The Electronic Evolution of Corporate Bond Dealers[*]

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February 14, 2020

Forthcoming, Journal of Financial Economics

Abstract

Technology transformed the trading of financial assets but has been slower to come to corporate bond trading. Combining proprietary data from MarketAxess with regulatory TRACE data, we investigate how electronic request for quote (RFQ) trading affects bond dealers and trading more generally. We demonstrate that electronic trading remains fairly small and segmented, but has wide-ranging effects on transaction costs and execution quality in both electronic and voice trading, and the inter-dealer market. We identify features particular to bond markets that have and may continue to limit electronic bond trading growth. We provide an intriguing portrait of a market in transition.

JEL classification: G14, G21, G23, G24

Keywords: Electronic trading, Voice trading, RFQ, Corporate bond markets, Bond dealers, Transaction costs, Execution quality, Inter-dealer trade, Rating downgrade

[*] We thank FINRA and MarketAxess for providing the data used in this study. We thank the editor (Bill Schwert), the referee, Jack Bao, Hank Bessembinder, Jonathan Brogaard, Alié Diagne, Terry Hendershott, Grace Xing Hu, Charles Khan, David Krein, Marco Machiavelli, Ananth Madhavan, Gideon, Saar, Ramu Thiagarajan, and seminar participants at the 2019 Conference on Financial System of the Future, the 2019 China Fintech Research Conference, and at State Street Global Advisors for their valuable comments. The views expressed herein are those of the authors and not necessarily of the Federal Reserve Board of Governors or its staff. All errors are our own.
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1. Introduction

Technology transformed the trading process for a wide range of financial assets, rendering obsolete the roles of exchange floors, traditional stock exchange specialists, two-dollar brokers, and other remnants of trading times past. Whether it be in equities, options, futures, or foreign exchange, electronic trading has become the norm, bringing with it measurable improvements in transaction costs and various market quality metrics, as well as a host of new market participants and venues. One notable exception to this trend, however, is corporate bond trading. Corporate bonds trade in dealer markets, and despite the in-roads made elsewhere, electronic trading has failed to dislodge the dominance of dealers. Yet change, too, is slowly coming to corporate bond trading in the guise of electronic platforms offering execution capabilities. How electronic trading is affecting corporate bond dealers, and what this portends for the future of corporate bond trading, is the focus of this paper.

Unlike other asset classes, where electronic trading has often supplanted market intermediaries, electronic bond trading platforms have generally worked with dealers via a request for quote (RFQ) process.[1] In a RFQ, a customer sends a buy/sell request over the platform to a number of dealers, and dealers in turn can respond with bids or offers. Alternatively, a customer can contact a dealer (or sequentially, many dealers) via traditional voice trading. Dealers generally operate in both voice and RFQ milieus. Hendershott and Madhavan (2015) examined theoretically the decision facing traders regarding whether to "click" or "call", focusing on the role of electronic venues in reducing search costs. Using data from January 2010 through April 2011, they show

[1] An alternative electronic trading approach, All-to-All trading, is tiny over our sample period. Since the launch of All-to-All trading in 2012, the daily share of dealer to customer trades that are executed through All-to-All as a fraction of overall trade volume has been growing steadily, but still remains below 2% by 2017. Therefore, we focus in this paper only on RFQ trading.

that electronic trading costs were generally lower, and particularly so for more liquid and larger bond issues, but the embryonic state of electronic trading at that time precluded analysis of more general issues.

Using an extensive data set provided to us by MarketAxess, the largest and dominant bond trading platform, as well as a regulatory version of corporate bond transaction data from the Trade Reporting and Compliance Engine (TRACE) provided by the Financial Industry Regulatory Authority (FINRA), we seek a more complete view of the electronic evolution of corporate bond trading. Our focus is on three main issues: First, what has happened to electronic trading in corporate bonds over time and is it showing the dominance that characterizes trading in other asset classes? Second, how has electronic bond trading affected the markets and, particularly, the behavior and structure of the dealer market? And, third, what are the limitations, if any, to the growth of electronic bond trading?

Our results provide an intriguing portrait of a market in transition. We show that electronic trading has continued to grow, albeit slowly: over our sample period it never exceeds 14% of market trading volume. But despite this small stature, electronic trading has had wide-ranging impacts. Transactions costs have fallen across the board, both for electronic trades and even more so for voice trading. We find the intriguing result that bond dealers who do more electronic trading offer better prices for their voice trades. The effects of electronic trading on voice trading costs are robust to controlling for time trends, selection bias, and potential endogeneity of electronic trading. Retail trades are particular winners – at the beginning of our sample, transaction costs for retail-sized trades were much higher than for block trades, but by the end of our sample in electronic trading they are approximately the same. High-yield bond execution costs also fall dramatically, despite electronic trading making smaller inroads here than in investment-grade bonds. Dealers appear to benefit in that they are able to find customers better, and so rely less on the inter-dealer market to offload positions – for investment-grade bonds, inter-dealer trading fell from 42% to 28% over our sample period. Electronic trading also appears to facilitate riskless principal trading as we find that 39% of such trades involve one leg completed via RFQ. We argue that these positive benefits are largely driven by three channels: enhanced dealer competition, reduced search costs for both customers and dealers, and greater information.

Yet, given these benefits, the puzzle remains why electronic trading has not taken on a larger role. Our research identifies some important limits to electronic bond trading. We show that bond illiquidity plays a large role. Using bond downgrades as periods where customers need to trade specific bonds, we show how trading shifts from electronic to voice trading, reflecting that electronic trading is not robust across stress periods. Size and composition effects are also important. We find that electronic trading is almost entirely constrained to small trade sizes. Larger trades rarely trade electronically, and unlike in equities, bond trades are not being broken up into smaller trade sizes. So, electronic trading has only made in-roads in smaller trades. We also find that most electronic trading involves investment-grade bonds, consistent with dealer unwillingness to trade more information-sensitive high-yield bonds in electronic settings. A third limit to greater growth is market structure. In other settings, electronic trading elicited a variety of new entrants. Dealer market structure in bonds, however, is little changed; the top ten dealers remain dominant and new entrants are few, resulting in a decrease in bond dealers over our sample period.

Overall, our results show that bond markets are evolving, and for the better. The impact of electronic trading to date, however, is more evolutionary than revolutionary. While the introduction of new technologies (such as the nascent all-to-all trading) may hasten this evolution, our work points to the particular nature of bond trading as imposing limitations on any eventual domination of electronic trading in bonds. For the foreseeable future, corporate bond dealers will be central to corporate bond trading.

Our research joins a growing body of work examining bond market microstructure. A variety of research has investigated execution quality differences in corporate bond trading, see, for example, Schultz (2001), Bessembinder, Maxwell, and Venkateramen (2006), Edwards, Harris, and Piwowar (2007), Goldstein and Hotchkiss (2007), Feldhutter (2012), Bias and DeClerck (2013), Hendershott et. al. (2017), and O'Hara, Wang, and Zhou (2018). More recent work has looked at changes in bond markets post-financial crisis, with research here by Dick-Nielsen, Feldhunter and Lando (2012), DiMaggio, Kern and Song (2016), Bao, O'Hara, and Zhou (2018), Bessembinder et al (2018), Flanagan, Kedia, and Zhou (2019), and Saar, Sun, Yang, and Zhu (2019). Other relevant research has looked at the impact of technology on trading, with research here by Hendershott and Madhavan (2015), Easley, Hendershott, and Ramadorai (2014), Brogaard, Hendershott, Hunt, and Ysusi (2014), and Brogaard, Hagstromer, Norden, and Riordan (2015). Our work also contributes to the broader literature on frictions in OTC markets, notable papers here being Duffie, Garleneau and Petersen (2005; 2007), Riggs et. al. (2019), and Uslu (2019).

This paper is organized as follows. The next section set out the data, sample construction, and explains the mechanics of RFQ trading. Section 3 investigates the growth of electronic trading in corporate bonds. Section 4 examines the benefits of electronic trading. We use the lens of competition, search costs, and information to examine the impact on execution quality, dealer voice trading, and the inter-dealer market. Section 5 examines the limitations of electronic trading in corporate bonds, focusing on market structure, size effects, and stress periods. Section 6 is a conclusion.

2. Data, Sample Construction, and the RFQ Mechanism

Our analyses rely on combining regulatory TRACE corporate bond transaction data with data on all trades executed on MarketAxess, a leading electronic trading platform, over the period from January 2010 to December 2017. TRACE data provide detailed information for each corporate bond trade, including bond CUSIP, trade execution date and time, trade price and quantity, and an indicator for whether the dealer buys or sells the bond.[2] In addition, the regulatory version of the data also provide information on dealer identity for each trade. For inter-dealer trades, identities of both counterparties are included in the data. Information on dealer identity is essential to our analysis on the effects of electronic trading on dealer behavior.

To identify electronic trades, we obtain data on all trades executed on MarketAxess. Since the MarketAxess data do not include the same trade identifier as in the TRACE data, we match the MarketAxess data with TRACE data using bond CUSIP, execution time, price, quantity, the buy or sell indicator and an indicator for inter-dealer trade. Based on these criteria, 98.9% of trades on MarketAxess find a unique match in the TRACE data. These trades are identified as electronic trades with the rest being classified into voice trades.[3]

We obtain from Mergent FISD characteristic information about corporate bonds, such as credit rating, date of issuance and maturity date, and the total par amount issued. To construct our sample, we start with all corporate bonds that are issued in US dollars by US firms in the following three broad FISD industry group: industrial, financial and utility. To be included in our sample,

[2] Primary market transaction are not executed electronically and hence are excluded from our sample.
[3] Trades executed through All-to-All are excluded from our sample.

we require each bond to have valid rating information from Moody's or S&P. We assign a numeric value to each notch of S&P (Moody's) credit rating, with 1, 2, 3, 4 … denoting AAA (Aaa), AA+ (Aa1), AA (Aa2), AA- (Aa3), …, respectively, and we take the lower of S&P and Moody's rating as a bond's credit rating. After removing private placements, we end up with a sample of over 105 million trades in 29,787 bonds.

