

Replication of The Illiquidity of Corporate Bonds: Project Overview and Table Results

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Abstract

Our project set out to replicate Tables 1 (Summary Statistics) and 2 (Measure of Illiquidity) from "The Illiquidity of Corporate Bonds" by Bao, Pan, and Wang (2010). This seminal paper evaluates the impact of illiquidity on corporate bond pricing, employing a novel measure of illiquidity, γ , for each bond. Focusing on corporate bonds from 2003 to 2009, the study meticulously calculates illiquidity measures and analyzes their valuation effects.

1 Overview

In the paper, Table 1 generates summary statistics for all corporate bonds and selected samples during 2003 - 2009, and Table 2 calculates illiquidity measure γ at both individual bond level and portfolio level.

In addition to replicating the original tables, we introduced our own supplementary statistics and visualizations of calculated bond illiquidity to further elucidate the data. These enhancements aim to provide a more comprehensive view of the datasets and their implications for corporate bond illiquidity.

1.1 Data

In order to replicate and automate both tables, we leverage four data sources:

1. **WRDS BondRet dataset:** A cleaned database incorporating two feeds: FINRA's TRACE (Trade Reporting and Compliance Engine) data for bond transactions, and Mergent FISD data for bond issue and issuer characteristics, reported on a monthly basis.
2. **Daily TRACE panel data:** Maintained by a group of contributors from [Open Source Bond Asset Pricing](#), this data includes individual level price-relevant data based on FINRA's TRACE data, reported on a daily basis.
3. **FINRA's TRACE data:** The original raw data containing individual level bond characteristics, reported on a trade-by-trade basis.
4. **MMN-corrected WRDS TRACE data:** The bond-level panel with characteristics adjusted for market microstructure noise, pulled directly from Open Source Bond Asset Pricing, reported on a monthly basis.

1.2 Replication Results

Table 1 was reconstructed using data from WRDS BondRet and the original TRACE, including all necessary summary statistics except for trade numbers and sizes, derived from the latter. For Table 2, the daily illiquidity measure leveraged the Daily TRACE panel and MMN-corrected panel, while trade-by-trade illiquidity and bid-ask spreads utilized data from the original TRACE and WRDS BondRet, respectively.

We are successful in replicating the whole process of generating the two tables, applying the filters of sample selection outlined in the paper, and generating similar results compared to the original paper. As informed by our unit tests, our results in the two tables are close to the original paper in terms of absolute values, or, at least, data trends. Additionally, we incorporated the latest data to refresh the tables, capturing recent market dynamics.

1.3 Challenges

However, challenges arose due to the limitations of the original datasets. The 2010 paper relied exclusively on TRACE data, which later research suggested might introduce bias due to short-term price reversals. Also, processing the extensive dataset of 346 million trades from 2003 to 2009 was time-intensive. To mitigate these issues, we primarily used pre-processed data from WRDS BondRet and the Daily TRACE panel, which have addressed these reversal effects. This approach, while necessary, occasionally resulted in discrepancies from the original figures due to the different data sources and the exclusion of some transactions recorded in the original TRACE data. We also employed MMN-corrected WRDS TRACE monthly bond data to reconstruct the Table 2 Panel A daily data table, which was a crucial update mentioned on open source bond asset pricing website to adjust for market microstructure noise. After MMN correction, the illiquidity measures are overall lower with higher standard deviation over years.

Updating the results to the current period revealed that the methodology’s exclusion of post-Phase 3 bonds (after February 7, 2005) significantly reduced the dataset over time, and certain bond filtering indicates bonds used in 2003-2009 may lose its ability to be included for the updated table, casting doubt on the recent relevance of the illiquidity measures.

