.71	3.53	7.01	3.78	3.55
Q5-Q1	1.90	-1.24	1.06	4.08	0.42	2.89
T-Stat	0.70	-0.47	0.79	0.97	0.16	**2.04**
Volatility	9.42	9.19	5.96	14.53	9.03	6.32
Sharpe	0.20	-0.13	0.18	0.28	0.05	0.46
Monthly Skew	3.35	-6.04	0.18	2.95	-6.71	2.36
Monthly Kurtosis	31.31	59.85	5.15	26.06	70.37	15.65
Spread Sharpe	0.14	-0.12	0.12	0.12	0.01	0.04

Table 6
Cross-sectional regressions

This table reports Fama-Macbeth-style cross-sectional regressions. The dependent variable in all regressions is the credit-excess return (XRET) for the following month. Credit-excess returns are the difference between total returns (cum-coupon) for the bond less the total return of a key-rate matched government bond. The independent variables include our respective liquidity measures and DTS as a summary measure for credit risk. We estimate multiple specifications allowing each liquidity measure with/without credit risk as well as a combined specification with all liquidity measures together. Regressions are standard OLS performed each month with regression coefficients averaged across months and test statistics based on temporal variation in estimated monthly regression coefficients. Averaged regression coefficients are reported above italicized test statistics. Bid-Ask (BA) spread is estimated for each bond using transaction data from the Trade Reporting and Compliance Engine (TRACE) and is measured in price terms. DTV is the average daily trading volume estimated from TRACE using exponential weights with three-month center-of-mass over a twelve-month window (in $ millions). Size is the par value of the bond (in $ millions). Amihud is the six-month rolling median of the ratio of the absolute value of daily returns (in basis points) to daily trading volume (in $ millions). PNT is the percentage of zero trading days over the prior six months. Age is the number of years since the bond was originally issued. DTS is the product of spread and duration. Spread is the difference between the corporate bond yield and a key-rate duration-matched government bond. Duration is the spread duration. For ease of interpretation of regression coefficients, we standardize all independent variables each month. The regression we run each month is summarized below. ILLIQ refers to the respective liquidity measure used across each regression specification. Each liquidity variable is increasing in relative illiquidity for ease of interpretation (i.e., we expect a positive regression coefficient under the null hypothesis that liquidity risk is priced). Returns are monthly in this table and are reported in percentages (i.e., 0.0014 means 14 basis points).

$$XRET_{i,t+1} = \alpha + \beta_k ILLIQ_{k,i,t} + \beta_{DTS} DTS_{i,t} + \varepsilon$$

Panel A: Investment-Grade Corporate Bonds

	I	II	III	IV	V	VI	VII
α	0.0014	0.0010	0.0008	0.0013	0.0011	0.0008	0.0013
	0.98	*0.83*	*0.97*	*0.92*	*0.85*	*0.97*	*0.90*
β_{BA_SPREA}	-0.0001						-0.0001
	-0.70						*-0.39*
β_{DTV}		-0.0001					-0.0001
		-0.48					*-0.75*
β_{SIZE}			-0.0000				0.0002
			-0.23				*1.74*
β_{Amihud}				0.003			0.0003
				1.04			*1.17*
β_{PNT}					-0.0001		-0.0003
					0.27		*-1.27*
β_{AGE}						0.0001	0.0005
						1.74	***2.82***
β_{DTS}	0.0014	0.0011	0.0007	0.0011	0.0012	0.0008	0.0012
	1.53	*1.42*	*1.31*	*1.25*	*1.44*	*1.38*	*1.28*
R^2	20%	17%	14%	22%	18%	13%	26%
Sharpe	-0.20	-0.14	-0.05	0.30	-0.15	0.39	
Avg Obs	1,947	3,514	3,544	1,194	3,547	3,543	1,076
T	144	144	240	144	144	240	144

Panel B: High-Yield Corporate Bonds

	I	II	III	IV	V	VI	VII
α	0.0047	0.0041	0.0027	0.0045	0.0041	0.0027	0.0051
	1.54	*1.41*	*1.31*	*1.38*	*1.43*	*1.31*	*1.65*
β_{BA_SPREA}	-0.0001						0.0000
	0.24						*0.07*
β_{DTV}		-0.0001					0.0003
		-0.09					*0.60*
β_{SIZE}			0.0000				-0.0003
			0.03				*-0.38*
β_{Amihud}				0.0002			-0.0001
				0.34			*-0.09*
β_{PNT}					-0.0001		0.0006
					-0.16		*0.81*
β_{AGE}						0.0005	0.0017
						1.59	***2.41***
β_{DTS}	0.0024	0.0021	0.0015	0.0023	0.0021	0.0015	0.0021
	1.14	*1.05*	*1.02*	*1.05*	*1.05*	*1.04*	*0.93*
R^2	14%	14%	11%	16%	14%	10%	20%
Sharpe	-0.07	-0.02	0.01	0.10	-0.05	0.36	
Avg Obs	824	1,105	1,118	517	1,111	1,118	484
T	144	144	240	144	144	240	144