As the electronic trades in our sample all involve an RFQ, it is useful to set out the mechanics of this MarketAxess trading process.[4] A customer initiates RFQ trading by entering into the MarketAxess platform one or more inquiries (a single vs. a list). Each inquiry includes all of the parameters needed to communicate the customer's interest to a dealer, who can then respond with their quote. A list of pre-approved dealers appears on the inquiry screen. This list considers the customer's existing permissioned trading relationships with specific dealers, as well as the dealer's permissioned trading relationships with specific customers. Only the dealers on this list can be contacted for a quote on the inquiry. The customer can select any or all of the dealers on this list on an inquiry-by-inquiry basis. The number of dealers contacted this way can range from 5 to 50 or more, but it is typically around 30.

When the customer submits the inquiry, the identity of the customer is disclosed along with the side, size and other relevant parameters. The dealers do not know the number or identities of the other dealers contacted. Each dealer typically has up to 10 minutes to respond to the RFQ in the investment-grade market. The dealers' responses are shared with the customer who then may select a dealer with whom to trade. Note that dealers do not have to respond to the RFQ and customers do not have to trade with any of the dealers. If a particular dealer quote is selected, the trade is completed. The other participating dealers will know only that they did not get a trade at

[4] We thank David Krein of MarketAxess for his help and insights on this institutional structure.

their quote. During our sample period, the price of the completed trade was disseminated to the market by FINRA within 15 minutes of the time of execution. Neither customer nor dealer identity is included in the dissemination.

It is important to note at the outset that our measure of electronic trading is based solely on trades executed on MarketAxess. During our sample period, there are some other electronic corporate bond trading venues, but these are generally small in size and data on trading there is not generally available.[5] We believe our data provide the most accurate depiction of electronic bond trading, but we caution that they should be interpreted as giving a lower bound on electronic trading activity in corporate bonds.

3. The Growth of Electronic Corporate Bond Trading

We begin by examining the growth of electronic bond trading. Figure 1 shows the share of electronic trading over the period 2010-2017. We define electronic trading as the average daily share of dealer to customer trades executed on MarketAxess as a fraction of overall dealer to customer trading. Panel A breaks these numbers down into the share of total par volume traded and into the number of trades. As is apparent, the volume of trade executed electronically has been increasing steadily, rising from a market share of approximately 6% in 2010 to a little over 13% in 2017. A more dramatic increase can be seen in the number of trades, where electronic trading has gone from 9% of trading to now executing approximately 25% of trades.

Panel B shows that most of this electronic trading volume is in investment-grade bonds. Electronic high-yield bond trading was almost non-existent at the start of our sample period, but it does show steady growth, particularly in the latter years of our sample. Still, by 2017, the market

[5] According to results from Greenwich Associates' surveys of U.S. institutional corporate bond investors, MarketAxess accounts for 85% of dealer to customer institutional electronic trading in corporate bonds. See <<Greenwich Associates 2018 Corporate Bond Trading>>.

share of electronic investment-grade volume has reached over 17% of total investment-grade volume, with electronic high-yield trading just over 5% of total high-yield volume.

Trade size is an important dimension in bond trading, with large trade sizes the norm in what is traditionally an institutional investor driven market. Following market norms, we classified all trades into four size categories: Micro ($1 to $100,000); Odd-lot ($100,000 to $1, 000,000); Round-lot ($1,000,000 to $5,000,000) and Block (above $5,000,000). We then calculate the share of electronic trading across trade size categories. Figure 2 Panel A presents the annual average daily share of electronic trading in each of the four size categories for investment-grade bonds; Panel B provides the same information for high-yield bonds.

The figures clearly show that electronic trading is concentrated in the smaller trade sizes. In investment-grade trading, almost 50% of Odd-lot trades are now done electronically. Micro trades and Round lots exhibit slow but steady growth over the sample period, with approximately 20% of trading volume in those categories gravitating to electronic trading. Block trades, however, remain almost entirely in the voice trading realm. The results for high-yield bonds show an even more dramatic trade size effect, with virtually all high-yield electronic trading concentrated in the smaller trade sizes.

If electronic trading experiences the largest growth in small trades, can institutional investors benefit from it by breaking their large trades and executing them electronically? This does not seem to be happening. Figure 3 shows the distribution of daily trade volume across the four trade size categories has remained remarkably stable. Therefore, the advent of electronic trading has not resulted in the trade-shredding found in equity markets nor has it changed the trading patterns of bond market participants. What is also important to note, is that bond market trading is heavily skewed towards larger trade sizes. Figure 3 shows that for both investment-grade and high-yield bonds, micro and odd-lot trades are a very small fraction of total volume. Block trades and round-lots together account for about 90% for either bond type, with blocks having a larger share in investment-grade than in high-yield. Have the benefits of electronic trading been limited to only those trades that execute on electronic trading platforms? Or, has electronic trading had broader impact on corporate bond trading, including the dominant voice trades to date, and affected dealer behavior more generally? We turn in the next section to investigate these questions.

4. The Benefits of Electronic Trading

In most market settings, electronic trading has reduced transaction costs, so a natural starting point is to ask how the rise of electronic trading has affected transaction costs in bond trading. An interesting wrinkle in bond markets is that voice and electronic trading occur simultaneously, so we need to consider executions costs in both venues, as well as how the interactions between the venues affect dealer behavior and, ultimately, prices. We examine these interaction effects by investigating three channels. First, electronic trading could reduce transaction costs by promoting dealer competition. Second, electronic trading could also reduce transaction costs by reducing search costs, potentially allowing dealers to better control their inventory risk. Third, if electronic trading provides more informative prices, then dealers more active electronically should be able to offer better prices to both their electronic and voice customers. As we demonstrate in this section, these competition, search cost, and information channels help explain a variety of effects accompanying the advent of electronic corporate bond trading.

4.1. Transaction Costs in Electronic and Voice Venues

Transaction cost estimation in bond markets is not straightforward. Our sample contains 29,787 bonds, many of which trade infrequently. A standard approach in the literature is to use the closest in time inter-dealer trade in that bond as a benchmark price from which to estimate the price impact of a trade. This is the approach used by Hendershott and Madhavan (2015) and for comparability with their results we use this approach as well. In Appendix 1, we consider the robustness of this approach by investigating alternative approaches for benchmarks in bond transaction cost measurement, including the most recent dealer to customer trade price, or any price in the bond.[6]

We estimate the transaction cost for each trade by:

$$Cost_j = ln\left(Trade\ Price_j / Benchmark\ Price_j\right) \times Trade\ Sign_j, \quad (1)$$

where $Trade\ Price_j$ refers to the transaction price for trade j, $Benchmark\ Price_j$ is the transaction price of the last trade in that bond in the interdealer market, and $Trade\ Sign_j$ is an indictor variable for trade direction. $Trade\ Sign_j$ takes the value of +1 for an investor purchase and -1 for an investor sale. We multiple $Cost_j$ by 10,000 to compute transaction cost in basis points of value.

4.1.1. Changes in Transactions Costs over Time

We first divide our sample of trades into two groups: electronic trades and voice trades. For each subsample, we estimate a bond-day level *Cost* measure by averaging $Cost_j$ across trades in the same bond on the same day. We then average the bond-day level *Cost* measure across bonds to get a daily measure for the market. Finally, the daily measure is averaged across days to get an

[6] As we discuss in Appendix 1, the general time trends in transaction costs persist across alternative benchmarks. We note, however, that the estimates can differ notably in terms of levels.

annual estimate. Panel A Figure 4 shows that transaction costs for electronic trades fell dramatically over our sample period for both investment-grade and high-yield bonds. Transaction costs for high-yield bonds traded electronically dropped from approximately 35 basis points in 2010 to below 20 basis points in 2017. Similarly, investment-grade transaction costs went from approximately 18 basis points to approximately 10 basis points.

Transaction cost in voice trading also fell over this period. Panel B shows a steady decline in both investment-grade and high-yield transaction costs, with voice trading transaction costs in high-yield now almost the same as in investment-grade trading. Comparing the two panels suggests that electronic trading is substantially cheaper than voice trading. Earlier we showed that electronic trading primarily involved smaller trade sizes, suggesting that the comparisons of trading costs between voice and electronic settings may suffer from selection bias. To address this concern, we estimate trading costs across size categories, by voice and electronic trading, and by bondtype.

Figure 5 reveals a variety of results. First, transaction costs are falling across our sample period for both electronic and voice trades, and for investment-grade and high-yield issues. But the patterns of change are very different between voice and electronic settings. Whereas voice trading costs decline almost monotonically, electronic trading costs are variable and at least for high-yield block trades, almost erratic.[7] Second, in all settings, transaction cost is highest for small trades and lowest for the largest trades. This pattern, the opposite of that found in equity markets, has traditionally characterized bond trading, but Panels A and C show that it is disappearing in electronic trading. Indeed, trading costs in electronic markets appear to be converging to 10 basis points for investment-grade trades of all sizes and to 20 basis points for high-yield trades of all

[7] The small sample of electronic block trades in high-yield bonds may be contributing to this erratic pattern.

sizes. Third, electronic trading is cheaper than voice trading for both investment-grade and high-yield bonds.