2 Tables

2.1 Table 1 Summary Statistics

Table 1 from the paper

Table 1: Summary Statistics

| Panel A: Bonds in Our Sample | | | | | | | | | | | | | | | | | | | | | |
|------------------------------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|------|------|------|------|------|
| | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | |
| | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std |
| #Bonds | 744 | | | 551 | | | 511 | | | 745 | | | 532 | | | 501 | | | 375 | | |
| Issuance | 1,011 | 987 | 735 | 980 | 750 | 714 | 980 | 750 | 719 | 909 | 750 | 673 | 909 | 750 | 690 | 918 | 750 | 690 | 972 | 750 | 737 |
| Rating | 5.36 | 5.22 | 2.13 | 5.55 | 5.08 | 2.32 | 5.67 | 5.00 | 2.40 | 5.38 | 5.00 | 2.30 | 5.33 | 5.00 | 2.35 | 5.71 | 5.92 | 2.35 | 6.60 | 6.67 | 2.13 |
| Maturity | 7.38 | 5.21 | 6.87 | 7.64 | 5.16 | 7.28 | 7.19 | 4.62 | 7.31 | 6.58 | 4.38 | 6.98 | 6.54 | 4.27 | 7.08 | 6.28 | 3.75 | 7.05 | 6.61 | 3.66 | 7.37 |
| Coupon | 5.84 | 6.00 | 1.63 | 5.71 | 6.00 | 1.69 | 5.23 | 5.80 | 1.67 | 5.44 | 5.50 | 1.65 | 5.47 | 5.62 | 1.65 | 5.55 | 5.70 | 1.65 | 5.80 | 5.88 | 1.60 |
| Age | 2.73 | 1.94 | 2.68 | 3.21 | 2.41 | 2.91 | 3.93 | 3.25 | 2.90 | 4.52 | 3.87 | 2.71 | 5.46 | 4.61 | 2.83 | 6.42 | 5.66 | 2.93 | 7.23 | 6.50 | 3.03 |
| Turnover | 11.43 | 8.52 | 9.33 | 9.47 | 7.09 | 7.71 | 7.51 | 5.92 | 5.87 | 6.53 | 4.99 | 3.99 | 4.87 | 4.11 | 3.28 | 4.70 | 4.19 | 2.83 | 5.98 | 5.06 | 4.12 |
| Tnd Size | 585 | 462 | 469 | 537 | 415 | 507 | 444 | 331 | 412 | 459 | 305 | 366 | 356 | 267 | 335 | 245 | 180 | 240 | 205 | 134 | 217 |
| #Trades | 245 | 153 | 372 | 187 | 127 | 201 | 209 | 121 | 316 | 151 | 110 | 121 | 145 | 107 | 129 | 219 | 144 | 219 | 408 | 221 | 511 |
| Avg Ret | 0.52 | 0.36 | 0.64 | 0.40 | 0.30 | 0.37 | 0.00 | 0.16 | 0.77 | 0.38 | 0.37 | 0.29 | 0.44 | 0.46 | 0.45 | -0.40 | 0.36 | 2.49 | 1.07 | 0.80 | 1.83 |
| Volatility | 2.49 | 2.25 | 1.48 | 1.72 | 1.59 | 0.98 | 1.62 | 1.24 | 1.39 | 1.28 | 1.01 | 1.18 | 1.39 | 1.08 | 1.07 | 0.61 | 0.14 | 8.22 | 4.94 | 3.09 | 5.11 |
| Price | 108 | 109 | 9 | 106 | 106 | 9 | 104 | 105 | 9 | 102 | 101 | 9 | 103 | 101 | 12 | 102 | 102 | 16 | 99 | 102 | 13 |

| Panel B: All Bonds Reported in TRACE | | | | | | | | | | | | | | | | | | | | | |
|--------------------------------------|-------|------|-------|--------|------|------|--------|------|------|--------|------|------|--------|------|------|--------|------|-------|--------|------|------|
| | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | |
| | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std |
| #Bonds | 4,181 | | | 15,270 | | | 23,415 | | | 22,657 | | | 21,640 | | | 21,442 | | | 20,199 | | |
| Issuance | 3,153 | 250 | 540 | 3,175 | 100 | 375 | 3,785 | 300 | 353 | 3,785 | 311 | 361 | 3,687 | 230 | 321 | 3,727 | 17 | 415 | 3,785 | 26 | 470 |
| Rating | 5.61 | 5.00 | 2.62 | 6.46 | 6.00 | 3.26 | 6.37 | 7.00 | 4.00 | 6.17 | 6.00 | 4.26 | 6.77 | 6.25 | 4.90 | 6.80 | 6.00 | 4.36 | 7.96 | 6.67 | 3.74 |
| Maturity | 8.51 | 4.85 | 10.07 | 8.34 | 5.38 | 9.86 | 7.86 | 5.00 | 8.41 | 8.01 | 5.12 | 8.65 | 8.08 | 5.05 | 8.97 | 7.84 | 4.80 | 8.67 | 8.04 | 4.84 | 8.99 |
| Coupon | 5.51 | 5.75 | 1.81 | 5.76 | 5.84 | 1.76 | 5.83 | 5.84 | 1.76 | 5.83 | 5.84 | 1.76 | 5.83 | 5.84 | 1.76 | 5.83 | 5.84 | 1.76 | 5.83 | 5.84 | 1.76 |
| Age | 4.61 | 3.75 | 3.87 | 3.22 | 1.82 | 3.61 | 3.37 | 2.00 | 3.74 | 3.65 | 2.44 | 3.78 | 3.78 | 2.84 | 3.71 | 3.88 | 3.16 | 3.71 | 4.25 | 3.64 | 3.80 |
| Turnover | 15.00 | 8.50 | 8.87 | 4.56 | 2.60 | 5.53 | 3.69 | 2.41 | 3.88 | 3.41 | 2.16 | 3.81 | 3.05 | 1.95 | 3.39 | 2.72 | 1.70 | 3.20 | 3.84 | 2.20 | 4.09 |
| Tnd Size | 1,017 | 584 | 587 | 1,260 | 574 | 901 | 1,017 | 584 | 587 | 1,017 | 584 | 587 | 1,017 | 584 | 587 | 1,017 | 584 | 587 | 1,017 | 584 | 587 |
| #Trades | 60 | 16 | 180 | 31 | 9 | 85 | 36 | 6 | 80 | 21 | 5 | 85 | 21 | 5 | 60 | 27 | 8 | 50 | 54 | 9 | 185 |
| Avg Ret | 0.62 | 0.37 | 4.07 | 0.49 | 0.28 | 2.36 | 0.10 | 0.21 | 2.38 | 0.84 | 0.35 | 2.06 | 0.85 | 0.45 | 2.02 | -0.80 | 0.15 | 6.42 | 2.69 | 1.44 | 1.86 |
| Volatility | 3.79 | 3.36 | 3.27 | 1.97 | 1.29 | 1.20 | 2.64 | 1.84 | 2.24 | 2.42 | 1.66 | 2.24 | 2.42 | 1.66 | 2.24 | 0.92 | 0.11 | 11.80 | 0.72 | 0.84 | 0.86 |
| Price | 109 | 110 | 12 | 105 | 105 | 13 | 100 | 100 | 17 | 99 | 99 | 100 | 100 | 100 | 34 | 92 | 97 | 84 | 84 | 92 | 46 |

