A Survey of the Microstructure of Fixed-Income Markets*

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Abstract

This paper surveys the literature that studies fixed-income trading rules and outcomes, including Treasury securities, corporate and municipal bonds, and structured credit products. We compare and contrast the microstructure and regulation of fixed-income markets with equity markets. We highlight the nature of over-the-counter trading in the face of search costs and the associated slow evolution of electronically-facilitated intermediation. We discuss the databases available for the study of fixed-income microstructure, as well as measures of trading costs and the determinants thereof, and the important roles of dealer networks and limited transparency. We also highlight unresolved issues.
I. Introduction

Financial markets create and transact a broad set of fixed-income instruments, characterized by contracts that specify the amount and timing of promised payments. With a few exceptions to be noted, fixed-income instruments trade in dealer-oriented over-the-counter (OTC) search markets that differ significantly from the more widely studied markets for equity instruments.

Treasury securities issued by central governments are in many ways the simplest fixed-income instruments, characterized by low default risk, high trading volumes, standardized contracts, and generally liquid markets. Bonds issued by corporations as well as municipalities comprise one of the largest segments of the fixed-income markets. In addition, fixed-income markets trade structured products, which are created by repackaging existing loans. Examples include mortgage-backed securities (MBS), either with (agency-MBS) or without (private-label MBS) the implicit backing of semi-government agencies, asset-backed securities (ABS) which are secured by assets such as auto loan or credit card debt, as well as packages of bank loans. Fixed-income markets also include collateralized debt obligations (CDOs), which are created from structured products by dividing cash flow promises into various “tranches.”

In general, fixed-income trading has been the focus of less research attention as compared to equity market trading, despite the fact that fixed-income markets are substantially larger and account for more capital raising as compared to equity markets (as discussed further in Section III.A below). Recent years have seen an increase in research, both theoretical and empirical, focused on fixed-income trading.

This paper attempts to review and summarize the key issues and many of the important studies to date, while laying out directions for potential future research.

II. Fixed Income vs. Equity Markets

Fixed income and equity markets share important common features. Each facilitates price

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discovery and the completion of transactions in financial assets. Investors seeking to buy and to sell do not necessarily arrive simultaneously in these markets, so intermediaries emerge to supply liquidity. When these intermediaries trade on a principal basis, they absorb order imbalances into inventory, and therefore are subject to price risk on the positions entered to facilitate transactions. Since the value of both fixed-income and equity instruments depends on market-wide variables, such as central bank policy and macroeconomic growth, as well as issuer-specific outcomes, and since some participants may have better access to such information than others, risks attributable to asymmetric information arise in both markets. Microstructure theory broadly applied therefore implies that the costs of demanding immediate trade execution in both equity and fixed-income markets should depend on return volatility, customer arrival rates, and the likelihood of information asymmetries adverse to the intermediaries who effectively supply liquidity.

A. Contrasts Between Fixed-Income and Equity Microstructures

Despite these similarities in the underlying economic issues, fixed-income microstructure differs significantly from that of the equity markets. While most equity trading has migrated in recent years to electronic limit order markets, with the exception of U.S. Treasury instruments and to-be-announced (TBA, discussed further below) MBS, relatively little fixed-income trading occurs on electronic platforms.\(^2\) For example, a recent industry report estimated that just 23% of U.S investment grade corporate bond trading was electronically-facilitated, mostly through “requests for quotations” (RFQs) transmitted to established dealers.\(^3\) Hendershott and Madhavan (2015) describe trading on the basis of indicative RFQs on MarketAxess. Clients select the number of dealers to be queried for a quote of a specified size in a given bond and specify the time by which quotes should be submitted. At that time all quotes are revealed to the client. If satisfied, the client can contact the dealer submitting the best quote

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\(^2\) Abudy and Wohl (2018) examine the Tel Aviv Stock Exchange data in 2014, where corporate bonds trade in a consolidated limit order book market structure, reporting that the market is liquid with narrow spreads and smaller price dispersion.

\(^3\) Greenwich Associates 2016 North American Fixed Income Research Study.
for execution. They report that RFQ usage is greatest for recently issued, investment grade, large-issue-size bonds.\(^4\)

Quotations in equity markets are firm, in that the submission by another market participant of an opposite direction order with a sufficiently aggressive limit price generates an immediate trade execution. In contrast, fixed-income quotes are typically indicative rather than firm commitments. Fixed-income trading is often facilitated by the electronic dissemination of quotations to at least some participants, even while trades cannot be automatically completed on the same platforms. The lack of electronically-executable quotations has largely kept high frequency trading (HFT) firms from establishing themselves as major players in the fixed-income markets. As a consequence, most liquidity provision in fixed-income markets continues to rely on dealer firms, with little direct access by public orders.\(^5\) The situation is somewhat analogous to the design of the National Association of Securities Dealers Automated Quotations (NASDAQ) equity markets, prior to the establishment of “order-handling” rules two decades ago.

Nevertheless, the electronic facilitation of bond trading is increasing. In Treasury markets, most interdealer trading is now electronic and automated, and a large share of customer-to-dealer trading relies on electronic communication. Platforms that allow for direct customer-to-customer (or “all-to-all”) trading have been introduced to corporate bond markets, though their share of trading remains low.\(^6\) Further, some liquidity providers now respond to corporate bond RFQs for trades below certain size thresholds using algorithms rather than human traders.\(^7\)


\(^5\) Biais and Green (2007) show that municipal and corporate bonds traded actively on the New York Stock Exchange (NYSE) before World War II (WWII). The study estimates that average trading costs for retail bond investors on the NYSE before WWII were lower than they are over-the-counter in recent years.

\(^6\) All-to-all trading accounts for only about 15% of investment grade corporate bond volume executed on Market Axess in the first quarter of 2017. https://www.marketaxess.com/trading/opentradingblog.php

The equity markets are highly transparent, as prices and quantities for completed trades (“post-trade” transparency) as well as the best available bid and ask quotes (“pre-trade transparency”) are widely disseminated in real time or with very short delays.\textsuperscript{8} In contrast, as discussed further in Section VI, fixed-income markets are relatively opaque, as quotations are distributed to only some market participants. The various market venues that trade equities are integrated both by regulation and competition. Regulation NMS in particular requires that no equity trade of limited size be executed at a price worse than the best electronically-accessible quotation on any exchange. Fixed-income markets are not subject to a similar regulation. While, as discussed further in Section VI, brokerage firms are subject to a duty of best execution, the enforcement of such a duty is potentially hindered by the lack of pre-trade transparency in fixed-income markets. In addition, each equity exchange disseminates electronic quotations that facilitate competition, resulting in what O’Hara and Ye (2011) refer to as “a single virtual market with multiple points of entry.” In contrast, competition across fixed-income dealers may be mitigated to an extent by limited pre-trade transparency and high search costs.

Bonds, like common stocks, can be sold short by borrowing the security. Short selling facilitates market making by allowing dealers to accommodate customer buy orders, even if the bond is not already held in inventory. Short selling also facilitates speculative trading motivated by the possibility of a price decline. A large literature studies short selling in the stock markets, generally concluding that short selling enhances liquidity (Beber and Pagano, 2013) and, since short sellers are relatively well-informed (Diamond and Verrecchia, 1987), they improve price discovery. In contrast, the literature on short selling in bond markets is sparse.

B. Dealer Capital Commitment

With the exception of Treasury securities and TBA-MBS, trading in fixed-income instruments is dominated by OTC trading between customers and dealer firms. Traditionally, dealers committed their own capital, completing most trades on a principal basis by absorbing customer orders into inventory. In

\textsuperscript{8} “Dark Pools,” which do not generally disseminate quotations, comprise an exception.
recent years, however, dealers have reduced their degree of capital commitment in corporate bond markets, as documented by Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018) and Bao, O’Hara and Zhou (2018). This reduction reflects in part an increased reliance on “prearranged” pairs of trades, where the dealer quickly resells the bond to a counterparty, who was in fact located prior to the completion of the initial trade (Schultz (2017), Goldstein and Hotchkiss (2018) and Choi and Huh (2017)). Further, Hollifield, Neklyudov, and Spatt (2017) document shorter “intermediation chains,” i.e., that fewer dealers are involved before a bond is transferred to another customer.

Most major bond dealers are affiliated with banks, though non-bank dealers have increased their participation in recent years. For example, Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018) report that non-bank dealers accounted for 12.5% of customer-dealer trading volume in corporate bonds during 2014-2016, as compared to just 2.4% prior to the 2007-2009 financial crisis. Decreased capital commitment by corporate bond dealers in recent years has been linked to post-financial crisis regulations, including higher capital requirements and the Volcker Rule limitations on trading by banks, as discussed further in Section VI below.

C. Trading Outcomes

Several empirical patterns differ notably across equity and fixed-income markets. Customer trade execution costs tend to be substantially larger in fixed-income markets as compared to equities. For example, Harris and Piwowar (2006) document that effective bid-ask spreads in municipal bonds averaged about 2% for trades of $20,000. In order for the cost of a similar-sized trade in a 40-dollar stock to be as large, the effective bid-ask spread would be 80 cents, while by comparison Chordia, Roll and Subrahmanyam (2008) report that actual median effective bid-ask spread in U.S. equity markets at a similar point in time was just 3.3 cents. This outcome is somewhat surprising, since fixed-income markets tend to be less volatile than equities and fixed-income securities are likely to be less sensitive to new information regarding issuer fundamentals. That is, standard microstructure arguments would imply

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9 Treasuries, where interdealer trades occur at very narrow spreads, and TBA-MBS comprise potential exceptions. Data on customer trades in Treasury securities are not publicly disseminated.
a lower cost of immediacy in fixed-income markets, because the intermediaries who supply liquidity are likely subject to both less inventory risk and asymmetric information costs.

It is also noteworthy that, while trade execution costs in equity markets tend to be greater for large trades than for small ones, presumably due to adverse selection and inventory costs, the opposite pattern is observed in fixed-income markets. For example, Edwards, Harris and Piwowar (2007) report estimated trading costs for corporate bonds that decrease monotonically from seventy-five basis points for trades of $5,000 to less than ten basis points for trades of $1 million or larger. Similarly, Bessembinder, Maxwell, and Venkataraman (2013) report estimates of trading costs for structured credit products (asset-backed securities, mortgage-backed securities, etc.) that range from 83 basis points for trades less than $100,000 to just five basis points for trades larger than $1 million.

Trade sizes and frequencies also differ dramatically across equity and bond markets. In recent years, the median trade size in equity markets is 100 shares (O'Hara and Ye, 2014), or about $3,000 to $5,000 for typically priced stocks. By comparison, a “round-lot” trade in corporate bond markets involves $1 million. Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018) report an average trade size of $1.2 million for their sample of corporate bond trades during 2014-16, while Bessembinder, Kahle, Maxwell, and Xu (2009) report that round-lot transactions accounted for nearly ninety percent of corporate bond dollar trading volume.

Most fixed-income products trade infrequently. For example, Bessembinder, Maxwell, and Venkataraman (2013) report that the majority of MBS and ABS (e.g., credit card and auto loan) in their 21-month sample never traded at all. Edwards, Harris, and Piwowar (2007) report that individual corporate bond issues did not trade on 52 percent of the days in their sample, and that the average number of daily trades in an issue, conditional on trading, is just 2.4. One reason that individual corporate bonds trade less frequently than equities is that an issuer often has multiple bond issues outstanding. While equity shares issued at different points in time by a given firm are fully substitutable, each bond issue is a distinct contract with differing promised payments, maturity dates, and priority in case of default, and is therefore traded separately.
III. Descriptive Overview of Fixed-Income Markets

A. Bond market size and ownership

According to Securities Industry and Financial Markets Association (SIFMA) statistics summarized on Table 1, as of 2017 the largest capital markets relative to GDP are those of the United States (360%) and Japan (388%), followed by the EU (245%) and China (167%). Fixed-income markets account for 56% of U.S. capital markets, based on market capitalization. Figure 1 displays the relative size of various U.S. fixed-income markets from 2003 to 2017, and for comparison the size of U.S. public equity markets, demonstrating that the fixed-income market in aggregate is substantially larger than the equity market. Fixed-income markets accounted for 97% of all U.S. security issuance during 2017. The volume of new issuance reflects in part that many fixed-income securities have short terms and are re-issued (i.e., refunded) at maturity. Treasury bonds accounted for 29% of all issuance, while mortgage-related and corporate issuances accounted for 26% and 22%, respectively.