4.1.2. Electronic Trading and Transaction Costs – Cross Venue Effects

The declining transaction cost for electronic trading is not surprising. What is intriguing is that transaction costs for voice trading also dropped substantially. Are these changes in transaction costs for voice trades a result of electronic trading or are they merely the reflection of general trends affecting bond trading? On the one hand, investors endogenously select the best mechanism for their trades (Hendershott and Madhavan (2015)). If easier trades in more liquid bonds increasingly migrate to electronic trading platforms, those that remain to execute in traditional voice trading are likely to be the difficult ones in less liquid bonds and, hence, might be expected to face larger transaction costs. This suggests that transaction costs in voice trading would increase as more trades execute electronically. On the other hand, there are several reasons to believe that greater electronic trading can lead to lower transaction costs in voice trading. First, increasing competition from electronic trading venues can force dealers to provide more competitive prices in their voice trading. Second, electronic trading reduces the costs for searching for the right counterparties, and so could facilitate dealers' inventory risk management. This, in turn, can lead dealers to provide better voice trade prices. Third, dealers' pricing in their traditional voice trading could be improved by information they learn from both trade interests and actual trades on electronic trading platforms.

We test for these hypothesized effects of electronic trading on the transaction costs in voice trading by estimating the following empirical model:

$$Cost_{i,t,s}^{v} = \alpha + \beta \times E\text{–}Share_{i,t,s} + \gamma \times X_{i,t} + \mu_s + \varepsilon_{i,t,s}. \quad (2)$$

The dependent variable $Cost^{v}_{i,t,s}$ represents the average voice trade transaction costs, calculated by taking the average of the trade level transaction cost estimates across voice trades with similar trade size (*s*) in the same bond (*i*), and on the same day (*t*). The key explanatory variable, $E\text{–}Share_{i,t,s}$, is the share of dealer to customer trade volume that occurs on MarketAxess, calculated at the same bond-day-trade size as $Cost_{i,t,s}$. This measure captures the importance of electronic trading for dealer to customer trades in a specific bond on a given day and with similar trade size. $X_{i,t}$ represents a set of bond-level controls for bond *i* on day *t*, including the log of the total par amount outstanding (*Log(Amount Out)*), the residual time to maturity of the bond (*Time to Maturity*), three industry dummies representing three broad industry groups (industrial, financial, and utility), and a set of dummy variables for the 21 credit ratings. Given the documented differences in transaction costs for trades with different sizes, we include trade size fixed effects (μ_s) based on the four size categories (i.e., Micro, Odd-lot, Round-lot, and Block).

To construct our sample to estimate Model (2), we match the voice trade cost measure ($Cost^{v}_{i,t,s}$) with the e-trading measure ($E\text{–}Share_{i,t,s}$), and the bond-level controls. The $Cost^{v}_{i,t,s}$ measure has a mean of 50 basis points, with the median being lower at 27 basis points. The $E\text{–}Share_{i,t,s}$ measure also has a skewed distribution. At the bond-day-trade size level, while electronic trading on average accounts for 21% of total dealer to customer trading, the majority of the sample has no electronic trading. The median bond in our sample carries a rating of BBB, has a total $700 million in total par amount outstanding, with about 6 years till maturity. Bonds issued in the industrial and the financial industry account for 55% and 40% of our sample respectively, with the rest of the sample belonging to bonds issued in the utility industry.[8] We estimate Model

[8] Appendix 2 provides more detailed information about our sample.

(2) with standard errors two-way clustered at the bond and the day levels, and the results are presented in Table (1).

Our results support that greater electronic trading is driving transaction fees for voice trading lower. The -14.634 coefficient on *E-share* (Column I) implies that a one-standard-deviation increase in *E-share* leads to 5.4 basis points reduction in voice transaction costs, which is about 11% of the mean transaction cost in our sample. As the relation between $Cost^{v}_{i,t,s}$ and $E\text{–}Share_{i,t,s}$ could be driven by their respective time trends documented earlier, we re-estimate Model (2) including day fixed effects. Such time fixed effects also allow us to control for potential changes in macroeconomic conditions (e.g., market volatilities, credit risk conditions, interest rate term structures). Column II shows that our results change little. Bonds with more electronic trading tend to have lower transaction costs even in their voice trading.

Our findings suggest that the benefits of electronic trading spill over to the traditional voice trading domain. Such cross-venue effects of electronic trading could arise through its impact on dealer behavior: dealers with more electronic trading in a given bond tend to provide better prices in their voice trading. To examine this, we average the trade level transaction cost estimate across trades in the same bond (i), on the same day (t), in the same size-category (s), and by the same dealer (d), to get a voice trading cost measure at the bond-day-trade size-dealer level ($Cost^{v}_{i,t,s,d}$). Similarly, we calculate $E\text{–}Share_{i,t,s,d}$ as the share of dealer d's volume of its trades in bond i, on day t, with size s, that execute electronically. We then estimate the following empirical model:

$$Cost^{v}_{i,t,s,d} = \alpha + \beta \times E\text{–}Share_{i,t,s,d} + \gamma \times X_{i,t} + \mu_t + \mu_s + \mu_d + \varepsilon_{i,t,s,d}. \quad (3)$$

As in Model (2), $X_{i,t}$ includes bond-level controls, μ_s and μ_t represent trade size fixed effects and day fixed effects, respectively. In addition, we include dealer fixed effects (μ_d) to control for unobservable dealer characteristics that could also affect dealers' transaction cost and electronic trading. Standard errors are two-way clustered at the bond-day and the dealer-day levels. Column (III) shows that our results continue to hold after controlling for dealer identity. A dealer with more electronic trading with certain size in a given bond on a given day tends to offer lower transaction costs in similar voice trades in the same bond and on the same day.

One could argue that the documented relationship between electronic trading and transaction costs in voice trading suffers from selection bias. Dealers executing more trades electronically can also be those trading in the most liquid bonds and, hence, provide lower transaction costs. To address this concern, we replace $X_{i,t}$, μ_t, and μ_s, with bond-day-trade size fixed effects ($\mu_{i,t,s}$). The bond-day-trade size fixed effects allow us to look within the combination of bond, day and trade size, and compare the voice trade costs offered by dealers with different electronic trading. They also allow us to control for both macro-economic factors and potential time varying influence of both bond and trade specific characteristics. Column IV shows that the coefficient on *E-share* changes little and continues to be negative and highly significant. Therefore, among dealers trading the same bond at the same time in the same size category, those with greater electronic trading tend to provide lower voice trading transaction costs.

Another concern is that the interpretation of our results can be complicated if both electronic trading and voice trading costs are driven by some omitted factors. For example, electronic trading can be high on days with little uncertainty, when transaction costs in voice trading venues are also low. We conduct two analyses to address the potential endogeneity concern. First, we follow the literature (e.g., Hasbrouck and Saar (2013), Buti et al. (2011), and Comerton-Forde and Putnins (2015)) and instrument the share of electronic trading in a bond-day-trade size category with the average share of electronic trading in the same trade size category on the same day but in other comparable bonds (*E-Share*^{Others}). Comparable bonds are those with the same credit rating, similar time to maturity and amount outstanding, and the same industry classification.[9] After controlling for time trends, electronic trading in other bonds is unlikely to directly relate to voice trading costs in a particular bond. Meanwhile, electronic trading in the particular bond should be related to that in other bonds. Indeed, in the first-stage of the two-stage least squares (2SLS) regression where we regress *E-Share* on *E-Share*^{Others} and all the control variables as in Model (2), the coefficient on *E-Share*^{Others} is positive and highly significant.[10] We then re-estimate Model (2) by replacing *E-Share* with the instrumented *E-Share* as the second stage regression. Column V shows that greater electronic trading continues to decrease voice trading costs using the instrument variable approach.

Second, we take a difference-in-difference approach and study how a dealer's voice trading costs change after it starts trading electronically. During our sample period, a total of 133 dealers started trading electronically on MarketAxess. For each of these 133 electronic dealers, we first identify the day on which its first electronic trade occurred. We then identify a control dealer that had the closest market share to the electronic dealer but did not start its electronic trading around the electronic dealer's first electronic trading day. The estimates of $Cost_{i,t,s,d}^{v}$ for the group of 133 electronic dealers and their respective control dealers during the six-months around each electronic dealer's first electronic trading day are then used to estimate the following regression:

[9] We classify bonds into four maturity groups using 1-year, 3-year and 10-year as the three cutoffs for time to maturity. Bonds are considered to have similar time to maturity if they belong to the same maturity group. We also use the bottom quartile, the median, and the top quartile in the distribution of total par amount outstanding in our sample to classify bonds into four size groups. Bonds are considered to have similar amount outstanding if they belong to the same size group.

[10] We conduct *F*-tests on the strength of the instrument in the first stage. The Kleibergen-Paap *F* statistic is 11.79, which is above the conventional critical value of 10.

$$Cost^{v}_{i,t,s,d} = \alpha + \beta \times Electronic\ Dealer_d \times Post\ Etrade_t + \mu_t + \mu_i + \mu_d + \varepsilon_{i,t,s,d}, \quad (4)$$

where $Electronic\ Dealer_d$ is a dummy variable for the 133 electronic dealers, and $Post\ Etrade_t$ is a dummy variable for trades occurring after the first electronic trading day. Column VI shows that the coefficient of the interaction of $Electronic\ Dealer_d$ and $Post\ Etrade_t$ is negative and highly significant. Thus, relative to control dealers, voice trading costs decrease for dealers after they start trading electronically. Together, our analyses from instrumenting the share of electronic trading and from studying changes in voice trading costs around dealers' first electronic trading alleviate concerns that omitted variables, such as market uncertainties, drive our findings on the relationship between electronic trading and voice trading costs.

Overall, our results show that greater electronic trading has reduced transaction costs in both electronic and voice venues. Our results hold at the individual dealer level, suggesting that dealer behavior might play an important role in explaining why this occurs. We turn now to studying various aspect of dealer behavior and how they are affected by electronic trading.