Panel B: All Bonds Reported in TRACE

| | 2003 | | | 2004 | | | 2005 | | | 2006 | | | 2007 | | | 2008 | | | 2009 | | |
|------------|-------|------|-------|--------|------|------|--------|------|------|--------|------|------|--------|------|------|--------|------|-------|--------|------|-------|
| | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std | mean | med | std |
| #Bonds | 4,091 | | | 15,297 | | | 25,415 | | | 22,077 | | | 25,540 | | | 25,442 | | | 20,197 | | |
| Issuance | 453 | 250 | 540 | 210 | 50 | 378 | 176 | 30 | 353 | 193 | 31 | 361 | 203 | 25 | 391 | 203 | 17 | 415 | 239 | 26 | 470 |
| Rating | 6.31 | 6.50 | 2.62 | 6.46 | 6.00 | 3.28 | 7.37 | 7.00 | 4.50 | 6.17 | 6.00 | 4.26 | 6.77 | 6.00 | 4.20 | 6.80 | 6.00 | 4.36 | 7.95 | 6.67 | 4.74 |
| Maturity | 8.51 | 4.55 | 10.77 | 8.34 | 5.39 | 8.88 | 7.86 | 5.06 | 8.41 | 8.01 | 5.12 | 8.65 | 8.08 | 5.05 | 8.97 | 7.84 | 4.80 | 8.87 | 8.04 | 4.84 | 8.99 |
| Coupon | 6.31 | 6.75 | 1.69 | 5.76 | 5.85 | 1.96 | 5.80 | 5.70 | 2.16 | 5.74 | 5.62 | 2.13 | 5.60 | 5.55 | 2.18 | 5.24 | 5.30 | 2.46 | 5.28 | 5.55 | 2.51 |
| Age | 4.61 | 3.75 | 3.87 | 3.25 | 1.82 | 3.61 | 3.37 | 2.00 | 3.74 | 3.65 | 2.44 | 3.78 | 3.78 | 2.84 | 3.71 | 3.88 | 3.16 | 3.71 | 4.25 | 3.64 | 3.80 |
| Turnover | 5.60 | 3.80 | 5.67 | 4.56 | 2.50 | 5.53 | 3.69 | 2.41 | 3.88 | 3.41 | 2.16 | 3.81 | 3.05 | 1.95 | 3.39 | 2.82 | 1.70 | 3.20 | 3.64 | 2.20 | 4.09 |
| Tnd Size | 1,017 | 532 | 1,263 | 534 | 59 | 991 | 477 | 55 | 869 | 509 | 58 | 905 | 487 | 40 | 899 | 366 | 46 | 701 | 321 | 48 | 658 |
| #Trades | 66 | 19 | 185 | 31 | 9 | 85 | 26 | 6 | 80 | 21 | 5 | 55 | 21 | 5 | 60 | 27 | 5 | 99 | 54 | 9 | 185 |
| Avg Ret | 0.62 | 0.37 | 4.07 | 0.49 | 0.28 | 2.96 | 0.10 | 0.21 | 2.36 | 0.84 | 0.53 | 2.06 | 0.36 | 0.45 | 2.02 | -0.80 | 0.16 | 6.42 | 2.60 | 1.44 | 7.86 |
| Volatility | 2.75 | 2.36 | 2.27 | 1.62 | 1.67 | 1.26 | 2.68 | 1.55 | 2.81 | 2.80 | 1.74 | 2.29 | 2.42 | 1.95 | 2.24 | 0.52 | 0.80 | 11.02 | 6.72 | 5.86 | 10.44 |
| Price | 109 | 110 | 12 | 105 | 103 | 21 | 100 | 100 | 17 | 99 | 99 | 19 | 100 | 100 | 34 | 92 | 97 | 30 | 84 | 92 | 46 |

#Bonds is the number of bonds. Issuance is the bond's face value issued in millions of dollars. Rating is a numerical translation of Moody's rating: 1=Aaa and 21=C. Maturity is the bond's time to maturity in years. Coupon, reported only for fixed coupon bonds, is the bond's coupon payment in percentage. Age is the time since issuance in years. Turnover is the bond's monthly trading volume as a percentage of its issuance. Tnd Size is the average trade size of the bond in thousands of dollars of face value. #Trades is the bond's total number of trades in a month. Med and std are the time-series averages of the cross-sectional medians and standard deviations. For each bond, we also calculate the time-series mean and standard deviation of its monthly log returns, whose cross-sectional mean, median and standard deviation are reported under Avg Ret and Volatility. Price is the average market value of the bond in dollars.