Table 7
Difference-in-difference design: returns from pair assets formed on bonds from the same issuer

This table reports returns from pair assets that are formed using bonds issued by the same company. This analysis is limited to only issuers with multiple bonds outstanding. Each month we sort all bonds for a given issuer and identify all possible pairs of bonds where the difference in time to maturity across bonds is less than two years and the difference in liquidity across the bonds is such that the more- (less-) liquid bond is in the top (bottom) tercile of the entire cross section. We then long (short) the more-illiquid (liquid) bond for each pair separately for Investment-Grade (panels A and B) and High-Yield (panels C and D) bonds. In Panels A and C we (i) size the long (short) side of the pair asset to be dollar neutral, (ii) equal weight across all pairs in a given month, and (iii) scale the portfolio through time such that it has a constant dollar exposure. In Panels B and D, we (i) size the long (short) side of the pair asset to be beta (DTS) neutral, (ii) weight each pair such that all pairs have an equivalent aggregate DTS (across long and short side), and (iii) scale the portfolio through time such that it has a constant DTS exposure. We repeat this approach for all liquidity measures. The table below summarizes both the return profile of these pair assets as well as the characteristics of each pair. Bid-Ask (BA) spread is estimated for each bond using transaction data from the Trade Reporting and Compliance Engine (TRACE) and is measured in price terms. DTV is the average daily trading volume estimated from TRACE using exponential weights with three-month center-of-mass over a twelve-month window (in $ millions). Size is the par value of the bond (in $ millions). Amihud is the six-month rolling median of the ratio of the absolute value of daily returns (in basis points) to daily trading volume (in $ millions). PNT is the percentage of zero trading days over the prior six months. Age is the number of years since the bond was originally issued. DTS is the product of spread and duration. Spread is the difference between the corporate bond yield and a key-rate duration-matched government bond. Duration is the spread duration. LIQ diff is the difference in the respective liquidity measure between the long (less-liquid) and short (more-liquid) leg of the pair asset. Pair spread, pair duration, and pair DTS is the difference in spread, duration, and DTS between the long (less-liquid) and short (more-liquid) leg of the pair asset. Returns are annualized percentages in this table (i.e., -0.08 means -8 basis points annualized).

Panel A: Investment-Grade: dollar-neutral pairs

	BA Spread	DTV	Size	Amihud	PNT	Age
Return	-0.08	0.11	0.24	0.04	0.25	0.19
T-Stat	-0.31	0.32	1.14	0.28	0.66	1.64
StDev	0.84	1.15	0.94	0.52	1.30	0.52
Sharpe	-0.09	0.09	0.25	0.08	0.19	0.37
# Pairs	209	154	169	175	142	163
# Issuers	137	102	104	113	95	102
LIQ diff	0.41	-4.23	-611.42	42.78	45.72	6.72
Pair Spread	4	10	8	1	11	11
Pair Duration	0.03	-0.16	-0.17	-0.02	-0.18	-0.25
Pair DTS	24	31	17	4	35	14

Panel B: Investment-Grade: beta-neutral pairs

	BA Spread	DTV	Size	Amihud	PNT	Age
Return	0.10	0.35	0.02	0.14	0.20	0.37
T-Stat	1.00	1.80	0.15	1.07	0.95	**3.02**
StDev	0.35	0.67	0.66	0.46	0.72	0.54
Sharpe	0.29	0.52	0.03	0.31	0.27	0.68
# Pairs	209	154	169	175	142	163
# Issuers	137	102	104	113	95	102
LIQ diff	0.41	-4.23	-611.42	42.78	45.72	6.72
Pair Spread	-5	3	5	-3	3	9
Pair Duration	-0.39	-0.65	-0.29	-0.30	-0.65	-0.95
Pair DTS	0	0	0	0	0	0

Panel C: High-Yield: dollar-neutral pairs

	BA Spread	DTV	Size	Amihud	PNT	Age
Return	0.33	-0.83	-0.44	1.10	-0.51	0.62
T-Stat	0.51	-1.04	-0.59	0.84	-0.56	0.51
StDev	2.22	2.74	3.32	4.49	3.12	5.44
Sharpe	0.15	-0.30	-0.13	0.25	-0.16	0.11
# Pairs	98	41	38	49	43	26
# Issuers	74	33	31	40	34	21
LIQ diff	0.25	-4.64	-465.14	60.21	45.93	6.16
Pair Spread	4	36	-29	59	24	5
Pair Duration	0.06	-0.06	-0.07	0.05	0.09	-0.35
Pair DTS	36	84	-110	146	133	-134