4.2. Electronic Trading and Dealer Competition

Electronic trading provides investors with an alternative method to source liquidity, and hence directly increases their bargaining power with dealers. To avoid losing customers to electronic trading platforms, dealers provide more competitive prices, resulting in lower transaction costs in their voice trading. Therefore, electronic trading can reduce voice trading costs by promoting dealer competition.

To capture the degree of competition among dealers in their voice trading, we take advantage of information on dealer identities included in the regulatory TRACE data and compare prices from different dealers in similar trades in the same bond and at the same time. Specifically, we calculate for each dealer, its average prices for certain type of voice trades (i.e., trades in the same trade size category (*s*) with the same trade direction (*B/S*)) in the same bond (*i*) on the same day (*t*)). We then take the difference between the highest and the lowest average voice trade prices among different dealers, and name it $PriceDiff^{v}_{i,t,s,B/S}$. A lower $PriceDiff^{v}_{i,t,s,B/S}$ suggests smaller price differences among dealers in voice trading and hence higher competition.

To study how electronic trading has affected dealer competition, we re-estimate our *E-share* measure at the same bond-day-trade size-trade direction level as $PriceDiff^{v}_{i,t,s,B/S}$. In the sample created from merging $E\text{–}Share_{i,t,s,B/S}$ with $PriceDiff^{v}_{i,t,s,B/S}$, as well as bond-level characteristics, $PriceDiff^{v}_{i,t,s,B/S}$ has a mean of 49 basis points, with the median lower at 16 basis points. Both $E\text{–}Share_{i,t,s,B/S}$ and bond characteristics exhibit similar distribution as in the sample for transaction costs. Price competition for customer buys and customer sells account for 57% and 43% of the sample respectively.

We then estimate the following model:

$$PriceDiff^{v}_{i,t,s,B/S} = \alpha + \beta \times E\text{–}Share_{i,t,s,B/S} + \gamma \times X_{i,t} + \mu_s + \mu_{B/S} + \varepsilon_{i,t,s,B/S}. \quad (5)$$

$X_{i,t}$ includes a set of bond-level controls for bond *i* on day *t* as defined in Model (2). In addition to trade size fixed effects (μ_s), we control for trade direction fixed effects ($\mu_{B/S}$) as the price competition measure is estimated separately for customer buys and customer sells. Standard errors are double clustered at the bond and the day levels.

Table 2 shows that electronic trading increases price competition and lowers price differences across dealers in voice trading. After controlling for bond characteristics and trade types, the coefficient on $E\text{–}Share$ is negative and highly significant (Column I). Our results change little after controlling for time fixed effects (Column II). The -0.634 coefficient on $E\text{–}Share$ implies that a one-standard-deviation increase in $E\text{–}Share$ leads to 16 basis points reduction in $PriceDiff$, which is about 32% of the mean $PriceDiff$ in our sample.

O'Hara, Wang, and Zhou (2018) find that dealers provide better execution quality to more active investors in corporate bond trading. Electronic trading allows traders to source liquidity at multiple dealers at potentially better prices, so it can limit dealers' ability to price discriminate among customers. This suggests that potential competition from other dealers in electronic trading can affect the execution quality a dealer provides in voice trading.

To test this hypothesis, we estimate an execution quality measure in the spirit of O'Hara, Wang, and Zhou (2018). Specifically, we calculate the difference between the highest and lowest trade prices using all voice trades in the same bond (*i*), on the same day (*t*), in the same trade size category (*s*), with the same direction (*B/S*), and by the same dealer (*d*), and name it $PriceDiff^{v}_{i,t,s,B/S,d}$. Given the infrequency of bond trading, the trades used to estimate $PriceDiff^{v}_{i,t,s,B/S,d}$ are likely from different investors. Therefore, although customer identity is not provided in our data, a larger $PriceDiff^{v}_{i,t,s,B/S,d}$ is likely to be indicative of greater price discrimination among clients by the same dealer.

We then re-estimate the *E-share* measure at the same bond-day-trade size-trade direction-dealer level as $PriceDiff^{v}_{i,t,s,B/S,d}$, and estimate the following regression:

$$PriceDiff^{v}_{i,t,s,B/S,d} = \alpha + \beta \times E\text{–}Share_{B/S,i,t,s,d} + \gamma \times X_{i,t} + \mu_t + \mu_s + \mu_{B/S} + \mu_d + \varepsilon_{i,t,s,B/S,d} \quad (6).$$

If, as hypothesized, electronic trading reduces dealers' bargaining power in their voice trading, we would expect a higher $E\text{–}Share$ to be associated with lower $PriceDiff$. Column III of Table 2 shows that this is indeed the case. The coefficient for $E\text{–}Share$ is negative and highly significant. This result is not driven by potential time trends in dealer execution quality as we have controlled for day fixed effects in the model. We also control for potential selection bias and time-varying influence of bond and trade characteristics and macro-economic conditions by replacing $X_{i,t}$, μ_t, μ_s, and $\mu_{B/S}$ with bond-day-trade size-trade direction fixed effects ($\mu_{i,t,s,B/S}$). Column IV shows that the results are qualitatively the same. Amongst dealers executing similar trades (i.e., with similar size and same trade direction) in the same bond and at the same time, those with greater electronic trading tend to provide better execution quality to their customers in voice trading.

4.3. Electronic Trading and Search Costs

The large number of bond issues, combined with typically large order sizes, means that inventory issues are always front and center for bond dealers. Dealers traditionally turned to the inter-dealer market, using dealer-to-dealer trading to offset unwanted inventory imbalances arising from dealer-to-customer trades. The more dealers involved between a customer and the natural counterparty for a trade, the higher markups to be reflected in the price and hence the higher the transaction cost for the customer. Because electronic trading facilitates matching between buyers and sellers, it can reduce the search costs of finding the natural counterparty, in effect shortening the intermediation chain of dealers. This, in turn, may contribute to better prices and hence lower transaction costs by providing dealers greater inventory control. We hypothesize that the search cost channel of electronic trading can reduce dealers' reliance on inter-dealer market for their inventory management.

To test this hypothesis, we estimate the share of inter-dealer trade out of total trade ($InterDealerShare_{i,t,s}$). For trades with similar size *s*, executed in the same bond *i* and on the same trading day *t*, we calculate the aggregate volumes for those between a dealer and a customer, and those between two dealers. $InterDealerShare_{i,t,s}$ is defined as the ratio of inter-dealer volume and total trade volume (the sum of inter-dealer volume and dealer-customer volume). We then match $InterDealerShare_{i,t,s}$ with $E\text{–}Share_{i,t,s}$ estimated at the same bond-day-trade size level and estimate the following model:

$$InterDealerShare_{i,t,s} = \alpha + \beta \times E\text{–}Share_{i,t,s} + \gamma \times X_{i,t} + \mu_s + \varepsilon_{i,t,s}. \quad (7)$$

The results in Table 3 strongly support our hypothesis: the greater the share of electronic trading in a given bond, the lower is the share of inter-dealer trading in that bond (Column I). The effect of electronic trading is also economically meaningful, with a one-standard-deviation increase in $E\text{–}Share$ being associated with a reduction in $InterDealerShare$ equivalent to about 30% of its mean value. Particularly important is that these results are robust to the inclusion of time fixed effects, which might be expected to play a role given the decline in inter-dealer trading from 42% to 28% of total volume over our sample period (see Figure 6).

The finding that greater electronic trading leads to less inter-dealer trading is also present when we examine individual dealers. Specifically, we re-estimate both $InterDealerShare$ and $E\text{–}Share$ at bond-day-trade size-dealer level, and estimate the following model:

$$InterDealerShare_{i,t,s,d} = \alpha + \beta \times E\text{–}Share_{i,t,s,d} + \gamma \times X_{i,t} + \mu_t + \mu_s + \mu_d + \varepsilon_{i,t,s,d}. \quad (8)$$

Column III shows that $E\text{–}Share$ remains negative and highly significant. A dealer with more of its trades to customers executed electronically in a given bond on a given day relies less on inter-dealer trading in the same bond on the same day. Our results are again robust to controlling for bond-day-trade size and dealer fixed effects (Column IV). Together, these findings underscore a perhaps unanticipated benefit to electronic trading – the ability to reduce dealer risk.

Electronic trading can also help dealers manage inventory risks by facilitating the arrangement of Riskless Principal Trades (RPT), where dealers execute a trade only after they locate both sides of the trade. One major change in corporate bond dealers' business model after the financial crisis is a greater switch from market making (with its concomitant capital commitment) to match making whereby trades are executed on an agency basis.[11] We identify Riskless Principal Trades as two offsetting trades in the same bond by the same dealer with the same trade size that occur within one minute. The data show that 39% of RPTs in voice trading are offset by electronic trades. This suggests another avenue for electronic trading to reduce voice trading costs by facilitating the arrangement of RPTs, which tend to offer lower transaction costs as dealers do not take inventory risks in these trades.

To test this hypothesis, we re-estimate Model (7) by replacing $InterDealerShare_{i,t,s}$ with $RPTShare^{v}_{i,t,s}$, which is defined as the share of RPT volume out of total voice trade volume. Table 4 shows the coefficient of $E\text{–}Share$ is positive and highly significant, meaning that more voice trades are executed on an agency basis when there is greater electronic trading. This finding is also evident at the bond-dealer level and it is robust to controlling for bond-day-trade size and dealer fixed effects. As RPTs are executed only after dealers locate both sides, our results also suggest that electronic trading can improve the speed of execution, a benefit that is difficult to measure.