2.1.1 Replicate Tables 1 in the Paper, For period 2003/04-2009/06

2.1.2 Update Table 1 in the Paper, For period 2009/06-Present

2.2 Table 2 Measure of Illiquidity $\gamma = -\text{Cov}(p_t - p_{t-1}, p_{t+1} - p_t)$

2.2.1 Replicate Table 2 in the Paper, For period 2003/04-2009/06

| Panel A: Individual Bonds, Trade-by-Trade Data, 2003-2009 | | | | | | | | |
|---|---------|---------|---------|---------|---------|---------|---------|---------|
| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
| Mean illiq | 1.4224 | 1.1943 | 0.5995 | 0.3912 | 0.4542 | 2.0812 | 2.3421 | 1.0302 |
| Median illiq | 0.3807 | 0.2436 | 0.1609 | 0.1317 | 0.1214 | 0.2567 | 0.3635 | 0.2037 |
| Per t greater 1.96 | 89.6847 | 90.2858 | 94.1035 | 93.5852 | 91.8786 | 82.6835 | 89.4832 | 90.9685 |
| Robust t stat | 3.5586 | 1.4498 | 4.7801 | 2.4407 | 2.9298 | 11.7010 | 13.4443 | 2.2156 |

Table 2 in the paperTable 2: Measure of Illiquidity $\gamma = -\text{Cov}(p_t - p_{t-1}, p_{t+1} - p_t)$

| Panel A: Individual Bonds | | | | | | | | |
|--|---------|---------|---------|--------|--------|---------|---------|---------|
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
| Trade-by-Trade Data | | | | | | | | |
| Mean γ | 0.64 | 0.60 | 0.52 | 0.40 | 0.44 | 1.02 | 1.35 | 0.63 |
| Median γ | 0.41 | 0.32 | 0.25 | 0.19 | 0.24 | 0.57 | 0.63 | 0.34 |
| Per t ≥ 1.96 | 99.46 | 98.64 | 99.34 | 99.87 | 99.69 | 98.80 | 97.98 | 99.81 |
| Robust t-stat | 14.54 | 16.22 | 15.98 | 15.12 | 14.88 | 12.58 | 9.45 | 19.42 |
| Daily Data | | | | | | | | |
| Mean γ | 0.99 | 0.82 | 0.77 | 0.57 | 0.80 | 3.21 | 5.40 | 1.18 |
| Median γ | 0.61 | 0.41 | 0.34 | 0.29 | 0.47 | 1.36 | 1.94 | 0.56 |
| Per t ≥ 1.96 | 94.62 | 92.64 | 95.50 | 96.26 | 95.57 | 95.41 | 97.59 | 98.84 |
| Robust t-stat | 17.28 | 17.88 | 18.21 | 19.80 | 14.39 | 7.16 | 8.47 | 16.53 |
| Panel B: Bond Portfolios | | | | | | | | |
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
| Equal-weighted | -0.0014 | -0.0043 | -0.0008 | 0.0001 | 0.0023 | -0.0112 | -0.0301 | -0.0050 |
| t-stat | -0.29 | -1.21 | -0.47 | 0.11 | 1.31 | -0.26 | -2.41 | -0.71 |
| Issuance-weighted | 0.0018 | -0.0042 | -0.0003 | 0.0007 | 0.0034 | 0.0030 | -0.0280 | -0.0017 |
| t-stat | 0.30 | -1.14 | -0.11 | 0.41 | 1.01 | 0.06 | -1.97 | -0.20 |
| Panel C: Implied by Quoted Bid-Ask Spreads | | | | | | | | |
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
| Mean implied γ | 0.035 | 0.031 | 0.034 | 0.028 | 0.031 | 0.050 | 0.070 | 0.034 |
| Median implied γ | 0.031 | 0.025 | 0.023 | 0.018 | 0.021 | 0.045 | 0.059 | 0.026 |

At the individual bond level, γ is calculated using either trade-by-trade or daily data. Per t-stat ≥ 1.96 reports the percentage of bond with statistically significant γ . Robust t-stat is a test on the cross-sectional mean of γ with standard errors corrected for cross-sectional and time-series correlations. At the portfolio level, γ is calculated using daily data and the Newey-West t-stats are reported. Monthly quoted bid-ask spreads, which we have data for 1,032 out of 1,035 bonds in our sample, are used to calculate the implied γ .

Panel A: Individual Bonds, Daily Data, 2003-2009

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Mean illiq | 1.0124 | 1.0549 | 0.8511 | 0.4090 | 1.1160 | 13.2716 | 17.9805 | 3.1199 |
| Median illiq | 0.1186 | 0.0610 | 0.0409 | 0.0364 | 0.0650 | 0.2328 | 0.3345 | 0.0726 |
| Per t greater 1.96 | 77.2839 | 77.3770 | 80.2972 | 87.9141 | 87.3263 | 67.4085 | 69.0074 | 79.6793 |
| Robust t stat | 2.5416 | 10.1838 | 4.0673 | 6.7154 | 1.8154 | 20.7878 | 1.1863 | 17.0572 |

Panel B: Bond Portfolios, 2003-2009

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
|-------------------|--------|---------|---------|---------|--------|---------|---------|---------|
| Equal weighted | 0.0061 | -0.0008 | 0.0000 | 0.0010 | 0.0006 | -0.0003 | -0.0080 | 0.0008 |
| EW t stat | 1.4540 | -0.5420 | -0.2565 | -0.1952 | 1.5554 | -0.0958 | -0.9542 | -0.2944 |
| Issuance weighted | 0.0065 | -0.0009 | -0.0008 | 0.0001 | 0.0013 | 0.0012 | -0.0175 | 0.0002 |
| IW t stat | 0.0406 | -0.7365 | -0.8902 | 0.1933 | 0.4756 | -1.1784 | -2.1805 | -1.7069 |