Panel D: High-Yield: beta-neutral pairs

	BA Spread	DTV	Size	Amihud	PNT	Age
Return	0.00	-0.11	0.12	-0.11	-0.06	0.49
T-Stat	0.01	-0.61	0.78	-0.76	-0.39	**2.42**
StDev	0.28	0.65	0.67	0.51	0.52	0.90
Sharpe	0.00	-0.18	0.18	-0.22	-0.11	0.54
# Pairs	98	41	38	49	43	26
# Issuers	74	33	31	40	34	21
LIQ diff	0.25	-4.64	-465.14	60.21	45.93	6.16
Pair Spread	-6	4	5	-3	-2	18
Pair Duration	-0.01	-0.03	0.00	-0.02	-0.02	0.02
Pair DTS	0	0	0	0	0	0

Table 8
Robustness analysis

This table reports returns from pair assets that are formed using bonds issued by the same company. For this table we either combine investment-grade and high-yield bonds together (panels A and B) or examine all liquidity measures jointly (panel C) to increase the sample size and hence power of our tests. This analysis is limited to only issuers with multiple bonds outstanding. Each month we sort all bonds for a given issuer and identify all possible pairs of bonds where the difference in time to maturity across bonds is less than two years and the difference in liquidity across the bonds is such that the more- (less-) liquid bond is in the top (bottom) tercile of the entire cross section. We then long (short) the more-illiquid (liquid) bond for each pair. In Panel A we (i) size the long (short) side of the pair asset to be dollar neutral, (ii) equal weight across all pairs in a given month, and (iii) scale the portfolio through time such that it has a constant dollar exposure. In Panel B we (i) size the long (short) side of the pair asset to be beta (DTS) neutral, (ii) weight each pair such that all pairs have an equivalent aggregate DTS (across long and short side), and (iii) scale the portfolio through time such that it has a constant DTS exposure. We repeat this approach for all liquidity measures. The table below summarizes both the return profile of these pair assets as well as the characteristics of each pair. Bid-Ask (BA) spread is estimated for each bond using transaction data from the Trade Reporting and Compliance Engine (TRACE) and is measured in price terms. DTV is the average daily trading volume estimated from TRACE using exponential weights with three-month center-of-mass over a twelve-month window (in $ millions). Size is the par value of the bond (in $ millions). Amihud is the six-month rolling median of the ratio of the absolute value of daily returns (in basis points) to daily trading volume (in $ millions). PNT is the percentage of zero trading days over the prior six months. Age is the number of years since the bond was originally issued. DTS is the product of spread and duration. Spread is the difference between the corporate bond yield and a key-rate duration-matched government bond. Duration is the spread duration. LIQ diff is the difference in the respective liquidity measure between the long (less-liquid) and short (more-liquid) leg of the pair asset. Pair spread, pair duration, and pair DTS is the difference in spread, duration, and DTS between the long (less-liquid) and short (more-liquid) leg of the pair asset. Returns are annualized percentages in this table (i.e., -0.11 means -11 basis points annualized).

Panel A: Dollar-neutral pairs (Investment-Grade and High-Yield combined)

	BA Spread	DTV	Size	Amihud	PNT	Age
Return	-0.11	-0.02	0.19	0.23	0.05	0.28
T-Stat	-0.47	-0.06	0.68	0.73	0.12	1.32
StDev	0.78	1.42	1.22	1.07	1.45	0.30
Sharpe	-0.14	-0.02	0.15	0.21	0.04	0.30
# Pairs	281	197	196	227	155	186
# Issuers	184	134	132	153	129	122
LIQ diff	0.39	-4.15	-577.35	46.57	45.72	6.70
Pair Spread	7	11	3	9	11	11
Pair Duration	0.03	-0.21	-0.16	0.01	-0.12	-0.23
Pair DTS	33	21	-18	30	36	5

Panel B: Beta-neutral pairs (Investment-Grade and High-Yield combined)

	BA Spread	DTV	Size	Amihud	PNT	Age
Return	0.11	0.27	-0.01	0.11	0.22	0.35
T-Stat	1.29	1.27	-0.05	1.07	1.21	**3.07**
StDev	0.28	0.72	0.58	0.37	0.62	0.51
Sharpe	0.37	0.37	-0.01	0.31	0.35	0.69
# Pairs	281	197	196	227	155	186
# Issuers	184	134	132	153	129	122
LIQ diff	0.39	-4.15	-577.35	46.57	45.72	6.70
Pair Spread	-4	5	6	-4	2	10
Pair Duration	-0.32	-0.64	-0.23	-0.24	-0.53	-0.82
Pair DTS	0	0	0	0	0	0

Panel C: Combining all possible pairs across liquidity measures

	Dollar-Neutral Pairs		Beta-Neutral Pairs	
	IG	**HY**	**IG**	**HY**
Return	0.15	0.29	0.22	0.05
T-Stat	0.85	0.54	1.70	0.58
StDev	0.63	1.86	0.44	0.32
Sharpe	0.25	0.16	0.49	0.17
# Pairs	818	229	818	229
# Issuers	221	93	221	93
Pair Spread	9	24	3	3
Pair Duration	-0.13	-0.04	-0.62	-0.02
Pair DTS	23	66	0	0