4.4. Electronic Trading and Information

A challenge facing every bond dealer is knowing the price to quote for a bond. As is well documented in the microstructure literature, dealers can learn from their own order flow, extracting

[11] See for example, Bao, O'Hara and Wang (2018), Bessembinder et al. (2018), Schultz (2017), and Saar et al. (2019).

information about potential supply and demand for a bond. Dealers (and market participants) can also learn about prices by watching the market, specifically, in the case of bonds, the TRACE consolidated tape. Electronic trading through RFQ provides two new potential sources of information for dealers. First, the ability to see electronic trade prices provides an immediate source of new information to the dealer. Second, and perhaps even more important, dealers can learn about a broader range of trading interest via being contracted for a request for quote. Thus, even if the dealer is not chosen to execute the trade, he or she can learn both that someone wanted to buy or sell the bond, and that the price they quoted was not competitive.

Both effects suggest that electronic trading provides information, allowing dealers who trade more electronically to offer better prices to their voice and electronic customers.[12] If this is the case, we would expect to see stronger effects in high-yield bonds given that they are more information sensitive. We divided our sample into investment-grade and high-yield subsamples based on the rating of bond *i* on day *t*. We then estimate Model (2) on each of the subsamples, with results presented in Columns I and II in Table 5.

The coefficient on *E-share* is negative and highly significant for both subsamples, but it is substantially higher for high-yield bonds than for investment-grade bonds. The stronger effects in high-yield bonds are also observed when we control for dealer identities (Columns III and IV). Therefore, although electronic trading has had limited growth in high-yield bonds, when it occurs, it has had a large impact on transaction costs in voice trading. These findings are consistent with electronic trading benefitting the market by increasing the information available to dealers and potentially to customers.

[12] Our previous analysis on how a dealer's voice trading costs change after it starts trading electronically also suggests that better information, in addition to greater competition, can contribute to lower voice costs as dealer competition does not change much during the short time window.

Together, our results highlight that even trades on traditional voice trading venues benefit from the growth of electronic trading. Underlying this benefit is the multi-faceted roles played by competition, search costs, and information. Electronic platforms allow customers to find dealers and allow dealers to find customers. The lower search costs, in turn, make the market more competitive for customers and less risky for dealers. Electronic trading also provides more information, allowing dealers to set, and customers to get, better prices. The end result is an improvement in market quality. Given these benefits, the muted growth in electronic trading to date is surprising. In the next section we investigate what factors may be limiting the electronic evolution of bond trading.

5. The Limits of Electronic Trading

As noted in the introduction, bond market microstructure has a variety of unique features including the prominent role of dealers and the dominance of institutional investors. In this section, we consider whether these features can explain the limited growth of electronic trading. We focus on three specific areas. First, we look at market structure, with a particular focus on whether electronic RFQ trading has elicited new entrants into bond trading. If this is the case, it suggests that the increased competitiveness in markets is due not just to greater within-market competition but to the addition of new dealers as well. Second, we investigate how electronic trading shapes liquidity provisions in large trades, which might be expected to suffer from dealers' reduced balanced sheet capacity caused by post-crisis regulations. Our focus here is on whether the benefits of electronic trading are shared equally across all trading clienteles. A third area of enquiry is whether the benefits of electronic trading observed in normal times prevail around stress events. We concentrate here on liquidity after downgrades, events that are particularly important to institutional investors.

5.1 Market structure effects of electronic trading

One potential opportunity that electronic bond trading brings is to allow smaller dealers to acquire new clients via more aggressive pricing on the electronic platform. Based on Greenwich Associates' interviews with 13 of the top 20 largest U.S. corporate bond dealers and 112 U.S.-based corporate bond investors, Kevin McPartland (2015) concludes that execution quality is the most important factor for investors in selecting which dealer to trade with, and that "dealers understandably want recognition for great execution."[13]

We examine whether electronic trading provides an opportunity for some dealers, especially the smaller ones, to increase their market share.[14] We first identify the top 10 dealers with the largest total customer trade volume over the sample period 2010-2017, and name them Dealer A, B, …, J. These 10 dealers together account for about 70% of the aggregate dealer-to-customer trade volume. For each dealer, we determine its ranking in terms of market share in both voice trading and electronic trading for each year in our sample. In other markets where electronic trading has emerged, new entrants capture market share from incumbents. We hypothesize that a similar effect should occur with the rise of electronic bond trading.

Our analysis shows that this is not the case. Electronic trading is dominated by the same dealers that intermediate most traditional voice trading. Six out of the ten dealers rank among the top ten dealers in both voice trading and electronic trading for each year in our sample. The other four dealers rank among the top ten dealers for about 90% of the times in voice trading, and for over 50% of the times in electronic trading. Since the exact ranking of a dealer can change slightly

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[13] See "U.S. Corporate Bonds: Investors Need Dealers, Dealers Need Incentives," a research report authored by Kevin McPartland, Head of Research for Market Structure and Technology at Greenwich Associates, and released on July 13, 2015.

[14] In addition to technology, post-crisis regulations may also increase the relative competitiveness of smaller dealers, as most of the large bond dealers are also bank dealers and hence they are subject to various banking regulations.

over time, we lower the cutoff and consider a dealer as a top dealer (in either voice trading or electronic trading) for a given year if it is ranked among the top 15 dealers in that year. We find that nine of the ten largest bond dealers rank in the top 15 dealers in both voice trading and electronic trading for each year in our sample. Thus, our results suggest that the opportunity provided by electronic trading to increase the competitiveness of smaller dealers, if any, has been minimal.

Further reinforcing this effect, Figure 7 shows that corporate bond trading has increasingly concentrated in a smaller number of dealers. A total of 775 dealers intermediated voice trades in 2010, and that number drops to 569 in 2017 (Panel A). The market share of the top 10 dealers with the largest voice trade volume in both investment-grade and high-yield bonds increases over our sample period (Panel B). A similar pattern is observed when we examine the Herfindahl index in dealers' voice trading, calculated as the summation of the squared market share of each dealer.

Even within the electronic trading realm, there is little sign of improvement in the competitiveness of small dealers. Although the number of dealers intermediating electronic trading in investment-grade bonds increases from 56 in 2010 to 67 in 2017, market concentration has not declined. Both the market share of the top 10 dealers with the largest trade volume and the Herfindahl index in dealer trading are relatively stable, and the metrics end our sample period slightly higher than at the beginning of the sample. In sum, smaller dealers do not seem to benefit much from the development of electronic trading.

We conjecture that this result reflects features specific to the RFQ process. As noted earlier, the RFQ requires the customer to specify the dealers to be contacted, and these dealers are those with whom the customer already has established trading relationships. Such a framework reflects the bi-lateral nature of OTC markets in which default (or settlement) risks are minimized by having such direct relationships. But this process also limits the ability of other dealers, or for that matter, other customers to participate in potential trades. A developing alternative electronic framework, termed All-To-All trading, allows broader participation, so it remains to be seen if the growth of such alternative electronic bond trading mechanisms fosters new entrants into corporate bond trading.

5.2 Size effects

Given that the growth in electronic trading is predominantly evident in smaller sized trades, an interesting question is how the effects of electronic trading on voice trading costs differ with trade sizes. To address this question, we divide our sample into four sub-samples: Retail, Odd-lot, Round-lot, and Block, and study the role of trade size in determining the benefits of electronic trading. We re-estimate Model (3) without size fixed effects (μ_s) for each of the four sub-samples, and the results are presented in Panel A of Table 6. The coefficient on *E-Share* is negative and highly significant across all trade size categories, suggesting that electronic trading has had a pervasive effect on bond trading costs. The coefficients are substantially larger, however, for retail and odd-lot trades, consistent with these effects being stronger in the smaller sized trades. We also note that the R^2 of the regressions is much smaller for the larger trade sizes, consistent with electronic trading having a greater effect on voice trading costs in smaller sized transactions.

The finding that voice trading costs for larger trades are less affected by electronic trading may also be due to the inherent limitation of the RFQ trading mechanism. During the RFQ process, a trader reveals his trading intentions to many potential counterparties, which can lead to costly information leakage. For some large trades, such cost can outweigh the benefits from greater competition, lower search costs and more informative prices. To study this, we reexamine the effects of electronic trading on dealer behavior for trades in each of the four size categories.

First, we revisit the effects of electronic trading on dealer competitiveness. We now estimate Model (5) without size fixed effects (μ_s) for each of the four trade size sub-samples. Although higher electronic trading leads to greater dealer competition in all trade size categories, the effects of electronic trading on dealer competition in voice trading is more pronounced in smaller sized trades (Panel B). This finding suggests that competition from electronic trading platforms has lower effects on price negotiations for larger trades in voice trading.

Second, we test the role of trade size in determining the effects of electronic trading on dealers' risk sharing in the inter-dealer markets. Larger trades impose greater inventory exposure on the dealer and these trades are not typically done in electronic venues, suggesting that the influence of electronic trading on the share of inter-dealer trading might be limited for large trades. We re-estimate Model (8) without size fixed effects (μ_s) separately for the four trade size categories with results reported in Panel C. Although we find statistically significant results that a greater share of electronic trading reduces the share of inter-dealer trading in all trade sizes, the coefficients on *E-Share* indicate that the effect is much stronger in smaller sized trades. This finding suggests that inter-dealer trading still plays an important role in off-loading inventories caused by large trades.

Lastly, we study how the role of trade size in determining the effects of electronic trading on voice trading costs differs between investment-grade and high-yield bonds. Consistent with information leakage being more costly for large trades in more information-sensitive securities, the effects of electronic trading on voice trading costs for large trades, especially blocks, are substantially smaller than for small trades in high-yield bonds (Panel E). For investment-grade bonds, the role of trade size is much weaker. Although electronic trading has the strongest effects in odd-lots where about 50% of the trades execute electronically, its effects in blocks and round-lots are not significantly lower than in the retail trades (Panel D).