Foreign investors held 42% of outstanding U.S. Treasury Bonds as of 2016 and were also significant holders of corporate bonds (29% of total) and agency-issued mortgage-backed securities (MBS, 14% of total). The U.S. Federal Reserve has been a large owner of Treasury bonds and agency-MBS. The Fed held significant quantities of bonds even before the 2007-09 financial crisis, but their holdings of Treasury and MBS securities spiked as a result of asset purchase programs during the crisis. Direct holdings by households account for less than 10% of all Treasury and corporate bond holdings. In contrast, households account for over 50% of municipal bond holdings, reflecting their federal tax-exempt status. Mutual funds account for 12%, 17%, and 16%, respectively, of holdings of Treasuries, municipal, and corporate bonds (each as of 2016).

B. Bond Trading Participation and Logistics

The trading activity in the secondary market for fixed income securities is dominated by

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11 Foreign ownership includes the holdings of foreign subsidiaries of U.S. corporations.
institutions, such as pension funds, mutual funds, hedge funds, insurance companies, and sovereign wealth funds. Quotation data are available to such institutions, with investment-grade bonds quoted in terms of spread over a Treasury security of similar maturity, while lower-rated bonds, the value of which depends more on firm-specific information (Schultz, 2001), are quoted in dollars. Dealers broadcast indicative bids and offers on lists of actively-traded bonds (called “Runs”) to potential institutional clients. In the past, dealers broadcast runs once a day, but in recent years runs are updated many times daily using automated pricing models. Data aggregators (for example, Bloomberg or Algomi ALFA) provide buy-side institutions with information from multiple sources, including recent transactions, proprietary dealer runs, quotations from electronic bond platforms, and electronic RFQ platforms (such as MarketAxess). Institutions can contact dealers, via instant messaging system or by phone, to obtain information on a bond that is not quoted, to obtain “color” on market conditions, or to negotiate the terms of a transaction. In some cases, institutional customers submit BWIC or OWIC (bid or offer wanted in competition) lists to dealers, requesting quotations on a specified set of bonds. Newer all-to-all trading venues (such as Trumid or MarketAxess’ Open Trading) offer institutions the ability to trade directly with each other, use hidden order types and allow for midpoint pricing. Retail investors purchase and sell bonds through retail brokers, and generally do not have direct access to dealer quotations.

Dealer firms trade with one another in the interdealer market, either directly or on interdealer broker (IDB) platforms, some of which offer fully electronic trading as well as over-the-phone trading via voice-assisted brokers. For corporate and structured bonds, transactions among dealers are most often completed on a bilateral basis using traditional (voice) methods. For U.S. Treasuries, about 70 percent of interdealer trading occurs on electronic IDB platforms (such as BrokerTec), where non-dealer participants, such as hedge funds and principal trading firms (HFTs), also participate. Wu (2018) reports that 60% of the interdealer trades in municipal bonds occur on electronic alternative trading systems.\textsuperscript{12}

Securities and Exchange Commission (SEC)-registered broker-dealers and trading platforms are required to report their transactions in Treasury, corporate and structured bonds to the Financial Industry Regulatory Authority (FINRA), and in municipal bonds to Municipal Securities Rulemaking Board (MSRB). With the exception of Treasury bonds and some categories of structured bonds, data on completed transactions are made available to the public. Mandatory reporting of trade prices for most credit instruments was phased in, beginning in 2002, according to the timeline summarized on Table 2. Prior to 2002, there was no comprehensive reporting of bond transaction data to regulators or the public.13

C. Data Sources for Fixed-Income Microstructure Studies

Table 3 summarizes sources of historical fixed-income data. Secondary market transaction data, including both dealer-to-customer trades and interdealer trades, are publicly available from the MSRB through the Electronic Municipal Market Access (EMMA) platform for municipal bonds and from FINRA through the Trade Reporting and Compliance Engine (TRACE) platform for corporate bonds and structured products. For each trade, the data includes the bond CUSIP, trade time, price, and transacted quantity (to a specified maximum reportable size), indication whether the trade was interdealer or dealer-customer; as well as a buy-sell indicator for dealer-customer trades.14 An enhanced version of the corporate bond TRACE data is now available from FINRA for purposes of academic research and includes information on masked dealer ids and actual transaction size. The enhanced TRACE data also includes trades reported to FINRA, but not disseminated to the public (e.g., trades in non-public “144A” securities that were completed prior to July 2014). Beginning July 2017, dealers are required to report both dealer-customer and interdealer trades in Treasury bonds to TRACE for regulatory analysis, but the

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13 A partial exception was the U.S. Treasury markets. In June 1991, GovPX was launched under SEC guidance to provide institutional market participants with real time interdealer book and transactions data in Treasury securities. Since reporting was voluntary, GovPX’s coverage of the interdealer Treasury market varied between 66% in the early 1990s to less than 42% in 2001.

14 FINRA rules on the requisite timing of trade reports for bond categories are available at: http://www.finra.org/industry/trace-reporting-timeframes. For large transactions, the trade size that is disseminated to the public is capped to allow dealers the opportunity to unwind inventory positions. For example, trade size is provided for investment grade and high-yield corporate bonds if the par value transacted is $5 million and $1 million, respectively; otherwise an indicator variable (“5MM+” and “1MM+”, respectively) denotes a trade of more than the capped size.
data are not yet available to the public. In addition, data on insurance company bond transactions are available beginning 1995 from the National Association of Insurance Commissioners (NAIC). Data on interdealer trades for Treasury securities completed on IDB platforms are available beginning 1991 from GovPX, and subsequent to 2001, from eSpeed and BrokerTec.

Information on bond characteristics (such as issue size, offering date, maturity date, credit rating, and issuer industry) is available for non-Treasury securities from Mergent Fixed Income Securities Database (FISD) or Bloomberg, and for Treasury securities from the U.S. Treasury. Data on investor flows into or out of bond mutual funds are available from the Investment Company Institute. Data on bond mutual fund holdings are available from the Center for Research in Security Prices (CRSP) Mutual Fund database, Morningstar database and Thomas Lipper eMaxx database, and for individual Treasury securities from the U.S. Treasury. Securities lending data for bonds are available from Markit Securities Finance database, and previously from Data Explorers.

IV. Trading Activity in Bond Markets

A. Treasury bonds

According to a 2017 Treasury report, the market for U.S. Treasury bonds is among the largest and most liquid markets in the world. Between August 1, 2017 and July 31, 2018 (the first year that dealers were required to report Treasury transactions to FINRA), daily Treasury trading volume averaged $574 billion. Transactions between dealers and customers account for about half ($269 billion) of Treasury activity. Intermediation in the dealer-to-customer market is provided by 23 primary government bond dealers, as designated by the Federal Reserve Bank of New York. Trades among dealers have historically been intermediated by IDBs. In recent years, about 70 percent of interdealer activity occurs on electronic IDB platforms, and the remaining on voice and manual screen platforms. According to the 2015 Joint

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15 https://www.treasurydirect.gov/
17 http://libertystreeteconomics.newyorkfed.org/2018/09/unlocking-the-treasury-market-through-trace.html. We thank Michael Fleming and Broket Tec for providing 2017 IDB Treasury trading data.
Staff Report on the U.S. Treasury Market, non-bank principal trading firms that implement HFT strategies account for a larger share of trading activity (62%) than primary bond dealers (33%) on electronic IDB platforms.\(^\text{18}\) Treasury IDB trading activity is concentrated in *on-the-run* securities, i.e., the most recently issued notes or bonds of a particular maturity. In terms of 2017 daily trading volume, the 5-year note is the most active on-the-run security ($48 billion par), followed by the 10-year ($40 billion par) and the 2-year note ($18 billion par). Trading activity in *off-the-run* issues is weighted towards shorter maturity bonds and is more likely to be intermediated on voice and manual IDB platforms. Figure 2 displays average daily trading volume and average trade size for *on-the-run* Treasury securities between 1991 and 2017.

Macroeconomic announcements comprise an important source of uncertainty for the valuation of Treasury instruments. Fleming and Remolona (1999) show that trading activity and bid-ask spreads adjust to scheduled macro-economic announcements in stages.\(^\text{19}\) Pre-announcement, the sensitivity of prices to order flow is lower than normal, suggesting an absence of information leakage. The announcement induces a sharp and nearly instantaneous price change accompanied by a reduction in trading volume and an increase in bid-ask spreads. These results are consistent with French and Roll’s (1986) assertion that public information “affects prices before anyone can trade on it” as well as models of inventory risk (e.g., Ho and Stoll (1983)), where dealers set wider bid-ask spreads when volatility is high. In the seconds after announcements trading volume increases, as do price volatility and the price impact of trades. These patterns support theoretical predictions (e.g., Kim and Verrecchia (1991, 1994)) regarding informed traders’ ability to quickly interpret the valuation implications of macro announcements. In the five to fifteen minutes after announcement, the market is characterized by high liquidity and smaller price impacts of trades, consistent with the interpretation that uninformed traders participate in portfolio rebalancing trades in the wake of these announcements.

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\(^{18}\) Principal trading firms account for 60% to 70% of the trading volume in Treasury bonds and about 50% of the trading volume in Treasury futures in recent years. The firms participate as short-term liquidity providers and rarely carry over-night inventory positions.

\(^{19}\) See Balduzzi, Elton and Green (2001), Green (2004), among others, for related evidence.
Brandt and Kavajecz (2004) document substantial variation in yields on Treasury instruments, even in the absence of macroeconomic or other news releases. They find that order flow imbalances account for 26% of yield variation on days with no news, implying that the trading process itself contains information for price discovery in government bonds. This finding parallels the French and Roll (1986) result that the trading process provides substantial information for equity pricing, even absent fundamental news.

B. Structured bonds

The most actively-traded structured securities are TBAs, which are forward contracts that allow the seller to deliver any agency MBS that meets agreed-upon criteria based on coupon, maturity, and issuer, on the settlement date.\textsuperscript{20} The buyer and seller negotiate the trade price and MBS face value to be transacted. The TBA price reflects the cheapest-to-deliver MBS that fulfills the terms of the TBA trade, although traders do not make or take delivery in most cases. The TBA market is used by banks and other intermediaries to hedge mortgages that they originate and by investors that buy and sell already-issued MBS. Gao, Schultz and Song (2017) report that the average dealer-to-customer transaction size of outright TBA trades during the May 2011 to April 2013 sample period was $32.6 million. Over 37% of trades between dealers and customers were over $10 million in size. Individual structured MBS bonds trade in the “specified pool” (SP) market, where buyers and sellers agree to exchange a particular bond. The average customer transaction size of SP trades during the same period was $6.5 million, and 10.7% of these transactions were for $10 million or more.

Bessembinder, Maxwell and Venkataraman (2013) study trading in structured products during the May 2011 to January 2013 period. Notably, they report that the large majority of outstanding structured bonds do not trade at all during their sample. They report that agency MBS are more likely to trade than structured bonds issued by private entities, such as Commercial Mortgage-Backed Securities (CMBS) or

\textsuperscript{20} Mortgage backed securities (MBS) are pass-through securities in which interest and principal payments on the underlying mortgages are passed on to bond investors. A basic pool of assets may have more than 100 securities or tranches, each with a unique payoff structure, with many of these issues being very small.
ABS, which are subject to credit risk. Trading activity in both MBS and ABS market is negatively related to bond age, credit risk, and interest rate risk and positively related to issue size.\textsuperscript{21} The study also finds that dealer-to-customer trades represent almost 80 percent of trading volume for individual structured bonds, compared to 52 percent for the TBA market. Gao, Schultz and Song (2017) attribute the high percentage of TBA interdealer trades to hedging activities of dealers, who also hold positions in the specified pools that are eligible for TBA delivery.

\textbf{C. Corporate bonds}

Trading activity in corporate debt is fragmented because an issuer often has multiple bond issues outstanding. Since each involves a unique set of promised payments, bond issues are not fungible, and each trade separately. As of December 2017, the firms in the S&P 500 index had 11,990 outstanding bond CUSIPs, while firms in the Russell 1000 index had 13,083 outstanding bond CUSIPs. Mizrach (2016) finds that trades for 33,945 distinct bond CUSIPs were reported in the TRACE database during the first nine months of 2015. Over 90\% of TRACE-reported bonds are rated investment grade, and the most common credit rating is BBB. A majority of corporate securities are privately placed structured bonds that do not trade actively.

Bessembinder, Maxwell, Jacobsen and Venkataraman (2018) report that the aggregate corporate bond trading activity, measured either by number of trades or transaction volume, has surged over their 2006-2016 sample period. This increase in trading activity was accompanied by even more rapid growth in corporate bond issuance. Annual trading activity relative to the amount of corporate bonds outstanding (i.e., turnover) generally trended downwards, from 94\% in 2006 to 62\% in 2015. The share of overall trading volume increased for investment-grade bond issues and large-issue-size bonds during the 2006-2016 period, as did the share of transactions that were more likely to be facilitated by electronic venues.