Panel C: Implied by Quoted Bid-Ask Spreads, 2003-2009

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Mean implied gamma | 0.0066 | 0.0054 | 0.0047 | 0.0043 | 0.0057 | 0.0124 | 0.0159 | 0.0066 |
| Median implied gamma | 0.0045 | 0.0036 | 0.0033 | 0.0031 | 0.0044 | 0.0090 | 0.0123 | 0.0042 |

2.2.2 Update Table 2 in the Paper, For period 2003/04-Present

Panel A: Individual Bonds, Trade-by-Trade Datas, 2003-Present

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Full |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Mean illiq | 1.4224 | 1.1943 | 0.5995 | 0.3912 | 0.4542 | 2.0812 | 1.7008 | 0.4149 | 0.3341 | 0.2796 | 0.9434 |
| Median illiq | 0.3807 | 0.2436 | 0.1609 | 0.1317 | 0.1214 | 0.2567 | 0.2685 | 0.1186 | 0.0864 | 0.0673 | 0.1882 |
| Per t greater 1.96 | 89.6847 | 90.2858 | 94.1035 | 93.5852 | 91.8786 | 82.6835 | 90.0700 | 90.9900 | 92.0814 | 53.9235 | 90.7933 |
| Robust t stat | 3.5586 | 1.4498 | 4.7801 | 2.4407 | 2.9298 | 11.7010 | 4.0919 | 1.9506 | 2.0201 | 1.0960 | 4.9323 |

Panel A: Individual Bonds, Daily Data, 2003-Present

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Full |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| Mean illiq | 1.0131 | 1.0708 | 0.8436 | 0.4180 | 1.1282 | 10.5194 | 4.0103 | 0.4441 | 0.3797 | 0.2672 | 1.3610 | 0.2226 | 0.4088 | 0.5588 | 0.2066 | 2.6832 | 0.2523 | 1.1915 | 0.1851 | 0.4878 | 1.8214 |
| Median illiq | 0.1176 | 0.0601 | 0.0395 | 0.0349 | 0.0625 | 0.2192 | 0.1827 | 0.0517 | 0.0368 | 0.0415 | 0.0310 | 0.0597 | 0.1931 | 0.2314 | 0.1441 | 0.1157 | 0.1393 | 0.2314 | 0.0818 | 0.1578 | 0.0698 |
| Per t greater 1.96 | 77.8502 | 77.7234 | 80.7667 | 87.7888 | 87.9456 | 67.8345 | 73.8943 | 91.0076 | 82.6296 | 92.3549 | 89.4840 | 91.8605 | 94.9772 | 95.3654 | 97.0425 | 88.9105 | 86.4929 | 26.8012 | 73.8462 | 73.7654 | 81.8534 |
| Robust t stat | 0.4910 | 6.1507 | 2.6359 | 0.9841 | 6.5223 | 0.3743 | 15.8570 | 40.5960 | 28.7681 | 0.1406 | 3.1707 | 0.6050 | 10.2701 | 1.4953 | 17.3204 | 2.6228 | 7.2106 | 2.9258 | 1.5125 | 0.9367 | 176.4516 |

Panel B: Bond Portfolios, 2003-Present

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Full |
|-------------------|--------|---------|---------|---------|--------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|--------|---------|
| Equal weighted | 0.0059 | 0.0015 | -0.0013 | 0.0010 | 0.0011 | -0.0031 | -0.0032 | -0.0007 | 0.0013 | 0.0026 | 0.0013 | 0.0033 | 0.0211 | 0.0085 | 0.0050 | 0.0302 | 0.0102 | 0.0007 | 0.0058 | 0.0189 | 0.0022 |
| EW t stat | 1.5139 | -0.3417 | -0.7052 | -0.1612 | 1.6158 | -0.3194 | -1.6198 | -1.6114 | 0.5978 | 2.3197 | 1.5456 | 1.6790 | 2.6883 | 1.2802 | 1.7161 | 2.7832 | 2.4762 | -1.1893 | 1.6406 | 1.4192 | -0.5163 |
| Issuance weighted | 0.0072 | -0.0010 | -0.0016 | 0.0002 | 0.0015 | -0.0007 | -0.0074 | 0.0012 | 0.0011 | 0.0021 | 0.0013 | 0.0047 | 0.0259 | 0.0191 | 0.0205 | 0.0087 | 0.0215 | 0.0148 | 0.0181 | 0.0224 | 0.0022 |
| IW t stat | 0.0837 | -0.7274 | -0.5380 | 0.1200 | 0.3620 | -1.0235 | -1.6335 | 0.1826 | -0.1351 | 1.1977 | 0.7017 | 2.0986 | 3.1313 | 2.1604 | 2.7049 | 0.9280 | 2.6681 | -0.9091 | 1.5237 | 1.0868 | -0.4640 |

Panel C: Implied by Quoted Bid-Ask Spreads, 2003-Present

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Full |
|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Mean implied gamma | 0.0067 | 0.0054 | 0.0047 | 0.0044 | 0.0058 | 0.0123 | 0.0124 | 0.0061 | 0.0054 | 0.0056 | 0.0052 | 0.0062 | 0.0082 | 0.0094 | 0.0072 | 0.0064 | 0.0067 | 0.0072 | 0.0045 | 0.0059 | 0.0065 |
| Median implied gamma | 0.0046 | 0.0036 | 0.0033 | 0.0031 | 0.0043 | 0.0089 | 0.0093 | 0.0045 | 0.0035 | 0.0037 | 0.0036 | 0.0050 | 0.0079 | 0.0086 | 0.0065 | 0.0059 | 0.0061 | 0.0056 | 0.0040 | 0.0049 | 0.0044 |