These results support the view that potential information leakage in the RFQ process can limit the benefits of electronic trading. Given that large trades remain the norm in corporate bond trading, almost all block trades execute in the voice market, and large trades are not shredded into small trades, it appears that the benefits of electronic trading have not, to date, been large enough for many institutional traders.

5.3 Stress periods

Our results so far rely on the full sample of trading days. It is not clear whether investors still benefit from electronic trading when they have an unusual demand for immediacy. Ambrose, Cai, and Helwege (2008), and Ellul, Jotikasthira, and Lundblad (2011) document fire sales by insurance firms in corporate bonds that are downgraded from investment-grade to high-yield. These fire sales, which are due to insurance companies facing higher capital requirements and other regulatory constraints on downgraded bonds, generate high demand for liquidity, and so provide an opportunity for us to study the robustness of liquidity provided through electronic trading.

For our sample period from 2010 to 2017, we obtain data on each corporate bond's rating history from the Mergent Fixed Income Securities Database (FISD). These data provide the timing of all rating actions by the three largest rating agencies: Standard & Poor's (S&P), Moody's and Fitch. Following Ellul, Jotikasthira and Lundblad (2011), we use the date when a bond is downgraded from investment-grade to high-yield by the first acting rating agency to identify a period with potential high demand for liquidity. Out of our sample bonds, 509 experience a rating downgrade to junk during the sample period.

Bao, O'Hara and Zhou (2018) show that trade volume spikes right after downgrade by the first acting rating agency, and it remains elevated for roughly a month. We therefore focus on studying trading during the one-month window following each rating downgrade. We consider the rating downgrade date as day +1, and define the period from day +1 to day +30 as the *Downgrade* period. To understand how liquidity provided through electronic trading changes following stress events, we also study the periods when demand for liquidity is likely to be at normal levels. We start by comparing the *Downgrade* period with a *pre-Downgrade* period, defined as a period that ends three months prior to the rating action ([-180, -90]). As rating actions tend to lag changes in issuers' default risk, informative trading can occur even prior to the actual downgrade (e.g., Pinches and Singleton (1978)). Such trading can potentially increase the demand for liquidity, so we exclude the three-months right before each rating downgrade to focus on a period when liquidity conditions for the bond is likely to be normal.

Panel A of Table 7 shows that electronic trading declines during periods with high demand for immediacy. Compared to the *pre-Downgrade* period, trading that occurs electronically is lower during the *Downgrade* period. The share of electronic trades out of total dealer to customer trades declines by 34% in terms of total number of trades, a statistically significant effect. The drop in terms of total trade volume is slightly smaller, but is still over 31% and is highly significant.

A potential concern on using *pre-Downgrade* period as a benchmark is that the same downgraded bond carries different ratings between the *pre-Downgrade* and the *Downgrade* periods. The documented drop in electronic trading therefore can simply reflect limited electronic trading in high-yield bonds. To mitigate this concern, we develop two alternative approaches to design the benchmark. First, we compare the *Downgrade* period with a *post-Downgrade* period, which starts three months after the rating downgrade (i.e., [+90, +120]). We exclude the three months after rating downgrades as selling pressure caused by the rating action can last several months (Elluel, Jotikasthira and Lundblad (2011)). Panel B shows that electronic trading rebounds when we move from the *Downgrade* period to the *post-Downgrade* period. The share of electronic trades out of total dealer to customer trades increases by 24% and 17% in terms of volume and number of trades respectively. This finding alleviates the concern that the decreased electronic trading during the *Downgrade* period is simply capturing the differential growth of electronic trading in investment-grade and high-yield bonds.

To control for the pattern of electronic trading across different credit ratings, we compare each downgraded bond with a control group of similar bonds during the same *Downgrade* period for the downgraded bond. We include a bond in the control group if it has the same credit rating, similar time to maturity, issued in the same industry, and similar par amount outstanding as the downgrade bond.[15] For bonds within each control group, we calculate the average share of electronic trading out of total dealer to customer trade, and then compare it with the downgraded bond. Using this approach, we are able to identify control bonds for a total of 498 downgraded bonds. Panel C shows that even compared to control bonds, electronic trading in downgraded bonds are substantially lower. The share of electronic trading in downgraded bonds is about 39% lower in volume, and about 22% lower in number of trades than that in control bonds.

The weakening advantages of electronic trading during stress time is also evident in transaction costs. During both the pre-Downgrade and the post-Downgrade periods, electronic

[15] We use 5-year and 10-year as the two cutoffs to define short-term, medium-term, and long-term bonds. A bond is considered to have similar time to maturity as the downgraded bond if both of them belong to the same maturity group. To be included into the control group, a bond's total amount outstanding cannot exceed that of the downgraded bond by 20%.

trades tend to have lower transaction costs than voice trades, despite being smaller in size (and smaller trades in corporate bond are more expensive to trade (see Table 8)). However, such advantages disappear during the Downgrade period, with electronic trading costs rising higher than voice trading costs. Together, these results suggest that when the demand for immediacy increases from some institutional investors, sourcing liquidity on electronic trading platforms can be challenging.

To understand how electronic trading affects voice trade costs during stress times, we estimate the following regression for the downgrade bonds during the *Downgrade* period:

$$Cost^{v}_{i,t,s,d} = \alpha + \beta \times E\text{–}Share_{i,t,s,d} + \mu_{i,t,s} + \mu_{d} + \varepsilon_{i,t,s,d}, \quad (9)$$

where both $Cost^{v}_{i,t,s,d}$ and $E\text{–}Share_{i,t,s,d}$ are as defined in Model (3). The model is estimated with both bond-day-trade size fixed effects and dealer fixed effects and standard errors are double clustered at the bond-day and the dealer-deal levels.

Column I of Table 9 shows that the benefits of electronic trading in reducing voice transaction costs for customers disappear around stress times. The coefficient for *E-Share* is not significant at any conventional level.[16] Interestingly, when we re-estimate Model (9) for the bonds in both *pre-Downgrade* and *post-Downgrade* periods, as well as bonds in the control group at the same *Downgrade* period, the coefficient for *E-Share* is negative and highly significant (see Columns II-IV). Thus, the benefits to electronic RFQ trading are not robust to stress periods of decreased liquidity. In such market conditions, orders gravitate to less transparent voice trading– a movement consistent with traders relying more on dealer relationships rather than on electronic

[16] The benefits of electronic trading disappeared in both customer buys and customer sells. We split our sample trades into customer buys and customer sells. We then re-calculate $Cost_{i,t,s,d}$ and $E\text{–}Share_{i,t,s,d}$ and estimate Model (9) for each subsample. The coefficient of β is not significant in either subsample.

transactional trading to source liquidity. When everyone is trying to find liquidity on the same side of the market, the optional (and transparent) nature of RFQ trading is not well-suited for the needs of large institutional orders.

These market structure, size effects, and stress period results provide compelling reasons why electronic trading has not yet attained the dominance found in other asset classes. Empirical evidence also points to another, perhaps more fundamental limitation - the risks of informed trading. Electronic trading is primarily concentrated in small orders sizes in investment-grade bonds during normal market trading conditions. This pattern is consistent with a lower risk of informed trading. Because dealers take on inventory risks, their willingness to transact in electronic venues is much lower when this informed trading risk is perceived to be high. Such informed trading risk may explain why high-yield bonds (whose price behavior is often viewed as more "equity-like"), very large trades, or trades in unbalanced markets have found limited success in electronic bond trading.

6. **Conclusion**

Technology has brought greater efficiency and competition to trading, and corporate bond markets are no exception. We show in this paper that electronic bond trading lowered transaction costs, reduced execution quality differences, enhanced dealers' ability to bear inventory risk, and diminished the inter-dealer trading market. These effects arise from channels relating to competition, search costs, and information. What is also clear is that bond markets are different from other asset classes, and these differences have impeded the dominance of electronic trading so typical of other markets. Market structure, size effects, and stress periods all point to very real limitations on the growth of electronic trading.

Dealers continue to play a crucial role in corporate bond trading, with electronic trading as currently designed so far serving to support rather than supplant this market structure. This may change going forward with the advent of new trading platforms such as all-to-all trading which could allow new entrants to gain a foothold in customer-to-customer trading. We conjecture, however, that the impediments identified in this research will continue to play a role in these electronic venues, suggesting that bonds may prove different than other asset classes when it comes to electronic trading. We hope to investigate these issues in future research.

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Table 1. Electronic trading and transaction cost for voice trades

Columns I, II and V, the dependent variable is $Cost_{i,t,s}^{v}$, which is the average transaction costs for voice trades in bond *i*, on trading day *t*, and within size category *s*. For Columns III, IV and VI, the dependent variable is $Cost_{i,t,s,d}^{v}$, which is the average transaction costs for voice trades in bond *i*, on trading day *t*, within size category *s*, and with dealer *d*. *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same frequency as the dependent variable. *Electronic Dealer* is a dummy for dealers that started electronic trading during our sample period. *Post Etrade* is a dummy for trades occurred after the first electronic trading day. Controls include the log of the total par amount outstanding (*Log(Amount Out)*), the residual time to maturity of the bond (*Time to Maturity*), three industry dummies representing three broad industry groups (industrial, financial, and utility), and a set of dummy variables for the 21 credit ratings, trade size fixed effects, day fixed effects, dealer fixed effects, and bond-day-size fixed effects. In Columns I, II and V, standard errors are double clustered at the bond and the day levels. In Columns III, IV and VI, standard errors are double clustered at the bond-day and the dealer-day levels.