\textsuperscript{21} See also Friewald, Jankowitsch and Subrahmanyam (2014), Atanasov and Merrick (2012), and Hollifield, Neklyudov and Spatt (2017), each of which study structured product trading.
The distribution of the number of days that a corporate bond issue trades in a year is highly skewed. 9.3% of TRACE bonds never traded during 2016, while 39% traded on five or fewer days, and only 1.5% traded every day.\textsuperscript{22} Among bonds with issue size greater than $1 billion, the average number of days in a year with any trading is 179 for investment-grade bonds and 150 for high-yield bonds. As a consequence, estimates (e.g. of transactions costs) obtained by weighting observations across observed trades largely represent outcomes in the more active segments of the corporate bond market.

Institutional-sized trades (greater than $1 million) account for the majority of the dollar volume of trades, in particular 88% of customer trading volume between 2014 and 2016 (Bessembinder et al. (2018)). Retail size trades (less than $100,000) account for between 60% and 70% of reported customer transactions, but only 2% of customer trading volume during the same period. The average size of trades has decreased over the last decade, from $2 million in 2006-2007 to $1.21 million in 2014-2016.\textsuperscript{23} The decrease in average trade size could reflect higher participation by retail investors, increased usage of electronic venues that typically execute smaller trades, and/or difficulty in locating counterparties for large trades that are desired.

Informed traders are active in corporate bonds, as evidenced by the finding in Wei and Zhou (2012) that abnormal bond trading activity before corporate earnings announcement predicts both the direction of earnings surprises and the post-announcement bond returns. Kedia and Zhou (2014) present evidence of an increase in trading activity and abnormal returns in the bonds of target companies prior to acquisition announcements. Das, Kalimipalli and Nayak (2014) report that large institutional traders shifted from corporate bonds to CDS trading after the introduction of the latter, resulting in reduced bond price efficiency.


\textsuperscript{23} By comparison, the sizes of equity trades also declined dramatically over the years—in part due to the consequences of Regulation NMS and in an earlier era, due to decimalization.
Informed trading may occur simultaneously in equity, debt and derivatives instruments of a firm. Back and Crotty (2015) examine the price impact of order flows in the stock and bond markets. When investor’s private information concerns the asset mean value, their model predicts that the cross-market price impacts are positive, and when investor’s information concerns the asset risk, the cross-market price impacts are negative. They show empirically that cross-market price impacts are positive, implying that private information primarily concerns mean asset values, and that both cross-market and own-market price impact estimates are larger for firms with high yield-debt than for firms with investment-grade debt.

Asquith, Au, Covert, and Pathak (2013) study corporate bond lending by one major depository institution, reporting that the cost of borrowing bonds is between 10 and 20 basis points (comparable to the cost of borrowing stocks) and declined during their 2004 to 2007 sample period. In contrast to results obtained for equity short selling, Asquith, Au, Covert, and Pathak report that bond short selling does not forecast price changes over the following month.

Two recent studies conclude that short selling does predict bond returns in scenarios where private information is more likely. Hendershott, Kozhan, and Raman (2018), who study data from the 2006 to 2011 period, report that short selling predicts bond returns in high-yield corporate bonds. They also show that short positions on average increase following periods of buying order imbalances, which is consistent with short sellers “leaning against the wind” in a de facto market making role. Using bond lending data over 2006 to 2015, Anderson, Henderson and Pearson (2018) also find that proxies for short-sale constraints predict negative three-month abnormal returns. The study concludes that information is incorporated more slowly in bonds than equities due to lower trading frequency and liquidity. On balance, the shorting of fixed-income instruments comprises a promising area for future research.

The literature finds mixed evidence regarding the relative information efficiency of stock versus corporate bond markets. Kwan (1996) and Downing, Underwood, and Xing (2009) report that stock prices lead corporate bond prices in incorporating firm-specific information, while Hotchkiss and Ronen (2002) and Ronen and Zhou (2013) report that corporate bond markets are as informationally efficient as
stock markets. Back and Crotty (2015) find that equity market leads the bond market for the portion of returns that are not explained by order flows.

**D. Municipal bonds**

Trading activity in municipal bonds is highly fragmented, as over 50,000 issuers, including state and local governments, towns, cities, and counties, have issued over 1.5 million distinct bonds, with outstanding principal value of $3.9 trillion at the end of 2017. Municipal bonds are issued in series, with larger issuances consisting of several smaller bonds of differing maturity. Municipal bond issuers typically disclose financial information at the time of bond issue, but they are not required to make periodic financial disclosures (see Downing and Zhang (2004)). Investor ownership tends to be geographically concentrated, as many jurisdictions only exempt own-state issues from state and local income taxes. Further, limited disclosure may result in bonds being disproportionately held by more knowledgeable local investors.

Most municipal bonds have had a credit rating of AA or better, reflecting the issuers’ tax authority and, prior to the financial crisis, the widespread use of credit enhancement via insurance. The use of municipal bond insurance comprises an interesting puzzle, as risk sharing is often viewed as a central purpose of financial markets, but it is unclear to what extent insurers had the capacity to bear capital market risks that have substantial systematic components. Indeed, the limited capacity to bear correlated risk was at the root of the failure of mortgage insurers during the financial crisis.

Chambers, Liu and Wang (2017) study MSRB data drawn from 2011-2012, reporting that transactions of less than $25,000 account for more than half of the trades, and those less than $100,000 account for 87% of trades, reflecting that individual investors hold the majority of outstanding municipal bonds. Trades greater than $1 million account for 1.5% of transactions but represent 47% of volume.

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25 One potential policy innovation is to introduce a forward market for municipal bonds, similar to the TBA market for agency MBS. For municipals, the basis risk is due to tax status and default risk, while for MBS the basis risk is due to prepayment and default risk.
traded. Wu (2018) reports that interdealer trades account for 28% to 37% of all par-value traded between 2005 and 2017. The volume of customer-buy transactions significantly exceeds the volume of customer-sell transactions, indicating that investors frequently hold municipal bonds until maturity. However, the difference in buy vs. sell volume has declined in recent years.

According to 2018 MSRB statistics, electronic platforms account for 59 percent of all interdealer trading in municipal bonds. The states with the highest secondary market trading volume in the municipal bond market are California (14.6%), Texas (13.8%), New York (9.3%) and Illinois (9.1%). Less than 1% of outstanding municipal bonds trade on a typical day, and less than 15% of the outstanding bonds trade in a typical month. Trading activity is highest during the month of the bond issuance and drops off sharply by the second month.

V. Trading Costs in Fixed-Income Markets

The estimation of trading costs in bond markets is challenging for several reasons. With the exception of Treasury securities, dealers do not post firm bid and ask quotes, and other indications of trading interest, such as indicative quotes and limit orders, are not widely disseminated and may not be available to researchers. This implies that simple measures often used in equity markets, such as quoted spreads (the difference between the bid and ask quote) or effective spreads (the difference between the trade price and the quote midpoint), cannot be readily implemented in the majority of bond markets.

Researchers have estimated bond market liquidity using methods that rely on transaction price data alone. For example, Bao, Pang and Wang (2011) estimate illiquidity in bond markets using the return reversal measure of Roll (1984), while Chen, Lesmond and Wei (2007) focus on the percentage of trading days with zero returns, taken to be indicative of a lack of trading due to high costs. Schestag, Schuster and Uhrig-Homburg (2016) study several bond liquidity measures including (a) trade price reversal measures such as Roll (1984) estimator, Hasbrouck’s (2009) Gibbs sampler, and the Pastor and

Stambaugh (2003) measure, (b) price impact measures such as Hasbrouck’s (2009) lambda and the Amihud (2002) measure; and (c) the high-to-low price ratio measure of Corwin and Schultz (2012)), which exploits that daily high (low) prices are most often buy (sell) orders. Jankowitsch, Nashikkar and Subrahmanyam (2011) and Feldhutter (2012), among others, use the dispersion in bond transaction prices to indirectly measure customer search costs attributable to limited pre-trade transparency.

A significant challenge in using transaction prices to estimate trading costs arises from the infrequent trading activity in the majority of corporate bonds, implying that there is potential for substantial information arrival between adjacent transactions, which introduce noise in the empirical estimates. In the absence of quotation data, an additional challenge arises in selection of a benchmark price for measuring trading costs.27

The most frequently implemented approaches to estimating trading costs in bond markets are the dealer round-trip cost method and indicator variable regression models. These methods take advantage of the fact that bond databases such as TRACE identify interdealer versus dealer-customer trades, and for customer trades, whether the customer was the buyer or the seller in the transaction. However, these measures rely on completed trades, and thus do not account for trades that were desired but not completed due to a lack of liquidity. Further, transaction-based estimates are inherently biased towards bonds and time periods with frequent trading, which will tend to be when liquidity is plentiful.

A. Dealer round-trip cost

The dealer round-trip (DRT) cost measures the difference between the average dealer sale price and the average dealer purchase price in dealer-to-customer transactions for a given bond during a specified time window. The time interval is most frequently one day (e.g., Green, Hollifield, and Schurhoff (2007)), though some studies examine shorter (15-minutes in Feldhutter (2012)) or longer (five

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27 For example, Hendershott and Madhavan (2015) use the last interdealer trade in the bond as the benchmark price. However, this benchmark contains noise, as interdealer trades cannot be classified as buyer or seller-initiated.
days in Goldstein et al (2007)) windows.28 Earlier studies calculate the average sale and purchase price across all dealers (e.g., Hong and Warga (2000) and Chakravarty and Sarkar (2003)), while studies using enhanced TRACE data with masked dealer identifiers calculate the average prices on an individual dealer basis (e.g. Goldstein et al (2007)).29 The advantages of the DRT measure are that (a) it is simple to interpret as an average realized bid-ask spread, and (b) it does not rely on any model assumptions. A limitation is that the measure does not capture transactions that are not offset by opposite-direction trades within the observation window, which limits the amount of usable data and makes the method difficult to implement for bonds that trade infrequently.

**B. Indicator-variable regression model of trading costs**

The indicator-variable regression model was first used to estimate trading costs in equity markets (see Huang and Stoll (1997) and Madhavan, Richardson and Roomans (1997)), but has since been adapted to bond markets.30 The model presumes that the transaction price for a customer buy (sell) is the intrinsic value of the bond at the time of transaction, plus (minus) half the bid-ask spread. The spread reflects dealers’ inventory, adverse selection, and order processing costs, and potentially, monopoly power over less sophisticated customers.

Specifically, trading cost estimates can be obtained by regressions of $\Delta P_{st}$, the percentage change in the trade price for a given bond between an observed trade at time ‘$s$’ to the next observed trade at time ‘$t$’, on $\Delta Q_{st} = Q_t - Q_s$, where $Q_s$ and $Q_t$ are indicator variables equal to one for customer buys and negative one for customer sells at times $s$ and $t$. The resulting slope coefficient estimates the effective

28 In fact, Hollifield, Neklyudov and Spatt (2017) discard intermediation chains that take more than 15 days to complete, controlling for valuation changes between the execution times by using several market-wide control variables and Goldstein and Hotchkiss (2018) examine sales within 60 days of the dealer’s buy order.

29 Studies that calculate dealer round-trip costs using NAIC insurance data include Chakravarty and Sarkar (2003) and Hong and Warga (2000), MSRB municipal bonds data include Green, Hollifield and Schurhoff (2007b), TRACE corporate bonds data include Goldstein, Hotchkiss and Sirri (2007) and Feldhutter (2012), and TRACE structured bonds data include Hollifield, Neklyudov and Spatt (2017).

one-way trade execution cost and can be interpreted as half the difference between the price at which dealers will sell a bond to a customer and the price at which they will purchase the bond from a customer. The analysis is typically implemented using trades between dealers and customers. To account for information flow between adjacent transactions, the model can incorporate additional measures of observable public information such as changes in Treasury interest rates, stock returns, market volatility, etc., that affect the intrinsic bond value. A key advantage is that the method can include all bond transactions, and using pooled estimation, can be implemented for subsets of bonds with modest trading activity. A limitation is that the impact of public information on intrinsic bond values could differ across bonds, which might introduce measurement errors in pooled estimation.