2.2.3 Table 2 Panel A Daily Data using MMN-Corrected Bond Data

Panel A: Individual Bonds, MMN-Corrected Bond Data, 2003-2009

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Full |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Mean illiq | 1.1264 | 1.3510 | 0.4334 | 0.3291 | 0.4035 | 4.3871 | 8.4361 | 1.5078 |
| Median illiq | 0.1078 | 0.0617 | 0.0453 | 0.0457 | 0.0803 | 0.2696 | 0.4247 | 0.0784 |
| Per t greater 1.96 | 71.4802 | 71.3777 | 79.9052 | 83.8984 | 88.2657 | 61.2684 | 63.1525 | 75.9952 |
| Robust t stat | 2.3045 | 10.1325 | 5.5754 | 0.4979 | 0.7750 | 10.1433 | 0.8237 | 7.2061 |

Panel A: Individual Bonds, MMN-Corrected Bond Data, 2003-Present

| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Full |
|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Mean illiq | 1.2639 | 1.4954 | 0.4658 | 0.3423 | 0.4142 | 4.4183 | 4.6618 | 0.2475 | 0.2889 | 0.2801 | 0.1969 | 0.2546 | 0.4005 | 0.4696 | 0.1924 | 0.1882 | 0.1443 | 0.6999 | 0.0771 | 0.1751 | 1.2808 |
| Median illiq | 0.1100 | 0.0644 | 0.0462 | 0.0463 | 0.0825 | 0.2690 | 0.2273 | 0.0662 | 0.0471 | 0.0664 | 0.0607 | 0.1116 | 0.2047 | 0.1609 | 0.0863 | 0.0714 | 0.0797 | 0.0770 | 0.0278 | 0.0605 | 0.0796 |
| Per t greater 1.96 | 72.1027 | 71.6347 | 79.5860 | 83.9946 | 89.8032 | 60.3363 | 70.2179 | 88.9231 | 79.5890 | 90.5763 | 82.8810 | 84.6400 | 84.2402 | 80.7229 | 80.8756 | 70.1657 | 77.9456 | 12.1212 | 66.3158 | 54.5455 | 77.3562 |
| Robust t stat | 8.0333 | 2.3127 | 4.8002 | 1.5020 | 9.3092 | 48.6802 | 50.5706 | 6.4627 | 12.2043 | 1.2469 | 0.9385 | 1.1688 | 8.5341 | 2.6728 | 6.7218 | 13.3750 | 2.9583 | 0.3793 | 3.5230 | 3.2977 | 8.6956 |

2.3 Monthly Bond Illiquidity Summary Statistics

Monthly Bond Illiquidity Summary Statistics Using Daily Data, 2003-2009

| year | min illiq | mean illiq | q1 0.25 | median | q3 0.75 | max illiq | std illiq | mean t stat |
|------|-----------|------------|---------|--------|---------|-----------|-----------|-------------|
| 2003 | -129.0095 | 1.0124 | 0.0307 | 0.1186 | 0.4168 | 1127.4809 | 15.9260 | 2.9252 |
| 2004 | -6.9843 | 1.0549 | 0.0140 | 0.0610 | 0.2430 | 718.6896 | 17.5463 | 3.0400 |
| 2005 | -12.6456 | 0.8511 | 0.0094 | 0.0409 | 0.1718 | 2116.8092 | 29.7287 | 3.1092 |
| 2006 | -20.1519 | 0.4090 | 0.0079 | 0.0364 | 0.1617 | 787.2365 | 9.3278 | 3.4375 |
| 2007 | -9.3454 | 1.1160 | 0.0153 | 0.0650 | 0.2402 | 1764.1170 | 26.6052 | 3.2489 |
| 2008 | -830.6648 | 13.2716 | 0.0595 | 0.2328 | 1.1329 | 5836.7472 | 190.9861 | 2.5173 |
| 2009 | -202.0453 | 17.9805 | 0.0706 | 0.3345 | 2.0137 | 8571.4286 | 233.0594 | 2.6543 |