	I	II	III	IV	V	VI
	Baseline Results	**Controlling for Time Fixed Effects**	**Bond-Dealer Level Evidence**	**Matched Sample**	**2SLS**	**Diff-in-Diff**
E-Share	-14.634***	-12.343***	-18.938***	-17.499***	-44.414***	
	(-36.55)	(-32.94)	(-3.58)	(-4.18)	(-11.67)	
Electronic Dealer*Post Etrade						-1.759**
						(-1.93)
Log(Amount out)	-4.039***	-3.830***	-2.906***		-2.620***	-2.605*
	(-28.81)	(-26.74)	(-3.88)		(-13.86)	(-1.79)
Time to Maturity	1.982***	1.978***	1.802***		1.954***	2.124***
	(-35.76)	(-35.32)	(-7.88)		(-34.88)	(-7.67)
Credit Rating FE	Yes	Yes	Yes	No	Yes	Yes
Industry FE	Yes	Yes	Yes	No	Yes	Yes
Size FE	Yes	Yes	Yes	No	Yes	Yes
Day FE	No	Yes	Yes	No	Yes	Yes
Dealer FE	No	No	Yes	Yes	No	Yes
Bond-Day-Size FE	No	No	No	Yes	No	No
Observations	8,067,056	8,067,056	14,774,258	9,726,101	8,067,056	659,706
R^2	0.15	0.15	0.31	0.6	0.05	0.27

Table 2. Electronic trading and dealer competition in voice trading

For Columns I and II, the dependent variable is $PriceDiff^{v}_{i,t,s,B/S}$, which is the difference between the highest and the lowest average prices across dealers for voice trades in the same bond *i*, on the same trading day *t*, within the same size category *s*, and with the same trade direction (i.e., whether the investor is buying (B) or selling (S) from the dealer). For Columns III and IV, the dependent variable is $PriceDiff^{v}_{i,t,s,B/S,d}$, which is the difference between the highest price and the lowest price across trades executed in the same bond *i*, on the same trading day *t*, within the same size category *s*, with the same trade direction (i.e., whether the investor is buying (B) or selling (S)), and with the same dealer *d*. *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same frequency as the dependent variable. Controls include the log of the total par amount outstanding (*Log(Amount Out)*), the residual time to maturity of the bond (*Time to Maturity*), three industry dummies representing three broad industry groups (industrial, financial, and utility), and a set of dummy variables for the 21 credit ratings, trade size fixed effects, day fixed effects, dealer fixed effects, trade direction fixed effects, and bond-day-size-trade direction fixed effects. Columns I provides results from using the full sample, while Columns II and III show results for the sub-samples of investment-grade and high-yield bonds respectively. In Columns I and II, standard errors are double clustered at the bond and the day levels. In Columns III and IV, standard errors are double clustered at the bond-day and the dealer-day levels.

	I	**II**	**III**	**IV**
	Dealer Competition	**Dealer Competition with Time Fixed Effects**	**Execution Quality**	**Execution Quality: Matched Sample**
E-Share	-0.655***	-0.634***	-0.227***	-0.192***
	(-106.02)	(-104.53)	(-12.21)	(-9.60)
Log(Amount out)	0.078***	0.081***	0.022***	
	(31.30)	(31.89)	(4.25)	
Time to Maturity	0.008***	0.008***	0.004***	
	(13.33)	(12.95)	(4.47)	
Credit Rating FE	Yes	Yes	Yes	No
Industry FE	Yes	Yes	Yes	No
Size FE	Yes	Yes	Yes	No
Direction FE	Yes	Yes	Yes	No
Day FE	No	Yes	Yes	No
Dealer FE	No	No	Yes	Yes
Bond-Day-Size-Direction FE	No	No	No	Yes
Observations	4,934,180	4,934,180	2,810,900	981,575
R^2	0.18	0.18	0.12	0.47

Table 3. Electronic trading and inter-dealer trading

For Columns I and II, the dependent variable is $InderDealerShare_{i,t,s}$, which is the share of inter-dealer trade volume out of total trade volume (the sum of inter-dealer volume and dealer-customer volume), calculated at the bond-day-trade size level. For Columns III and IV, the dependent variable is $InderDealerShare_{i,t,s,d}$, which is the share of inter-dealer trade volume out of total trade volume (the sum of inter-dealer volume and dealer-customer volume), calculated at the bond-day-trade size-dealer level. *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same frequency as the dependent variable. Controls include the log of the total par amount outstanding (*Log(Amount Out)*), the residual time to maturity of the bond (*Time to Maturity*), three industry dummies representing three broad industry groups (industrial, financial, and utility), and a set of dummy variables for the 21 credit ratings, trade size fixed effects, day fixed effects, dealer fixed effects, and bond-day-size fixed effects. In Columns I and II, standard errors are double clustered at the bond and the day levels. In Columns III and IV, standard errors are double clustered at the bond-day and the dealer-day levels.

	I	II	III	IV
	Bond Level Evidence	**Bond Level Evidence: Controlling for Time Fixed Effects**	**Bond-Dealer Level Evidence**	**Bond-Dealer Level Evidence: Matched Sample**
E-Share	-0.241***	-0.242***	-0.061***	-0.058***
	(-185.75)	(-191.66)	(-3.87)	(-4.68)
Log(Amount Out)	0.019***	0.019***	0.010***	
	(37.63)	(36.26)	(4.16)	
Time to Maturity	-0.002***	-0.002***	-0.000**	
	(-15.61)	(-15.52)	(-2.43)	
Credit Rating FE	Yes	Yes	Yes	No
Industry FE	Yes	Yes	Yes	No
Size FE	Yes	Yes	Yes	No
Day FE	No	Yes	Yes	No
Dealer FE	No	No	Yes	Yes
Bond-Day-Size FE	No	No	No	Yes
Observations	12,955,236	12,955,236	22,779,777	14,444,377
R^2	0.26	0.26	0.38	0.58

Table 4: Electronic trading and riskless principal trades

For Columns I and II, the dependent variable is $RPTShare^{v}_{i,t,s}$, which is the share of RPT trade volume out of total voice trade volume, calculated at the bond-day-trade size level. For Columns III and IV, the dependent variable is $RPTShare^{v}_{i,t,s,d}$, which is the share of riskless principal trade (RPT) volume out of total voice trade volume, calculated at the bond-day-trade size-dealer level. *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same frequency as the dependent variable. Controls include the log of the total par amount outstanding (*Log(Amount Out)*), the residual time to maturity of the bond (*Time to Maturity*), three industry dummies representing three broad industry groups (industrial, financial, and utility), and a set of dummy variables for the 21 credit ratings, trade size fixed effects, day fixed effects, dealer fixed effects, and bond-day-size fixed effects. In Columns I and II, standard errors are double clustered at the bond and the day levels. In Columns III and IV, standard errors are double clustered at the bond-day and the dealer-day levels.

	I	**II**	**III**	**IV**
	Bond Level Evidence	**Bond Level Evidence: Controlling for Time Fixed Effects**	**Bond-Dealer Level Evidence**	**Bond-Dealer Level Evidence: Matched Sample**
E-Share	0.149***	0.138***	0.234***	0.138***
	(52.11)	(51.25)	(50.77)	(43.84)
Log(Amount Out)	-0.007***	-0.009***	0.002***	
	(-14.35)	(-17.32)	(11.70)	
Time to Maturity	-0.002***	-0.002***	-0.001***	
	(-15.72)	(-15.35)	(-27.75)	
Credit Rating FE	Yes	Yes	Yes	No
Industry FE	Yes	Yes	Yes	No
Size FE	Yes	Yes	Yes	No
Day FE	No	Yes	Yes	No
Dealer FE	No	No	Yes	Yes
Bond-Day-Size FE	No	No	No	Yes
Observations	10,484,065	10,484,065	17,777,860	10,743,569
R^2	0.12	0.12	0.5	0.65

Table 5. Electronic trading and transaction cost for voice trades: investment-grade vs. high-yield

This table reports results from estimating alternative specifications of Model (2) separately for investment-grade and high-yield bonds. For Columns I and II, the dependent variable is $Cost^{v}_{i,t,s}$, which is the average transaction costs for voice trades in bond *i*, on trading day *t*, and within size category *s*. For Columns III and IV, the dependent variable is $Cost^{v}_{i,t,s,d}$, which is the average transaction costs for voice trades in bond *i*, on trading day *t*, within size category *s*, and with dealer *d*. *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same frequency as the dependent variable. Controls include the log of the total par amount outstanding (*Log(Amount Out)*), the residual time to maturity of the bond (*Time to Maturity*), three industry dummies representing three broad industry groups (industrial, financial, and utility), and a set of dummy variables for the 21 credit ratings, trade size fixed effects, day fixed effects, dealer fixed effects, and bond-day-size fixed effects. In Columns I and II, standard errors are double clustered at the bond and the day levels. In Columns III and IV, standard errors are double clustered at the bond-day and the dealer-day levels.

	I	II	III	IV
	Bond Level Evidence: Investment-grade	**Bond Level Evidence: High-yield**	**Bond-Dealer Level Evidence: Investment-grade**	**Bond-Dealer Level Evidence: High-yield**
E-Share	-10.918***	-17.525***	-13.347***	-29.356***
	(-27.26)	(-19.49)	(-4.12)	(-4.35)
Log(Amount out)	-4.355***	-2.715***		
	(-28.66)	(-7.89)		
Time to Maturity	2.002***	1.867***		
	-37.45	-12.47		
Credit Rating FE	Yes	Yes	No	No
Industry FE	Yes	Yes	No	No
Size FE	Yes	Yes	No	No
Day FE	Yes	Yes	No	No
Dealer FE	No	No	Yes	Yes
Bond-Day-Size FE	No	No	Yes	Yes
Observations	5,831,213	2,235,843	6,906,160	2,819,941
R^2	0.20	0.11	0.65	0.56

Table 6. The effects of electronic trading across trade size categories

This table reports how the effects of electronic trading vary across trade size groups. In Panels A, D and E, the dependent variable is the bond-day-trade size-dealer level transaction cost measure ($Cost^{v}_{i,t,s,d}$). Panel A reports the full sample results, and Panels D and E report the results from subsamples of investment-grade and high-yield bonds respectively. In Panel B, the dependent variable is the measure of price difference across dealers for voice trading, estimated at bond-day-trade size-trade direction level ($PriceDiff^{v}_{i,t,s,B/S}$). In Panel E, the dependent variable is the share of inter-dealer trading measured at the bond-dealer-trade size-day level ($InterDealerShare_{i,t,s,d}$).