C. Estimates of trading costs in bond markets

The secondary market for Treasury bonds is extremely liquid, with an estimated interdealer bid-ask spread on the BrokerTec IDB during 2017 of about one basis point. The average quoted depth at the best price on the BrokerTec limit order book averaged $645 million for the 2-year note, $125 million for the 5-year note, and $109 million for the 10-year note. The market is even deeper when considering the hidden portion of iceberg orders and the “work-up” feature that allows participants to negotiate to expand the trade size after agreeing on a price. Spreads are higher for longer duration bonds and smaller for larger issue size and recently-issued bonds. Figure 2 displays average daily bid-ask spreads and depth in the IDB market for on-the-run Treasury securities between 1991 and 2017. Bid-ask spreads exhibit a spike during the peak of the financial crisis but have been relatively stable over the last decade.

In the structured bond market, Bessembinder, Maxwell and Venkataraman (2013) report an average customer round-trip trade execution cost between 2011 and 2013 of 0.48%. Trading cost

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31 We thank Michael Fleming for providing BrokerTec statistics for 2017.
32 The importance of a “workup” mechanism in Treasuries in which additional size can be transacted immediately after a transaction at the specified price is highlighted by Bonnie and Leach (2004), Fleming and Nguyen (2013), Fleming, Schaumburg and Yang (2015) and Schaumburg and Yang (2016). Duffie and Zhu (2017) show that such a workup or dark pool mechanism can limit the allocative inefficiency that can result from larger transactions, but due to adverse selection about the order imbalances of other investors would only be used by investors with relatively large position imbalances.
estimates decline with trade size, averaging 1.65% for small (less than $100,000) trades, 0.48% for medium-sized (between $100,000 and $1 million) trades, and only 0.10% for large (greater than $1 million) trades. Trade execution costs vary substantially across types of structured bonds, with higher cost estimates observed for products of smaller issue size. The lowest trading costs are estimated for TBA securities (0.02%) while the highest cost estimates are for agency Collateralized Mortgage Obligations (CMOs, 1.5%). Average customer trading cost estimates for agency-MBS are 0.80%, for CMBS are 0.24%, and for ABS are 0.48%.

For agency CMOs, Hollifield, Neklyudov and Spatt (2017) find that 144A instruments have smaller spreads than registered instruments, which may reflect the greater bargaining power of the relatively more sophisticated investors in 144A bonds as compared to investors in registered bonds. Friewald, Jankowitsch and Subrahmanyam (2012) report that trading costs for structured bonds are lower if they are traded in institutional size, are issued by a federal authority, or have low credit risk. Vickery and Wright (2013) and Gao, Schultz and Song (2017) find that mortgage bonds that are eligible for delivery in the TBA market are cheaper to trade than TBA-ineligible mortgage bonds, reflecting that the TBA market allows dealers to effectively hedge TBA-eligible MBS positions.

Schultz (2001) relied on the NAIC database to report the first large sample estimates of corporate bond trading costs, documenting that average trading costs are large as compared to equities, and that costs for large institutional trades exceed those for small. Bessembinder et al. (2018) provide what may be the broadest study of corporate bond trading to date, studying TRACE data from 2006 to 2016. For the recent 2014 to 2016 period they estimate average round-trip trading costs of 0.84%. Trading cost

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33 The SAS programs used by Bessembinder, Maxwell, Jacobsen and Venkataraman (2018) to read and clean the Enhanced corporate bond TRACE data, estimate trading costs using indicator regression model and calculate dealer capital commitments are available at: https://people.smu.edu/kumar/tracecorporatebonds/

estimates decrease with trade size, averaging 1.25% for trades less than $100,000, 0.58% for trades between $100,000 and $1 million, 0.40% for trades between $1 million and $10 million, and 0.32% for block trades that exceed $10 million. Figure 3 (panel A) plots estimated average one-way trading costs over the 2006-2016 period. While trading costs temporarily increased during the financial crisis, average cost estimates at the end of the sample period are nearly equal to those at the beginning. Edwards, Harris and Piwowar (2007) report that corporate bond trading costs are lower for corporate bonds with larger issue size, with better credit quality, for younger (more recently-issued) bonds and those closer to maturity, for simpler bonds without options, and for bonds issued by private issuers, Rule 144a issues, and foreign issuers.

Bessembinder, Jacobsen, Maxwell and Venkataraman (2018) report that the majority of corporate bond transactions, over 90% each year between 2006 and 2016, are facilitated by dealers as “principal” trades, where the dealer commits capital to take bonds into inventory. Several studies (see Harris (2016), Choi and Huh (2017) and Schultz (2017)) report that the incidence of agency trading, where a dealer facilitates trades between customers without taking ownership or where the dealer briefly owns the bond before completing a previously-arranged transfer to another customer, has increased in recent years. Choi and Huh (2017) report that trading costs for those transactions where dealers continue to commit capital have increased in recent years.

Harris and Piwowar (2006) estimate trading costs for municipal bonds during the earlier November 1999 to October 2000 period. They report higher trading cost estimates for municipal bonds of lower credit quality, smaller issue sizes, and those with complex features. Trading cost estimates are also lower for younger bonds and those near maturity. Wu (2018) studies dealer round-trip trading costs for municipal bonds using MSRB transactions data between 2005 and 2018, reporting average cost estimates of 0.90% for retail-size trades (par value less than $10,000) versus 0.15% for institutional-size trades that exceed $1 million in April 2018. Figure 4 displays annual estimates of round-trip municipal bond trading costs compiled by Wu (2018). Estimated trading costs declined, particularly for small trades, between 2009 and 2018, while costs increased for all trade size categories during the financial
crisis. Although the trading cost differential between retail and institutional trades has narrowed in recent years, institutional-size trades continue to obtain lower cost executions as compared to retail-size trades in municipal bond markets.

These estimates of trade execution costs focus on the direct cost of trades that were successfully completed. As such, they do not account for the potential delays in completing transactions or costs associated with trades that were desired, but not completed. Unfortunately, proprietary datasets from buy-side bond institutions that include information on execution delays and fill rates are not available to researchers. To obtain additional perspective, researchers have studied dealers’ capital commitment, i.e., the extent to which dealers use their own capital to absorb imbalances in customer order flow. Capital commitment is particularly important in markets, such as corporate bonds, where customers arrive infrequently and search costs are large.

It is possible to estimate dealers’ capital commitment using the enhanced TRACE database that includes masked individual dealer identities. Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018) and Bao, O’Hara and Zhou (2018) both report that, though average transaction costs have not increased in recent years, dealers’ capital commitment has declined markedly (see Figure 3, panel A). The decreases in capital commitment are attributable to bank-affiliated dealers, while in contrast, non-bank dealers have increased their capital commitment, albeit from low initial levels. Each study concludes that post-crisis banking regulation, including the Volcker Rule (which restricts proprietary trading by banks), likely contributed to the decline in bank-affiliated dealer capital commitment, and accelerated the increase in capital commitment by non-bank dealers due to their equilibrium response. Goldstein and Hotchkiss (2018) show that dealers are particularly hesitant to commit capital to accommodate larger trades in riskier bonds. Duffie (2018) and Adrian, Fleming, Shachar and Vogt

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35 However, the reasons for this decline have been the source of some debate. See https://www.bondbuyer.com/news/bdas-problems-with-msrb-spreads-study.
36 In contrast, data on institutional investors’ actual and desired equity market transactions are compiled by Abel Noser (a consulting firm that works with institutional investors to monitor execution costs). See, for example, Puckett and Yan (2011) and Anand, Irvine, Puckett and Venkataraman (2012).
(2017) observe that Basel 2.5 and Basel III banking regulations increased the required capital (i.e. equity) requirements for inventory holdings of credit products with higher default risk. This led to an increase in dealers’ inventory funding costs, particularly for corporate bonds and credit derivatives, and likely also contributed to the decline in dealer capital committed to market making.

A striking pattern observed in most bond markets is that smaller transactions, which are more likely to originate from retail investors, are more expensive to complete than larger transactions, which more likely originate from institutional investors. Figure 3, panel B displays annual estimates of customer trade execution costs in U.S. corporate bond markets, for small (less than $100,000), medium ($100,000 to $1 million), large ($1 million to $10 million) and institutional (greater than $10 million trades). This pattern of higher percentage execution costs for small trades is the opposite of that typically observed in equity markets. It is difficult to attribute the trade size cost differential in bond markets to higher adverse selection, since institutional investors have more resources than individual investors to analyze credit risk, or to higher inventory risk, since large trades involve more dealer capital than small trades.

The explanation for differential effects of trade size on transaction costs across bond and equity markets likely lies in market structure. Equity markets are more transparent and governed by order-handling rules that require execution at the best available price, whether posed by the trading public or a dealer. The opaque and decentralized nature of the bond market involves high search costs that can place less-sophisticated investors at a significant disadvantage. Duffie, Gârleanu, and Pedersen (2005) develop the seminal search and matching model of an over-the-counter market, deriving the bid-ask spreads charged by dealers and predicting that bilaterally negotiated prices depend on the relative bargaining power of traders, while Green, Hollifield and Schurhoff (2007b) predict that fragmentation and the lack of transparency in the bond market create opportunities for dealers to exploit monopoly power over retail investors.

While the market power hypothesis may have considerable explanatory power (especially for municipal bonds, where retail participation is especially high), it is not necessarily a complete
explanation. For example, smaller trades have larger spreads than larger trades in securitized trading (e.g., Hollifield, Neklyudov, and Spatt (2017)), even though structured products can only be purchased by accredited investors. Further, as discussed later, a similar size effect arises in the studies of Bessembinder, Maxwell, and Venkataraman (2006) and O’Hara, Wang and Zhou (2017), even though their samples are based entirely upon insurance company transactions.

D. Trading Costs and Equilibrium Asset Pricing

Trade execution costs matter not only because they measure the cost of completing trades, but also because they can affect the cost of capital for issuing entities. Amihud and Mendelson (1986) propose that expected asset returns should increase with asset illiquidity, as investors require compensation for the costs of buying and selling an asset. Amihud and Mendelson (1991) compare yields on short-term U.S. Treasury notes and Treasury bills with the same maturity. While each instrument has identical cash flows and interest rate risk, the market for bills is substantially more liquid than the market for notes. The study finds that yields on notes are higher than those on bills, and the differential is a decreasing function of time to maturity, which supports the theoretical prediction that bond market liquidity affects the pricing of credit instruments. Similarly, Krishnamurthy (2002) attributes the yield differential between on-the-run and off-the-run Treasury bonds to liquidity.

In corporate bonds, illiquidity has been offered as an explanation for the puzzle that credit spreads (i.e., yields relative to Treasury securities) are higher than those predicted by structural models of corporate default risk. Chen, Lesmond and Wei (2007) present evidence that bond illiquidity significantly explains variation in yield spreads across corporate bonds. Chen, Huang, Sun, Yao, and Yu (2018) find that the relation between trading costs and illiquidity in corporate bonds is concave, and attribute the non-linearity to clientele effects where investors with longer horizons hold less liquid bonds, as also predicted by Amihud and Mendelson (1986).

Friewald, Jankowitsch and Subrahmanyam (2012) and Dick-Neilsen, Feldhutter and Lando (2012) find that impact of liquidity on bond pricing is significantly larger both during periods of crisis,
and for non-investment grade bonds. Bao, Pan and Wang (2011) report that changes in market-wide illiquidity explains a substantial portion of the time series variation in yield spreads of high-rated (AAA to A) bonds. They conclude that illiquidity risk was more important in explaining the increase in corporate yield spreads during the 2008 financial crisis than credit risk. Friewald and Nagler (2018) find that time-varying measures of inventory, search and bargaining frictions in the corporate bond market explain the systematic component of yield spread changes. Lin, Wang and Wu (2011) report that the sensitivity of corporate bond returns to fluctuations in an aggregate corporate bond liquidity factor helps to explain corporate bond yields, implying that systematic liquidity risk is relevant for bond valuation. However, Bongaerts, de Jong and Driessen (2017) argue that while exposure to the equity market price and liquidity risk affect corporate bond yields, the effect of exposure to a corporate bond liquidity factor is economically negligible.

VI. The Relevance of Dealer Networks

A. Dealer networks and Client Costs

Researchers in recent years have increasingly focused attention on the fact that dealer markets, including those that dominate fixed income trading, exhibit a rich network structure. The dealer network in many bond markets exhibits a core-periphery structure. The central or core dealers are highly interconnected, participate in intermediation chains that can involve multiple dealers, and account for a high proportion of trading activity. For example, 10 to 12 dealers account for 70% of trading volume in corporate bonds between 2006 and 2016 (see Bessembinder et al. (2018)). Peripheral dealers are sparsely connected and execute relatively few transactions.