3 Visualizations

3.1 Monthly Illiquidity Per Bond and Average Illiquidity By Year

Monthly Bond Illiquidity Summary Statistics Using Daily Data, 2003-Present

| year | min illiq | mean illiq | q1 0.25 | median | q3 0.75 | max illiq | std illiq | mean t stat |
|------|-----------|------------|---------|--------|---------|-----------|-----------|-------------|
| 2003 | -129.0095 | 1.0131 | 0.0309 | 0.1176 | 0.4071 | 1127.4809 | 16.1396 | 2.9296 |
| 2004 | -6.9843 | 1.0708 | 0.0140 | 0.0601 | 0.2412 | 718.6896 | 17.7673 | 3.0512 |
| 2005 | -12.6456 | 0.8436 | 0.0093 | 0.0395 | 0.1675 | 2116.8092 | 30.1023 | 3.1397 |
| 2006 | -20.1519 | 0.4180 | 0.0078 | 0.0349 | 0.1555 | 787.2365 | 9.4784 | 3.4512 |
| 2007 | -8.9327 | 1.1282 | 0.0149 | 0.0625 | 0.2264 | 1764.1170 | 27.0673 | 3.2647 |
| 2008 | -284.1272 | 10.5194 | 0.0586 | 0.2192 | 1.0137 | 5836.7472 | 172.6313 | 2.5626 |
| 2009 | -162.9935 | 4.0103 | 0.0413 | 0.1827 | 1.1041 | 883.5966 | 23.2900 | 2.6879 |
| 2010 | -32.6263 | 0.4441 | 0.0151 | 0.0517 | 0.2429 | 54.3453 | 2.2485 | 3.7396 |
| 2011 | -2.3940 | 0.3797 | 0.0104 | 0.0368 | 0.2169 | 17.5307 | 1.2358 | 3.3557 |
| 2012 | -20.1613 | 0.2672 | 0.0097 | 0.0415 | 0.2195 | 36.9817 | 1.4741 | 3.7840 |
| 2013 | -47.8704 | 1.3610 | 0.0050 | 0.0310 | 0.1716 | 1605.8952 | 41.5828 | 3.5638 |
| 2014 | -0.6750 | 0.2226 | 0.0063 | 0.0597 | 0.2647 | 11.4411 | 0.5136 | 4.0144 |
| 2015 | -5.3071 | 0.4088 | 0.0426 | 0.1931 | 0.5524 | 5.3490 | 0.6641 | 4.1939 |
| 2016 | -0.5927 | 0.5588 | 0.0655 | 0.2314 | 0.6820 | 9.2924 | 0.8820 | 3.9617 |
| 2017 | -52.2769 | 0.2066 | 0.0339 | 0.1441 | 0.3060 | 12.9757 | 2.3985 | 3.8839 |
| 2018 | -26.5423 | 2.6832 | 0.0250 | 0.1157 | 0.3247 | 813.9595 | 37.7518 | 3.5731 |
| 2019 | -2.8221 | 0.2523 | 0.0416 | 0.1393 | 0.3066 | 6.5013 | 0.5358 | 3.4018 |
| 2020 | -9.7284 | 1.1915 | 0.0480 | 0.2314 | 0.8400 | 67.3578 | 4.8853 | 1.3364 |
| 2021 | -1.2447 | 0.1851 | 0.0150 | 0.0818 | 0.2299 | 4.0193 | 0.3715 | 3.1882 |
| 2022 | -3.8559 | 0.4878 | 0.0290 | 0.1578 | 0.4758 | 10.0916 | 1.1636 | 2.8679 |

Monthly Bond Illiquidity Summary Statistics Using MMN-Corrected Bond Data, 2003-2009

| year | min illiq | mean illiq | q1 0.25 | median | q3 0.75 | max illiq | std illiq | mean t stat |
|------|-----------|------------|---------|--------|---------|-----------|-----------|-------------|
| 2003 | -9.1433 | 1.1264 | 0.0255 | 0.1078 | 0.3455 | 751.2174 | 16.7972 | 2.7336 |
| 2004 | -20.0387 | 1.3510 | 0.0137 | 0.0617 | 0.2471 | 778.5893 | 21.1987 | 2.8324 |
| 2005 | -18.1375 | 0.4334 | 0.0103 | 0.0453 | 0.1786 | 926.1567 | 12.3415 | 2.9953 |
| 2006 | -40.3311 | 0.3291 | 0.0105 | 0.0457 | 0.1672 | 550.7363 | 7.1427 | 3.2997 |
| 2007 | -4.4272 | 0.4035 | 0.0220 | 0.0803 | 0.2725 | 500.2215 | 6.7293 | 3.2232 |
| 2008 | -249.7849 | 4.3871 | 0.0656 | 0.2696 | 1.1296 | 1084.7152 | 34.3248 | 2.2465 |
| 2009 | -73.6781 | 8.4361 | 0.0866 | 0.4247 | 2.2894 | 925.4092 | 46.1308 | 2.3772 |

Monthly Bond Illiquidity Summary Statistics Using MMN-Corrected Bond Data, 2003-Present