An interesting way to cast the dealer network is that it arises in response to heterogeneity in dealer valuations and/or costs.\footnote{A baseline search and matching model with heterogeneous search technology that leads to a centrality discount (lower spreads for central dealers than peripheral dealers) is Neklyudov (2018).} This has been a central theme in much of the theoretical network
literature that has emerged to study fixed-income trading, reflecting a significant extension of the original Duffie, Gârleanu, and Pedersen (2005) model in which dealers are homogenous and the interdealer market is frictionless. This paper provides the foundation for the extensive theoretical literature on interdealer trading networks and intermediation chains that followed. Hugonnier, Lester, and Weill (2018) develop solution techniques to analyze a framework with general heterogeneity and are able to examine model implications with regard to average time to trade, the distribution of the length of intermediation chains, the volume of trade in dealer-customer and interdealer trades and the relationship between intermediation chain length and the bid-ask spread, and to calibrate their model to market characteristics. In their framework, an agent with a median-preference for holding bonds emerges in a central position and endogenously intermediates the order flow.

Given the widespread empirical importance of a core-periphery interdealer structure for a broad set of markets, a fundamental feature of network formation demonstrated by Wang (2018) is that a core-periphery structure arises as an endogenous response even when all agents are ex ante identical. An important facet of Wang’s framework is that it provides a game theoretic foundation for the core-periphery structure in which agents who form the core do not have special ex ante advantages. Wang (2018) analyzes the equilibrium number of “core agents” (e.g., dealers) as reflecting a tradeoff between the benefits of concentration, including lower inventory risk due to the ability to quickly offset trades, and enhanced price competition that may arise from the presence of a larger number of dealers.

Dealers can unwind unwanted inventory by trading with their own clients, or via the dealer network. Schultz (2017) shows that interdealer trades are more important than trades with customers for managing inventory risk in corporate bonds. Li and Schurhoff (2018) find that central dealers in municipal bond markets are more likely than peripheral dealers to trade on a principal basis and more likely to unwind the position with a customer than with another dealer. They also report that central dealers are associated with shorter intermediation chains and more informative trades, while Hollifield,  

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38 Duffie, Gârleanu and Pedersen (2007) extend the model to focus on how search affects asset pricing in the presence of risk aversion and risk limits.
Neklyudov and Spatt (2017) report corresponding evidence for structured bonds. On balance, the results suggest that dealers with wider trading networks have better ability to manage inventory risk and to extract information from customer order flow.

The empirical regularity that bid-ask spreads tend to be larger for small trades may also be a manifestation of the importance of dealer networks. In particular, Lester, Rocheteau and Weill (2015) present a competitive model with a search friction, while in the model of Bernhardt, Dvovracek, Hughson and Werner (2005), brokers who have more valuable relationships with dealers use more frequent and larger orders. Babus and Kondor (2018) argue that dealers with few trading partners (peripheral dealers) must execute smaller traders and face greater adverse selection and wider spreads (while aggregating less information) than dealers with more trading partners (central dealers). Complementing this asymmetric information analysis, Colliard, Foucault and Hoffman (2018) analyze the effect of inventory on OTC dealer networks. Core dealers share the inventory costs in an efficient manner, providing liquidity to peripheral dealers who have heterogeneous access to them. This work analyzes the connection between inventory management and the structure of the interdealer trading network.

There is evidence indicating that bid-ask spreads paid by customers vary depending on a dealer’s position in the network. Schultz (2001) shows that small bond dealers charge customers more than large dealers. Di Maggio, Kermani and Song (2017) and Li and Schurhoff (2018) report evidence of a “centrality premium,” by which central dealers charge customers significantly higher spreads than peripheral dealers, for corporate and municipal bonds, respectively. In contrast, Hollifield, Neklyudov and Spatt (2017) report a negative relationship between a dealer’s centrality and bid-ask spreads in structured product markets. The theoretical model in Hollifield et al. (2017) suggests that the contrasting results across markets can be explained by differences in customer sophistication. Customers in structured bonds tend to be sophisticated institutional investors with more information and better alternatives as compared to the retail investors, who are more important in corporate and municipal

39 Using a broader sample and additional control variables, Goldstein and Hotchkiss (2018) obtain different results than Di Maggio, Kermani and Song (2017) in applying network measures to corporate bonds.
bonds. Issa and Jarnecic (2018) report that relationship strength is associated with higher client trade execution costs, except during periods of heightened information asymmetry when customer order flow is more valuable. In the interdealer market, Di Maggio et al. (2017) find that trading costs are significantly lower among dealers with strong trading relationships.

Trading relationships are relevant to trading costs paid not only across retail and institutional investors, but also for large versus small institutions. Schultz (2001) studies NAIC insurance company transactions in corporate bonds from 1995 to 1997, reporting that large institutions (based on the size of bond holdings) obtain lower trading costs than small institutions. Focusing on the 2001 to 2011 period, O’Hara, Wang and Zhou (2017) report that trading cost differences across large and small insurance companies are (a) larger for small-size trades (but not different for block trades), (b) larger when a dealer maintains a dominant market presence in the bond, and (c) smaller after introduction of TRACE reporting. Their evidence supports the reasoning that dealers possess sufficient market power to price discriminate among clients.

Hendershott, Li, Livdan and Schurhoff (2017) find that insurance companies typically form few, long-lasting relationship with dealers, and that less active insurance companies benefit from a concentrated trading relationship with dealers. Their model implies that customers trade off the benefits of existing relations, including those that accrue outside of trading per se, against potential speed and execution improvements that could be obtained from searching across dealers. Empirically, they report a non-monotone relation between trading costs and network size in the corporate bond market.

B. Dealer Networks and activity around new bond issuance

The impact of trading relationships is particularly pronounced during the new bond issuance process. Investment banks negotiate terms with issuers, and their trading arms serve as dealers in the

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41 According to 2017 Greenwich Associates North American Fixed Income survey, the typical institutional investor executes about 55% (85%) of their trading volume in investment grade corporate bonds with their top five (10) dealers. According to 2017 Citi report “Developments in credit market liquidity”, for one active (unnamed) corporate bond dealer, the top 25 (101) institutional clients account for 50% of total U.S. investment grade volume.
secondary market. Underwriting banks are compensated by purchasing the bond from the issuer at the offering price and placing it with customers at a higher reoffering price. Unlike Treasuries, where the primary allocation is determined by an auction that is open to participation by the public, the allocation of corporate and municipal bonds to customers is at the discretion of the underwriting syndicate, similar to standard practice for equity market IPOs. Customers with established underwriter relations that help the syndicate by participating in a “cold” issue are likely to obtain better allocations in subsequent offerings. Allocations are valuable because of underpricing. In addition, some institutions “flip” the bond on the first trading day by selling it to smaller dealers or institutions who did not obtain allocations in the primary offering.

Unlike equity offerings where the entire issue is sold at the reoffering price, Green, Hollifield and Schurhoff (2007a) find that a substantial fraction of municipal bonds are sold to customers at a premium to the stated reoffering price. In particular, large purchases take place at or near the reoffering price, while small purchases involve substantial markups over reoffering price. Schultz (2012) finds that the dispersion in purchase prices declined sharply with the introduction of trade reporting for municipal bonds in January 2005. Markups over the reoffering price also tend to increase with the length of the sequence of interdealer trades that precede the eventual purchase by a bond investor.

Corporate bonds trading activity tends to be greatest in recently issued bonds. According to Mizrach (2016), the share of overall market volume attributable to newly-issued corporate bonds declines significantly three months after issuance, and the decline in trading activity in the quarter after bond issuance is substantially greater in 2015 as compared to 2007. The decline likely reflects both that long-

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42 In the equity IPO context Spatt and Srivastava (1991) demonstrate the potential optimality of a fixed-price mechanism with pre-play communication and participation restrictions for allocating a new issue.

43 The magnitude of underpricing in corporate bonds averages about 50 basis points, and is more pronounced for riskier bonds (Datta, Iskandar-Datta and Patel (1997) and Cai, Helwege, and Warga (2007)), and mega bonds (Helwege and Wang (2017)). In Treasury bonds, underpricing is about 1 basis point when the auction price is compared with the benchmark price on the auction day (Goldreich (2007)) and about 9 basis points when compared with the benchmark price five days before the auction (Lou, Yan and Zhang (2013)).

44 Hollifield, Neklyudov and Spatt (2017) note in the context of securitization trading that secondary market bid-ask spreads increase with chain length.
horizon investors, such as insurance companies and pension funds, who implement buy-and-hold strategies, have acquired the bonds, and that institutional investors are receiving higher allocations in recent years. The relation between new issuance and trading activity is particularly striking in the case of Treasury bonds. Barclay, Hendershott and Kotz (2006) report that upon the issuance of a new Treasury security, trading volume in the previously-issued security of the same maturity drops by more than 90%.

**VII. The Regulation of Fixed-Income Trading**

Regulation plays a central role in the organization of fixed-income markets due to the classic liquidity externality associated with trading, issues of standardization and coordination in the design of markets, the potential importance of adverse selection, as well as the degree of delegated decision-making to broker-dealers and investment funds. The financial crisis of 2008 highlighted the importance of liquidity and systemic risk and led to a larger role for government and central banks in the fixed-income markets and their design.

**A. Transparency**

The regulation of fixed-income markets is influenced to a degree by the underlying market structure. A prominent example concerns market transparency, i.e., the extent to which relevant market information is readily observable to all participants. For example, while a limit order market structure involves the continuous compilation of information regarding unexecuted orders at various prices, it naturally accommodates pre-trade transparency, but this is not an intrinsic feature of an OTC market. Similarly, since a limit order market necessarily gathers a record of all transactions that occur on the market, dissemination does not involve further information aggregation. In contrast, transaction price data in an OTC market is dispersed, so dissemination requires additional information aggregation. Indeed, most fixed-income markets have moved toward post-trade transparency only since 2002, and as a result of regulation.

The timing of the adoption of post-trade transparency varied across markets (see Table 3). U.S. regulators first moved to require post-trade transparency in markets that they viewed as relatively more
liquid, and initially allowed dealers a delay between the time of a trade and its public report, to avoid potential adverse liquidity consequences that could arise if a dealer were not able to hedge or sell a portion of his position prior to disclosure of the trade.

Despite the overall movement in recent years towards greater transparency in fixed-income markets, the SEC’s Fixed-Income Market Structure Advisory Committee (FIMSAC) recently proposed that the dissemination of prices for very large transactions (at least $10 million for investment grade and $5 million for high-yield bonds) be delayed for 48 hours. Back, Liu, and Teguia (2018) provide a model showing that the disclosure of transaction prices conveys information possessed by the dealer about the asset quality and reduces the dealer's rents when she disposes off the inventory in a second transaction.

Much of the empirical literature on fixed-income trading emerged in the aftermath of transaction prices becoming available through TRACE, which reflects mandatory reporting of OTC secondary market transactions in eligible fixed-income securities by all FINRA (Financial Industry Regulatory Authority) members. These prices were collected by FINRA for a period of time even before they began to be disseminated to the public. For example, FINRA began to collect transaction prices for securitized products in May 2011 with an eye towards public post-trade reporting, which was implemented for various securitized products at later dates, as summarized in Table 2. As a consequence, some authors were able to study transactions prices from still-opaque markets, reflecting FINRA’s interest in understanding the characteristics of these markets prior to introducing transparent trading and pricing.46

The first three studies of transparency in the corporate bond market used different, but complementary, methods. The initial introduction of transparency in corporate bonds in July 2002 required price dissemination only for a set of liquid bonds, rather than a randomized control design. Goldstein, Hotchkiss and Sirri (2007) studied the third set of bonds (all BBB-rated) phased into

45 The Advisory Committee had diverse views regarding the desirability of a price reporting delay, with academic members generally opposed while many industry members were in favor, as evidenced in the transcript available at https://www.sec.gov/spotlight/fixed-income-advisory-committee/fimsa-040918transcript.txt. Some committee members wrote a dissenting letter available at https://www.sec.gov/comments/265-30/265-30.htm.
transparency in April 2003. These bonds were selected as a stratified random sample, along with a control sample of non-disseminated bonds. Edwards, Harris and Piwowar (2007) compared execution costs for transactions disseminated to the public to those for trades not publicly disseminated between January 2003 and January 2005. Bessembinder, Maxwell and Venkataraman (2006) used a difference-in-difference design, studying changes in trade execution costs for insurance company bond trades in the NAIC database after July 2002 for bonds where transaction reporting was initially mandated as compared to bonds where it was not. Despite the differing samples and research designs, all three studies conclude that public transaction reporting through TRACE is associated with significant reductions in customer trade execution costs. The results in Bessembinder, Maxwell and Venkataraman (2006) also indicated the possibility of a “liquidity externality” by which trade reporting for some bonds led to reduced execution costs, even for bonds without transaction reporting (which would suggest that the bonds are competing as trading substitutes). The introduction of post-trade transparency has also been shown to be associated with reduced trading costs in credit default swap markets (Loon and Zhong, 2016), the TBA-MBS market (Schultz and Song, 2018), and the Rule 144A corporate bond market (Jacobsen and Venkataraman (2018)).