| year | min illiq | mean illiq | q1 0.25 | median | q3 0.75 | max illiq | std illiq | mean t stat |
|------|-----------|------------|---------|--------|---------|-----------|-----------|-------------|
| 2003 | -9.3580 | 1.2639 | 0.0264 | 0.1100 | 0.3613 | 767.2553 | 19.5645 | 2.7561 |
| 2004 | -20.0387 | 1.4954 | 0.0141 | 0.0644 | 0.2603 | 778.5893 | 23.0873 | 2.8465 |
| 2005 | -18.1375 | 0.4658 | 0.0105 | 0.0462 | 0.1854 | 926.1567 | 12.3580 | 3.0188 |
| 2006 | -40.3311 | 0.3423 | 0.0109 | 0.0463 | 0.1726 | 550.7363 | 7.1426 | 3.3127 |
| 2007 | -1.7845 | 0.4142 | 0.0230 | 0.0825 | 0.2807 | 500.2215 | 6.7189 | 3.2582 |
| 2008 | -249.7849 | 4.4183 | 0.0654 | 0.2690 | 1.0993 | 1084.7152 | 34.9089 | 2.2688 |
| 2009 | -73.6781 | 4.6618 | 0.0519 | 0.2273 | 1.1253 | 925.4092 | 32.3789 | 2.4732 |
| 2010 | -6.3152 | 0.2475 | 0.0199 | 0.0662 | 0.2173 | 19.6215 | 0.7107 | 3.4391 |
| 2011 | -11.1267 | 0.2889 | 0.0124 | 0.0471 | 0.2260 | 19.9247 | 1.0737 | 3.1756 |
| 2012 | -1.6461 | 0.2801 | 0.0169 | 0.0664 | 0.2708 | 26.3509 | 0.8675 | 3.7077 |
| 2013 | -3.2834 | 0.1969 | 0.0112 | 0.0607 | 0.2319 | 7.8376 | 0.4362 | 3.2835 |
| 2014 | -0.8871 | 0.2546 | 0.0303 | 0.1116 | 0.3131 | 3.5000 | 0.4075 | 3.8890 |
| 2015 | -8.7366 | 0.4005 | 0.0521 | 0.2047 | 0.5541 | 6.7399 | 0.8311 | 3.5203 |
| 2016 | -4.2843 | 0.4696 | 0.0447 | 0.1609 | 0.5103 | 11.6422 | 1.0501 | 3.1075 |
| 2017 | -0.4161 | 0.1924 | 0.0214 | 0.0863 | 0.2327 | 4.2988 | 0.4057 | 3.1933 |
| 2018 | -2.6733 | 0.1882 | 0.0154 | 0.0714 | 0.1885 | 19.9444 | 1.0902 | 2.9130 |
| 2019 | -0.4971 | 0.1443 | 0.0135 | 0.0797 | 0.1862 | 3.3472 | 0.3048 | 2.8892 |
| 2020 | -9.2546 | 0.6999 | 0.0069 | 0.0770 | 0.2977 | 34.1160 | 3.3343 | 0.7079 |
| 2021 | -0.1431 | 0.0771 | 0.0006 | 0.0278 | 0.0871 | 1.8462 | 0.1783 | 2.1471 |
| 2022 | -2.0668 | 0.1751 | -0.0135 | 0.0605 | 0.1995 | 5.4572 | 0.5837 | 1.3503 |

Figure 1: Illiquidity by Year with Mean Illiquidity, 2003-2009

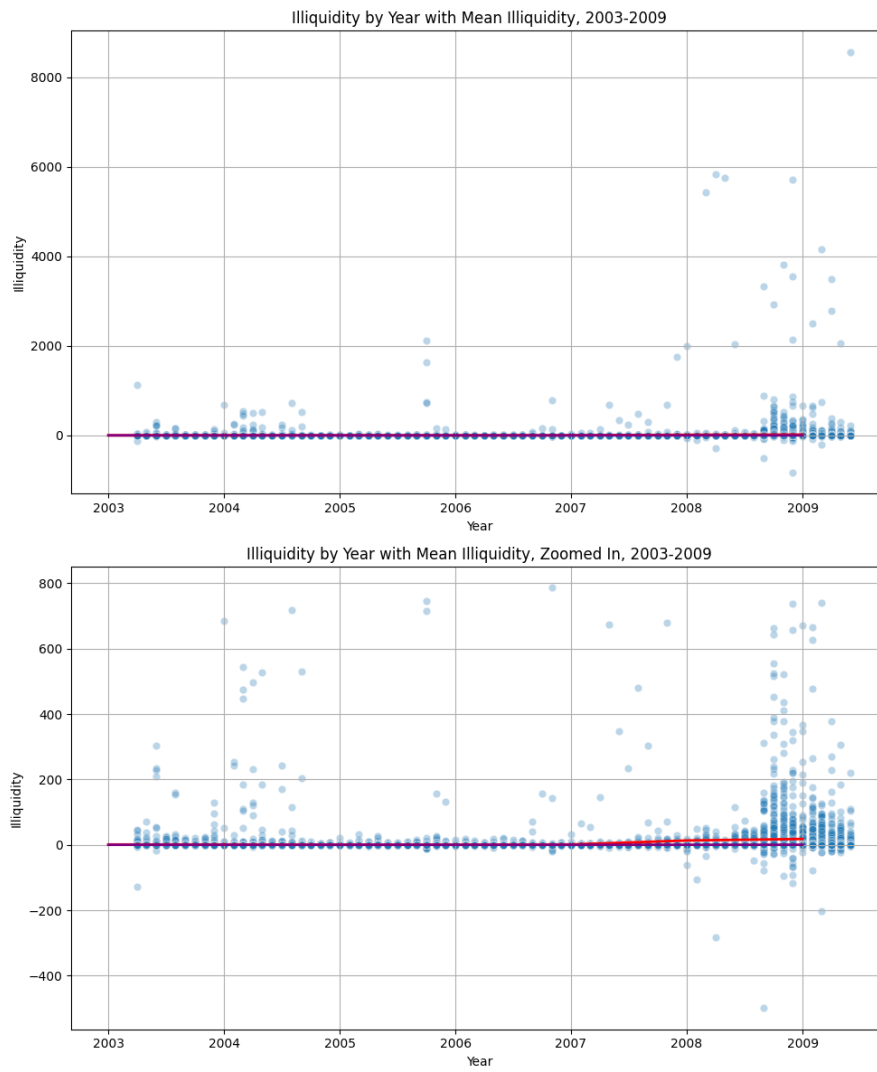


Figure 2: Illiquidity by Year with Mean Illiquidity, 2003-Present