In Europe, fixed-income securities traded without either pre- or post-trade transparency until the implementation of the Markets in Financial Instruments Directive (MiFID II) in January 2018. MiFID II requires broker-dealers and trading venues (e.g., exchanges or electronic platforms) to report transactions in fixed-income securities, including sovereign bonds and corporate bonds, to a national regulator. The timing of public disclosure of transactions depends on security characteristics, transaction size, and the venue where the transaction is conducted. While the framework is quite complex, the guiding principles are that securities that are categorized by regulators as liquid and transactions that are deemed by regulators as non-block (based on security and asset-class specific size thresholds) are subject to real-time dissemination of completed transactions. MiFID II also includes a pre-trade transparency requirement to

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47 See the transcript of SEC panel titled “Pre-Trade Transparency under MiFID II” available at https://www.sec.gov/spotlight/fixed-income-advisory-committee/fimsac-071618transcript.txt
report individual bids and offers for small prospective transactions in a limited number (i.e., 200 bonds) of sovereign securities. As these data become available to researchers, it will be of interest to study whether the broad patterns observed in U.S. markets are also observed in European markets, and further whether differences in country-level regulation within the European Union could explain variations in bond market quality across markets and securities.

B. Fairness in Pricing

Some of the key regulatory issues in fixed-income markets are oriented towards the fairness of pricing. In particular, regulators restrict price “markups”, thereby limiting dealer profits. It is atypical for financial regulators to regulate pricing directly, and such regulation may effectively limit the market power of dealers in thinly-traded and relatively opaque search markets. Indeed, the enforcement of markup rules has been an important component of the regulatory agenda in fixed-income markets in recent years.48 By misstating the origins and history of a position, a dealer can potentially misrepresent the pricing allowed under regulation and the willingness of a counterparty to accept a given price.49 In the aftermath of an SEC enforcement action in 2015, both FINRA for corporate bonds and the MSRB for municipal bonds passed rules effective May 14, 2018 requiring markup disclosure on confirmation slips for riskless principal trades.50 The markup disclosure rule points to some interesting open questions. At a high level, the rule presents an opportunity to evaluate the importance of “consumer” disclosure requirements. For example, after the rule goes into effect, what happens to the implicit spread on riskless principal trades and the mix between principal and agency trades? How does this vary among instruments and dealers?

48 See, for example, http://www.seclaw.com/markups-markdowns/.
49 Enforcement actions by FINRA and the SEC arise due to violations of the markup rules. One example in which a dealer allegedly attempted to misstate the history of acquisition of a bond was Larson, Van Voris and Dolmetsch (2017), where the misrepresentation was prosecuted by the Department of Justice as a criminal matter. Ultimately, the Department of Justice (and subsequently, the SEC) dropped the case after losing two rounds of appeals in the Federal Circuit Court of Appeals. The convictions obtained in earlier stages of those rounds were overturned.
50 Of course, historically agency trades have required commission disclosure. To the extent that implied commissions on riskless principal trades are large, the required markup disclosure could lead to push back from retail clients and tighter implied commissions, especially on retail-sized transactions.
Traditional approaches to the regulation of the equity markets have been adapted in the fixed-income markets to a limited degree. FINRA adopted a best execution rule for the trading of corporate bonds, and the MSRB has adopted such a rule for municipal bonds. However, there is no analogy to the equity-market order-handling rules (which require respecting the potential priority of orders that originate with investors rather than dealers) or to the order protection rule under Regulation NMS which bans “trade-throughs,” i.e., the execution of a trade at a price worse than the best available quote.

The lack of systems for creating consolidated quotations in bond markets implies that many participants, particularly retail investors and smaller institutional traders, do not see the best available prices as they do in equities, and therefore have difficulty in identifying trade-throughs and in measuring execution quality. Harris (2015) documents a high proportion of trade-throughs in the corporate bond market when he compares trade prices to a non-public database of indicative quotations. A related problem is the lack of uniform practices regarding the quotation data that is produced by dealers and electronic venues. Larger institutions that have the resources to consolidate quotation data benefit from the information advantage. Nor do fixed-income markets have regulations analogous to SEC Rules 605 and 606, which require disclosure of order execution quality and broker order routing procedures for equities. Regulatory initiatives that lead to a centralized quotation system with standardized price data could help investors better understand the quality of their trade executions.

C. Systemic Risk and Market Stability

The regulation of fixed-income markets in recent years has emphasized systemic risk and financial stability issues, as well as the impact of the changing environment on liquidity. Among other initiatives, regulators now require most standardized derivatives, including interest rate swaps, to be cleared through centralized clearinghouses. Benos, Payne, and Vassios (2018) study proprietary trading data and conclude that centralized clearing has reduced bid-ask spreads and enhanced liquidity, a result that they attribute to enhanced competition between dealers.
At the heart of the changes in regulatory focus since the financial crisis has been the Volcker Rule, an important portion of the Dodd-Frank Act. The Volcker Rule restricts the trading activity of banks and major financial institutions to avoid subsidizing them in light of their regulatory advantages (e.g., deposit insurance, access to the discount window of the Federal Reserve and the presence of implicit “too big to fail” guarantees) and with the intent of mitigating incentives toward excessive risk-taking in proprietary trading. The Volcker restrictions effectively barred proprietary trading desks and internal hedge funds for the affected institutions, resulting in their decisions to spin off these entities.

The effects of the Volcker Rule on market making are more complicated, and arguably more significant for fixed income markets. As Duffie (2012) observes, while the Volcker Rule allows market making activities by banks, the distinction between a proprietary trade and a trade undertaken to facilitate customer activity is a subtle one. The empirical evidence discussed earlier supports the reasoning that the Volcker Rule has had the effect of reducing the willingness of dealers to commit capital to market making, even though the rule was not directly intended to impact market making.

Financial institutions would likely also attribute part of the decline in the commitment of their capital to fixed-income trading to the greater capital costs associated with higher bank capital (equity) requirements. In effect, the underlying structure of trading changed in recent years—there has been a move toward pre-arranged trading that does not rely upon dealer inventory (Schultz (2017) and Choi and Huh (2017)), as well as toward shorter intermediation chains. This can be seen as a natural response to the changes in the regulatory environment and greater reluctance of dealers to commit capital. However, focusing only on capital being supplied by bank-affiliated dealers potentially overstates the impact on the markets, because it does not capture endogenous responses such as the increased involvement of non-bank dealers, the growth in electronic intermediation services, or the effective provision of liquidity by customers through prearranged trades.

Harris (2018) observes that most bond brokers do not display limit orders from their customers in electronic bond trading systems, an important liquidity source in equity markets. Recent years have witnessed growth in “all-to-all” trading platforms that allow select buy-side institutions to participate in
liquidity provision (e.g., Market Axess’ Open Trading platform). Nonetheless, access remains limited to date, and the bond dealer remains involved in virtually all transactions between buyers and sellers. Regulatory initiatives that focus on increasing customer access can reduce the reliance on dealer capital and significantly expand the pool of liquidity suppliers.

Market making in Treasuries is presumably less affected by the Volcker Rule, as Treasury securities are less risky and more liquid as compared to the speculative securities that the Volcker Rule targeted. It would be of interest to assess the extent to which dealer capital commitment to Treasury market making has changed in recent years, and to contrast the results to those for corporate bonds and analyze the impact on spreads.

Data on transactions in U.S. Treasury securities intermediated by SEC-registered broker-dealers is currently being collected by regulators through TRACE under an initiative of the Treasury and SEC, but the data has not yet been made available to academics for analysis (though it is available to at least some researchers within regulatory institutions). The tradeoffs facing Treasury officials, who are responsible for both financial stability as well as government funding costs, are of particular interest. It could be argued that Treasuries (and perhaps some other sovereigns) should be exempt from the Volcker Rule, as they are subject to less credit risk, and the Volcker Rule is intended to limit risk taking and the costs of “too big to fail” guarantees. Of course, government bonds are subject to interest rate risk, and sovereign credit is not necessarily free of default risk. Under crisis conditions in particular the challenges to sovereign credit would be greatest and the implications of the Volcker Rule would be most germane.

Indeed, in the parallel context of bank capital adequacy, the use of “zero risk” weights for sovereign credit has been widely criticized in Europe and has potentially created vulnerability to sovereign credit issues. More broadly, regulatory policies and the use of unconventional monetary policy may have reduced the willingness to commit dealer capital to market making. In contrast to the Modigliani-Miller irrelevance propositions that are central to academic thinking, financial institutions appear to view equity capital as especially costly, so higher equity capital requirements (under Basel and
U.S. regulation) also would be expected to result in a reduction of dealer capital being allocated to market making.

Among the environmental changes that may have affected the commitment of dealer capital to market making are the enhancement of transparency for structured products, as dealers have argued that greater transparency reduces the profitability of market making, as well as other changes in market conditions. Both low interest rates and increases in interest rate volatility potentially affect the willingness of dealers to commit capital to market making.51

The nature of market making has adjusted in response to the changing environment, as hedge funds and the buy-side partially fill the void created by reduced bank involvement. Dick-Nielsen and Rossi (2019) study bond index exclusion events and conclude that liquidity is reduced around these events, requiring greater customer patience, and Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018), document increased market participation by non-bank market makers. Researchers (e.g. Ellul, Jotikasthira, and Lundblad (2011) and Choi and Shin (2018)) have documented the existence of “fire sales” in corporate bond markets, where the need to sell specific bonds results in temporary downward price pressure. In extreme circumstances, the reduced availability of capital for market making could result in fire sales of increased magnitude. While the goal of the Volcker Rule is to increase financial stability, the potential for increased fire sales implies that stability may be reduced instead, which could increase the desirability of maintaining standby capital (see Menkveld (2016)).

While regulatory and monetary policy arguably each contributed to a perception of a recent decline of fixed-income market liquidity, it would be a mistake to conclude that liquidity prior to the financial crisis was necessarily optimal, and therefore provides the right benchmark. In particular, the period prior to the financial crisis may have been characterized by unrecognized costs that were not internalized by institutions deemed “too big to fail”, and that emerged only during the financial crisis.

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51 It would be interesting to further examine how changes to the monetary policy interest rate environment (such as changing interest rate levels, interest rate volatility and Fed ownership of longer term debt under QE programs) have influenced market making, including the number of dealers and dealer capital measures.
D. Bond ETFs and Mutual Funds

Investors can obtain exposure to fixed-income markets by purchasing individual instruments, or by purchasing ownership interests through mutual funds or exchange-traded funds (ETFs). Funds provide an important mechanism for obtaining liquidity, especially in light of the limited liquidity associated with the dispersed trading of individual instruments. Theory (e.g., Subrahmanyam (1991) and Gorton and Pennacchi (1993)) predicts that portfolio liquidity should be superior to that of individual instruments, due to reduced adverse selection.

At the same time there are structural issues associated with fixed-income portfolio trading. The open-end mutual fund model is priced on a daily basis, based on closing valuations of the underlying assets. A question that arises is whether the apparent liquidity of the composite portfolio could be illusionary. Many open-end funds allow investors to transact at the fund closing price, which is in turn based upon the closing prices of the underlying holdings. This offers an illusion of costless liquidity (see Spatt (2014)), though, it is not actually costless for a mutual fund to offer such liquidity. In an attempt to mitigate the possibility of “runs” by mutual fund investors, recent regulatory changes allow the use of “swing pricing” by which a mutual fund can attempt to internalize the consequences of substantial orders at the close.

The liquidity mismatch also arises between individual bonds and ETFs, though they are all traded instruments. An ETF is traded directly on stock exchanges throughout the trading day, while its price is anchored to those of its components through a redemption and creation mechanism for the underlying fund in which only a limited set of “authorized participants” can engage in the arbitrage mechanism. The lower liquidity of underlying credit instruments relative to that of the ETF potentially increases the fragility of liquid ETFs and reduces the arbitrage capacity of ETF markets. Indeed, when the conflict in the roles of the Authorized Participants as bond dealers and ETF arbitrageurs is large, mispricing can arise (see Pan and Zeng (2017) and Goldstein, Jiang, and Ng, 2017)).

52 Many ETFs require the Authorized Participants to exchange the ETF for a basket of securities. An in-kind redemption mechanism allows the ETF to avoid selling securities to raise cash to meet redemptions. Under stressful
Since many individual bonds are highly illiquid, bond index funds often rely on sampling methods rather than purchasing all of the bonds that comprise the index to be replicated. Of course, the discrepancy between trading individual bonds and a fund offering costless liquidity through closing prices is greater when the underlying component assets held by the mutual fund are themselves highly illiquid.

On October 16, 2016, the SEC had adopted reporting requirements with respect to mutual fund liquidity to quantify for regulators and the public the extent to which assets could be sold over a specified interval. However, these requirements have been the subject of active debate, and the final rule adopted on September 10, 2018, only requires funds to disclose information about the operation and effectiveness of their liquidity risk management program. Managers of index funds are often evaluated based on the performance of their fund relative to the specified index. However, the weighting on individual bonds in the index changes each month, as new bonds are issued, existing bonds approach maturity, etc. Ottonello (2019) documents predictable patterns in bond returns related to the combination of mutual funds rebalance trading and the illiquidity of the underlying bonds.

Since mutual funds normally hold some cash reserves, they potentially supply liquidity at times. Wang, Zhang, and Zhang (2018) document that mutual funds comprise an important source of liquidity supply when other market participants are forced to sell bonds. Anand, Jotikasthira and Venkataraman (2018) show that some bond mutual funds exhibit a persistent trading style that supplies liquidity by absorbing the inventory positions of dealers. To the extent that liquidity management rules in the event of a shock preclude a mutual fund from being a net buyer, such rules may lead to more dramatic “fire sales.”

**E. Short-Term Funds**

The financial crisis also highlights the importance of the market structure for short-term financial instruments. Money market mutual funds in particular played an important role during the financial

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market conditions, it will be important to understand whether in-kind redemptions work smoothly, whether price discovery occurs at the ETF or the underlying bonds, and the relevance of publishing intraday NAVs that are possibly incorrect when the underlying bond market is illiquid.

crisis. These issues arose in the aftermath of the collapse of Reserve Fund, which did not have policies and procedures in place to adjust its valuation from the $1 per share level considered standard for money market funds, even in the face of adverse events. The conversion of shares to cash was suspended, setting off a run on money market mutual funds. This run was amplified by the custom of pricing funds at $1, rather than marking the net asset value to market.

Schmidt, Timmerman and Wermers (2016) studied the aftermath of the collapse of Lehman Brothers, showing that institutional products are more susceptible to runs. A series of reforms emerged in the aftermath of the Lehman Brothers collapse, intended to ensure that funds have appropriate policies and procedures for altering their valuations, to limit the riskiness of the assets in the fund and to require floating net asset values for institutional funds that invest in non-government securities. These “reforms” led to a substantial reduction in the holdings and size of money market mutual funds, especially institutional “prime portfolios,” effectively transforming our system of short-term financing. Much of the institutional holdings shifted to governmental money market funds from prime (non-governmental) funds, suggesting considerable demand for quasi-fixed pricing.

**F. Federal Reserve Policy and Fixed Income Markets**

Another structural change in the aftermath of the financial crisis is the extent of participation of central banks in various fixed-income markets. In particular, the Federal Reserve dramatically expanded its balance sheet and acquired a substantial portion of outstanding mortgage-backed securities, reflecting efforts to circumvent limitations on monetary policy attributable to the nominal “zero interest rate bound.” In addition to providing direct support to the housing market, this led to a substantial increase in the maturity and duration profile of Fed holdings. Of course, the underlying issues are not specific to

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54 An alternative way (compared to holding long-term bonds) for a central bank to engage in expansionary policy near the zero-interest bound is to support negative interest rates (e.g., by taxing deposits and/or currency).

55 This was viewed as somewhat controversial because of the extent of active credit allocation being undertaken by the Federal Reserve and questions as whether the macro-economy/monetary policy required such activities. The first round of expansion of the Federal Reserve’s balance sheet, QE, was widely supported as part of the response to the core of the financial crisis, but subsequent rounds, QE2 and QE3, were more controversial and perhaps less effective, as there was less of a surprise, diminishing returns and heightened concerns about the difficulty of unwinding these exposures.
the United States, as the consequences of the “zero interest rate bound” are relevant around the globe. For example, Bird (2018) documents that the European Central Bank (ECB) became one of the largest buyers of corporate bonds a few years ago, which has had substantial effects in narrowing interest rate spreads between Treasuries and corporate bonds and has effects across the credit spectrum.

The effects of central bank transactions on the microstructure of fixed-income markets comprise a promising research area. Among the contributions to date, Schlepper, Hofer, Riordan, and Schrimpf (2018) study ECB activity, reporting that greater purchases are associated with lower transactions costs, but reduced book depth. Pasquariello, Roush, and Vega (2018) develop a model implying that greater central bank activity should improve liquidity despite heightened information asymmetry and report supportive evidence for U.S. markets.

VIII. Some Open Questions

While there have been considerable advances in the understanding of the microstructure of fixed-income markets over the years, there remain a range of important and interesting unresolved questions. Among the most fundamental questions is why trading costs tend to be higher in dealer-oriented fixed-income markets as compared to equity markets. Are fixed-income markets structured optimally? The large number of individual issues, infrequent trading, and the relative dearth of retail participation are clearly relevant but may reflect endogenous outcomes. That is, to what extent do infrequent trading and a lack of retail participation result from higher execution costs? Are higher execution costs an inherent feature of dealer-oriented OTC markets, or are such markets the optimal mechanism for liquidity provision in light of the costs associated with infrequent trading and search? Would the market function more effectively if it was more consolidated? If so, how can the consolidation of a search-oriented dealer market be facilitated?

Currently, most customers have limited access to fixed-income markets, as they may not be able to observe in real time even the indicative quotes that are available from dealers, and their orders are not displayed as quotations to other market participants. Would regulations requiring the public display of
customer trading interest (along the lines of the 1997 Nasdaq equity market reforms studied by Barclay, Christie, Harris, Kandel, and Schultz, 1999) as advocated by Harris (2015) improve the functioning of fixed-income markets? More broadly, would regulations requiring all quotations and indications of interest, whether originating with customers or dealer, to be consolidated and publicly displayed enhance the functioning of fixed-income markets? What would be the effect of requiring that electronically disseminated quotations be firm and subject to automated execution?

Many of these questions relate to whether the market or portions of it should be organized more like an Exchange rather than an OTC market. An interesting perspective that bears on this indirectly by explaining the prevalence of intermediation chains is Glode and Opp (2016), who suggest that a chain of moderately informed intermediaries can mitigate market power compared to a market structure organized around a dominant broker (or exchange) and that a multi-round intermediation chain can reduce adverse selection. Long intermediation chains can lead to limited adverse selection at each stage of trading to avoid the breakdown of trading, providing a fundamental explanation for intermediation chains and the emergence of trading networks. Glode and Opp (2019) argue that the OTC markets where most fixed income trading occurs encourage the acquisition of expertise, which is useful when this improves the efficiency of allocations, but problematic when the expertise results in adverse selection. This provides a nice explanation for the co-existence of exchange and OTC trading and the choice of trading protocol for different types of instruments. Lee and Wang (2018) present a model where investors can choose between OTC and Exchange trading, showing that dealers’ ability to price discriminate can benefit customers in some cases.

Closely related is the need to better understand the differential relation between trading costs and trade sizes across fixed-income and equity markets. Do fixed-income markets inherently tend to favor large and sophisticated customers who are better informed and better able to negotiate as compared to retail customers? Markup restrictions on bond pricing have played an important role in the regulation of fixed-income markets but lack a direct counterpart in the equity markets at least since the abandonment of “price continuity” rules along with the specialist system on the New York Stock Exchange. The
underlying question is in which markets and circumstances do direct restrictions on pricing improve outcomes?

Differences in regulatory treatment and instrument characteristics across equity and bond markets can potentially be exploited to enhance our understanding of these issues. For example, to what degree do best execution requirements in the bond market have bite as compared to the equity market, and how might these requirements be better tailored to the specific circumstances of the fixed-income markets? These issues tie to whether there should be a centralized market; is it more advantageous to promote competition among dealers or intermediaries to reduce trading fees or to facilitate competition across orders to achieve the best price execution?

As noted, fixed-income instruments tend to trade infrequently, in part because of the large number of unique instruments that are issued. To what extent is there scope to increase trading frequencies and decrease trading costs by consolidating instruments? Helwege and Wang (2017) study very large bond offerings as compared to multiple simultaneous smaller offerings by the same issuer and conclude that while liquidity is improved for mega issues, yields are not lower, a result that they attribute to price pressure associated with issue size. An alternative is to issue identical securities at multiple dates. In “tack-on” offerings, the terms of new issues are selected to match those of an existing issue. However, tack on offerings are uncommon. Are “tack-on” issues fully fungible with existing issues? More broadly, are there inefficient impediments to such issues? In mortgage markets, TBA instruments, which are packages of yet-to-be issued “specified pool” instruments, trade frequently with relatively low customer costs. Is there scope for the trading of packages of corporate bonds based on a set of prescribed characteristics, along the lines of “blind auction” transactions in equity markets?

Another prominent and unresolved issue concerns the role of post-trade transparency in fixed-income markets. Though several studies have considered changes in post-trade transparency, the optimal

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56 Garriott, Lefebvre, Nolin, Rivadeneyra, and Walton (2018) provide specific proposals for consolidation of sovereign debt issues.
57 Goh and Yang (2018) report only 77 “tack-on” offerings during the 2006 to 2016 period.
58 See Kavajecz and Keim (2005).
degree of transparency has not been established, as illustrated by the ongoing debate as to whether the dissemination of information regarding large trades should be delayed. Much of the existing evidence regarding post-trade transparency has focused upon execution costs for completed trades, which may reflect a degree of order-splitting, and do not capture the potential cost and difficulty in executing large orders. Dealers, and in some cases large buy-side investors, have often been critical of greater transparency. It would be beneficial to further investigate the economic issues underlying the dealers’ perspective. Is it simply that the market-making is less profitable for dealers in a transparent setting, or is liquidity for large orders reduced such that large buy-side customers are disadvantaged by transparency? Further, in light of the large number of instruments and cross-sectional variation in both clientele and trading frequencies, the transparency regime that is optimal in one fixed-income market may not be optimal in another.

As noted, the extent of electronic quotation and trading in fixed-income markets has been modest to date, particularly as compared to equity markets. However, the role of electronically-facilitated trading in fixed-income markets is growing, and electronic interdealer trading of Treasury instruments is routine. Still, future growth in the electronic trading of fixed income instruments is far from guaranteed. U.S. Treasury markets were, on October 15, 2014, subject to a “flash crash” where the yield on the 10-year Treasury note dropped by sixteen basis points and then recovered, within a twelve-minute period. This incident raises the question of whether algorithmic trading is associated with an inherent potential for instability. It will be of interest to assess the effects of electronically-facilitated trading on fixed-income microstructure outcomes as its role increases. More broadly, it is periodically asserted that financial crises tend to originate in credit markets. Studies of fixed-income microstructure focusing on

how regulations affect liquidity provision, execution costs, and trades’ price impacts have potential to inform policymakers regarding the effects of policy initiatives on the fragility of the credit markets.

An interesting puzzle related to the municipal bond market is the widespread usage of municipal bond insurance prior to the financial crisis. Why wouldn’t the capital market simply bear the default risk just as it bears (and shares) so many types of capital market risks? Default risks are presumably positively correlated across bonds, and as such have a substantial systematic component. To the extent the insurance was credible, it resulted in instruments that were relatively more substitutable. One hypothetical advantage of such increased fungibility would have been to support the use of forward or futures contracts in which different insured instruments could be delivered, thereby potentially resulting in improved liquidity, similar to TBA trading of MBS or the trading of generic MBS instruments as opposed to those “on special” (due to their prepayment or perhaps default characteristics, as discussed by Spatt, 2004). Of course, the fungibility of municipal bonds might still be limited by differences in tax treatment associated with the within-state tax exemption.

The shorting and lending of fixed-income securities has been relatively little studied relative to equity markets.⁶¹ This also would seem to be an important area of research focus in light of the limited liquidity in most bond markets and the lack of transparency about the shorting process (in the equity as well as fixed-income markets).

As noted, in recent years the magnitude of bond issuances has far outstripped that of equity issues. Equity issuances, including both initial (IPO) and seasoned (SEO) offerings have been studied extensively, both in terms of issue pricing and post-issue liquidity. In contrast, the issuance process and microstructure of fixed-income issues has been little studied to date. Further, the diversity of fixed-income instruments imply that regularities established for one segment of the fixed-income markets, e.g. Treasuries, may well not carry over to other segments such as corporate or municipal bonds.

A substantial portion of the empirical research related to fixed income microstructure focuses on

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⁶¹ At the same time there has been interesting research about the Treasury repo specials market, as illustrated by Duffie (1996), Jordan and Jordan (1997) and Fleming and Garbade (2007).
data generated during or after the financial crisis, which were periods of unconventional monetary policy. As a consequence, it is desirable to develop a better understanding of interrelations between monetary policy, post-crisis regulations, and microstructure outcomes. For example, how does the impact of the zero interest-rate bound affect monetary policy, interest rates, and the liquidity of the various instruments that may be involved in non-traditional policy? How do changes in the Fed’s ownership of various instruments under Quantitative Easing and successor policies influence spreads, the number of dealers and dealer capital? What can we learn about optimal market structure from cross-country comparisons, particularly in light of the variation in monetary policies across countries?

Monetary policy impacts corporate issuance decisions, in part due to its effects on interest rates. The near-zero interest rates over the last decade are associated with a record amount of corporate bond issuance, with Triple B-rated corporate bonds now representing almost 50% of all outstanding investment-grade debt. Do the combination of increased market size, decreased credit worthiness, and dealers who may be less inclined to commit capital to market making imply that a future economic downturn could prompt larger fire sales and greater financial fragility?
References


Table 1: Size, Issuance and Ownership in Bond Markets

<table>
<thead>
<tr>
<th>Type of bonds</th>
<th>Issuer</th>
<th>Outstanding ($B, 2017)</th>
<th>Issuance ($B, 2017)</th>
<th>Ownership (as of 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>U.S. Treasury</td>
<td>14,450</td>
<td>2,200</td>
<td>Foreign (42%), Federal Reserve (17%), Mutual funds (12%), Pension funds (10%), Banks (5%), Insurance (2%). #</td>
</tr>
<tr>
<td>Money market</td>
<td>U.S. Treasury, Financial Institutions, Corporations</td>
<td>950</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Agency debt</td>
<td>Freddie Mac, Fannie Mac, FHLBs</td>
<td>1,950</td>
<td>750</td>
<td>-</td>
</tr>
<tr>
<td>Mortgage-backed securities (MBS)</td>
<td>Financial Institutions</td>
<td>9,300</td>
<td>2,000</td>
<td>Foreign (14%), Federal Reserve (20%), Mutual funds (11%), Insurance/Pension (9%), Banks (25%) a</td>
</tr>
<tr>
<td>Asset-backed</td>
<td>Financial Institutions</td>
<td>1,450</td>
<td>600</td>
<td>-</td>
</tr>
<tr>
<td>Corporate</td>
<td>Corporations</td>
<td>9,000</td>
<td>1,650</td>
<td>Foreign (29%), Insurance companies (27%), Mutual funds (16), Pension funds (10%), Households (6%), Banks (7%).</td>
</tr>
<tr>
<td>Municipal</td>
<td>State and local governments and agencies.</td>
<td>3,850</td>
<td>450</td>
<td>Households (51%), Banks (30), Mutual funds (17%) @</td>
</tr>
<tr>
<td>U.S. fixed income</td>
<td></td>
<td>40,950</td>
<td>7,650</td>
<td>-</td>
</tr>
<tr>
<td>U.S. stock market</td>
<td>Corporations</td>
<td>32,100</td>
<td>224</td>
<td>-</td>
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<td>U.S. capital markets</td>
<td></td>
<td>73,050</td>
<td>7,874</td>
<td>-</td>
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<tr>
<td>U.S. GDP</td>
<td></td>
<td>19,400</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

# Board of Governors of the Federal Reserve System, Financial Accounts of the United States.
@ Municipal Securities Rulemaking Board (MSRB), Trends in Municipal Bond Ownership, 2017.
Table 2: Regulatory data collection and post-trade reporting in U.S. fixed-income markets: Timeline 1997-2017
## Transparency Timeline

<table>
<thead>
<tr>
<th>DATE</th>
<th>MILESTONE</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul-97</td>
<td>Municipal</td>
<td>Dealers report all municipal bond transactions to MSRB after close of business each day. Publicly disseminated after two weeks</td>
</tr>
<tr>
<td>Jul-02</td>
<td>Corporate - Phase I</td>
<td>Dealers report all corporate bond transactions to FINRA within 75 minutes. Public dissemination is immediate for large 500 IG and 50 HY bonds. Transactions in other bonds are not disseminated.</td>
</tr>
<tr>
<td>Mar-03</td>
<td>Corporate - Phase II</td>
<td>Public dissemination is expanded to smaller IG bonds in March 2003 and further expansion to approximately 4,650 corporate bonds in April 2003. Reporting lag is reduced to 45 minutes in October 2003.</td>
</tr>
<tr>
<td>Oct-04</td>
<td>Corporate - Phase III a</td>
<td>Additional corporate bonds are included for public dissemination. Reporting lag is reduced to 30 minutes.</td>
</tr>
<tr>
<td>Jan-05</td>
<td>Municipal</td>
<td>Dealers report all municipal bond transactions to MSRB within 15 minutes. Public dissemination is immediate.</td>
</tr>
<tr>
<td>Feb-05</td>
<td>Corporate - Phase III b</td>
<td>Additional corporate bonds are included for public dissemination. About 99% of transactions in registered corporate is covered. Reporting lag is reduced to 15 minutes in July 2005. All registered corporate bonds are disseminated by January 2006</td>
</tr>
<tr>
<td>Mar-10</td>
<td>Primary Market</td>
<td>Dealers report all U.S. Agency Debenture transactions, as well as primary market transactions in TRACE eligible securities.</td>
</tr>
<tr>
<td>May-11</td>
<td>ABS / MBS</td>
<td>Dealers report all transactions in asset-backed and mortgage-backed securities to FINRA. These trades are not publicly disseminated.</td>
</tr>
<tr>
<td>Nov-12</td>
<td>MBS - TBA</td>
<td>To-be-announced (TBA) transactions are included for public dissemination.</td>
</tr>
<tr>
<td>Jul-13</td>
<td>MBS - Specified Pools</td>
<td>Mortgage backed securities (MBS) transactions are included for public dissemination.</td>
</tr>
<tr>
<td>Jun-14</td>
<td>Rule 144 Securities</td>
<td>Transactions in SEC Rule 144A securities are included for public dissemination.</td>
</tr>
<tr>
<td>Jun-15</td>
<td>Asset Backed Securities</td>
<td>Transactions in Asset backed securities (ABS) are included for public dissemination.</td>
</tr>
<tr>
<td>Mar-17</td>
<td>Collateralized Mortgage Obligations</td>
<td>Transactions in collateralized mortgage obligations (CMOs) are included for public dissemination.</td>
</tr>
<tr>
<td>Jul-17</td>
<td>Treasury Securities</td>
<td>Dealers report all Treasury securities transactions to TRACE. Transactions are not reported to the public.</td>
</tr>
</tbody>
</table>

*Transactions that exceed a size threshold are reported with quantity field = Threshold+. For example, the threshold for IG corporates is $5 million and for HY corporates is $1 million. Transactions that exceed the thresholds are reported as $5M+ and $1M+, respectively.

# Source: 2017 FINRA Fact Book; FINRA Rulings
## Table 3: Data sources, trading platforms and trading activity

<table>
<thead>
<tr>
<th>Type of bonds</th>
<th>Data source</th>
<th>Coverage begins</th>
<th>Daily trading volume 2017, $B</th>
<th>Average trade size, $M</th>
<th>Customer / total trading, %</th>
<th>Customer trading costs, basis points</th>
<th>Electronic trading platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>GovPX</td>
<td>1991</td>
<td>505</td>
<td>2-Year: 28&lt;sup&gt;a&lt;/sup&gt; 5-Year: 12 10-Year: 10</td>
<td>50</td>
<td>2-Year: 1&lt;sup&gt;a&lt;/sup&gt; 5-Year: 1 10-Year: 2</td>
<td>BrokerTec&lt;sup&gt;x&lt;/sup&gt; eSpeed&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>BrokerTec</td>
<td>2001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agency MBS</td>
<td>TRACE</td>
<td>2011</td>
<td>209</td>
<td>TBA: 33&lt;sup&gt;g&lt;/sup&gt; MBS: 6</td>
<td>TBA: 52&lt;sup&gt;g&lt;/sup&gt; SP: 80</td>
<td>TBA: 2&lt;sup&gt;d&lt;/sup&gt; MBS: 80</td>
<td>BrokerTec&lt;sup&gt;x&lt;/sup&gt; Tradeweb&lt;sup&gt;x&lt;/sup&gt; Tradeweb&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>CMBS</td>
<td>TRACE</td>
<td>2011</td>
<td>3</td>
<td>Reg: 18&lt;sup&gt;e&lt;/sup&gt; 144A: 47</td>
<td>84&lt;sup&gt;d&lt;/sup&gt;</td>
<td>Reg: 53&lt;sup&gt;e&lt;/sup&gt; 144A: 72</td>
<td>Tradeweb&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>ABS</td>
<td>TRACE</td>
<td>2011</td>
<td>1</td>
<td>Reg: 8&lt;sup&gt;e&lt;/sup&gt; 144A: 19</td>
<td>80&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Reg: 48&lt;sup&gt;e&lt;/sup&gt; 144A: 0.44</td>
<td>Tradeweb&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>Corporate</td>
<td>TRACE</td>
<td>2002</td>
<td>31</td>
<td>1.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>70&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Retail: 124&lt;sup&gt;b&lt;/sup&gt; Institution: 36</td>
<td>Market Axess&lt;sup&gt;z&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>NAIC</td>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal</td>
<td>MSRB</td>
<td>1997</td>
<td>11</td>
<td>0.41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>70&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Retail: 75&lt;sup&gt;c&lt;/sup&gt; Institution: 20</td>
<td>Municenter&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Adrian, Fleming, and Vogt (2017), Sample period: 2017; BrokerTec IDB transactions data
<sup>b</sup> Bessembinder, Jacobsen, Maxwell and Venkataraman (2018); Table 3; Sample period: 4/14-10/16; TRACE data.
<sup>c</sup> MSRB 2017 Factbook and Wu (2018), Sample period: 2017; MSRB data.
<sup>d</sup> Bessembinder, Maxwell and Venkataraman (2013); Table 7; Sample period: 5/11-1/13; TRACE data.
<sup>e</sup> Hollifield, Neklyudov, Spatt (2017); Table 2; Sample period: 5/11-2/12; TRACE data.
<sup>f</sup> SIFMA Factbook (2018); Page 34.
<sup>g</sup> Gao, Schultz, and Song (2017); Sample period: 5/11-4/13; TRACE data.

TRACE: Trade Reporting and Compliance Engine; MSRB: Municipal Securities Rule Making Board’s EMMA database.
MBS: Mortgage backed securities specified pools; TBA: Agency MBS to-be-announced; Reg: Registered bonds; 144A: Private bonds.
Retail transaction size: ≤ $100,000; Institutional transaction size: ≥ $1 million
x: electronic limit order book IDB platform; y: voice+electronic IDB platform; z: request-for-quote (RFQ) platform
Figure 1: Size of Equity and Fixed-Income Markets 2003-2017

Source: Author calculations based on data provided by Securities Industry and Financial Markets Association (SIFMA).
Figure 2: Trading activity, bid-ask spreads and depth in the U.S. Treasury bond market 1991-2017

The figure plots the trading volume, bid-ask spreads, and book depth in the Treasury market between 1991 to 2017 in inter-dealer broker trading platform using data from GovPX and BrokerTec.

Figure 3: Trading Costs and Dealer Capital Commitment in U.S. Corporate Bond Market

Source: Author calculations based on enhanced Trade Reporting and Compliance Engine (TRACE) data used in Bessembinder, Jacobsen, Maxwell and Venkataraman (2018).

Panel A:

Customer Trading Costs and Dealer Capital
Corporate bond market (2006-2016)

Panel B:

Monthly Corporate Bond Trading Costs (%) on Customer Transactions
Trade Sizes
Figure 4: Trading Costs in the U.S. Municipal Bond Market 2005-2018

The figure plots the dealer round-trip trading costs for all customer-to-dealer trades, and for five trade size groups for municipal bonds between 2005 to 2018 using the Municipal Securities Rulemaking Board (MSRB) database.