Panel A: Transaction Costs

	I **Retail**	II **Odd-lot**	III **Round-lot**	IV **Block**
E-Share	-9.767***	-8.837***	-7.022***	-6.628***
	(-2.65)	(-5.80)	(-5.42)	(-3.43)
Dealer FE	Yes	Yes	Yes	Yes
Bond-Day-Size FE	Yes	Yes	Yes	Yes
Observations	7,779,149	942,231	866,193	138,528
R^2	0.61	0.55	0.41	0.48

Panel B: Dealer Competition

	I **Retail**	II **Odd-lot**	III **Round-lot**	IV **Block**
E-Share	-0.697***	-0.462***	-0.353***	-0.209***
	(-99.15)	(-80.86)	(-54.55)	(-32.36)
Controls	Yes	Yes	Yes	Yes
Trade Direction FE	Yes	Yes	Yes	Yes
Day FE	Yes	Yes	Yes	Yes
Observations	3,491,958	722,497	615,684	104,041
R^2	0.13	0.14	0.1	0.14

Panel C: Inter-dealer Trading

	I **Retail**	II **Odd-lot**	III **Round-lot**	IV **Block**
E-Share	-0.057***	-0.046***	-0.029***	-0.021***
	(-3.86)	(-4.99)	(-5.66)	(-7.36)
Dealer FE	Yes	Yes	Yes	Yes
Bond-Day-Size FE	Yes	Yes	Yes	Yes
Observations	10,563,258	2,323,578	1,381,168	176,373
R^2	0.53	0.65	0.63	0.73

Panel D: Transaction Cost in Investment-grade Bonds

	I **Retail**	II **Odd-lot**	III **Round-lot**	IV **Block**
E-Share	-6.740**	-9.173***	-6.334***	-6.109***
	(-2.44)	(-6.46)	(-4.73)	(-3.27)
Dealer FE	Yes	Yes	Yes	Yes
Bond-Day-Size FE	Yes	Yes	Yes	Yes
Observations	5,686,167	656,554	450,573	112,866
R^2	0.64	0.61	0.44	0.49

Panel E: Transaction Cost in High-yield Bonds

	I **Retail**	II **Odd-lot**	III **Round-lot**	IV **Block**
E-Share	-21.456***	-17.434***	-16.344***	-10.056
	(-2.85)	(-5.47)	(-6.11)	(-0.96)
Dealer FE	Yes	Yes	Yes	Yes
Bond-Day-Size FE	Yes	Yes	Yes	Yes
Observations	2,092,982	285,677	415,620	25,662
R^2	0.56	0.52	0.4	0.48

Table 7. Electronic trading around rating downgrades from investment-grade to high-yield

This table studies electronic trading during the one-month after a bond is downgraded from investment-grade to high-yield. Day +1 is the day when rating action happens. Panel A compares electronic trading during the one-month post downgrade period ([+1, +30]) with that in the same bond during a three-month period before rating downgrade ([-180, -90]). Panel B compares electronic trading during the one-month post downgrade period ([+1, +30]) with that in the same bond during a three-month period after rating downgrade ([+90, +180]). Panel C compares electronic trading during the one-month post downgrade period ([+1, +30]) in a downgraded bond with that in a control group of bonds during the same time period. For each downgraded bonds, we identify a control group of bonds that have the same credit rating, similar time to maturity, same industry classification, and similar par amount outstanding as the downgraded bonds. *N* refers to the number of matched bonds. *E-share in volume* (*E-share in number of trades*) refers to the percentage of dealer to customer trade volume (number of trades) that occurs on MarketAxess.

Panel A. Comparing with e-trading in the same bonds before rating downgrade

				Test on Difference	
	N	Downgraded Bonds over [+1,+30]	Downgraded Bonds over [-180,-90]	Difference	p-value
E-share in volume (%)	490	7.92	11.52	-3.60	0.00
E-share in number of trades (%)	490	8.68	13.17	-4.49	0.00

Panel B. Comparing with e-trading in the same bonds after rating downgrade

				Test on Difference	
	N	Downgraded Bonds over [+1,+30]	Downgraded Bonds over [+90,+180]	Difference	p-value
E-share in volume (%)	474	7.34	9.11	-1.77	0.03
E-share in number of trades (%)	474	8.66	10.10	-1.44	0.00

Panel C. Comparing with e-trading in similar bonds at the same time

				Test on Difference	
	N	Downgraded Bonds over [+1, +30]	Control Bonds over [+1,+30]	Difference	p-value
E-share in volume (%)	498	7.64	9.76	-2.12	0.00
E-share in number of trades (%)	498	8.61	14.11	-5.50	0.00

Table 8. Transaction cost in electronic and voice trading venues around rating downgrades

Downgrade period refers to the one-month period ([+1, +30]) following a bond's downgrade from investment-grade to high-yield. Pre-Downgrade period refers to a three-month period before a rating downgrade ([-180, -90]). Post-Downgrade period refers to a three-month period after a rating downgrade ([+90, +180]). The sample consists of 339 bonds that were traded in both electronic and voice venues across all three time periods. *Cost* is volume weighted average transaction cost and it is expressed in basis points. *% of Total Volume* provides the shares of total dealer-customer trade volume in electronic venues and voice venues. *Trade Size* is the average par amount of each trade, and it is expressed in $ million.

	Pre-Downgrade Period			**Downgrade Period**			**Post-Downgrade Period**		
	Cost	**% of Total Volume**	**Trade Size**	**Cost**	**% of Total Volume**	**Trade Size**	**Cost**	**% of Total Volume**	**Trade Size**
Voice Trade	44.86	85.78	0.838	48.04	91.49	1.088	45.45	88.89	0.708
Electronic Trade	43.6	14.22	0.462	53.55	8.51	0.546	34.26	11.11	0.400

Table 9. Electronic trading and transaction cost for voice trades around rating downgrade

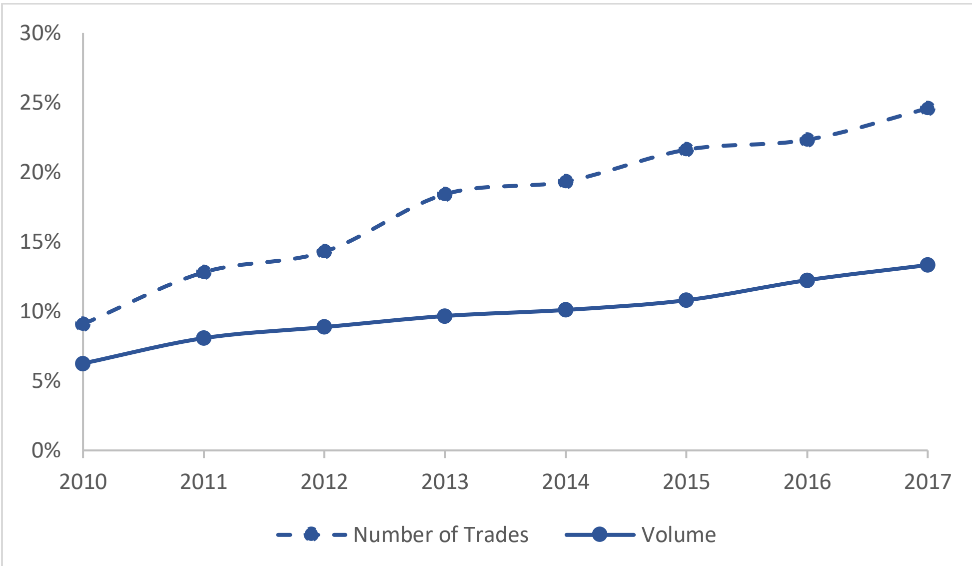
This table report results from estimating Model (3) for bonds downgraded from investment-grade to high-yield, as well as those in normal periods. To estimate the dependent variable $Cost_{i,t,s,d}^{v}$, we first calculate the transaction cost for each voice trade as in Hendershott and Madhavan (2015). We then average the estimate across trades executed in bond *i*, on trading day *t*, within size category *s*, and with dealer d. *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same bond-dealer-day-trade size level as $Cost_{i,t,s,d}^{v}$. All regressions are estimated with both dealer fixed effects and bond-day-trade size fixed effects. Standard errors are double clustered at the dealer-day and the bond-day levels. Column I uses all observations for downgraded bonds during the one-month after rating downgraded ([+1,+30]). Columns II and III are based on observations for the downgrade bonds during a three-month period before and after rating downgrade respectively (i.e., [-180,-90] and [+90,+180]). Column IV includes observations in bonds with similar characteristics (i.e, rating, time to maturity, amount outstanding and industry classification) as the downgrade bonds during the same one-month period.

	I	**II**	**III**	**IV**
	Downgraded Bonds over [+1,+30]	**Downgraded Bonds over [-180,-90]**	**Downgraded Bonds over [+90,+180]**	**Control Bonds over [+1,+30]**
E-Share	-15.759	-40.464***	-31.012**	-28.804**
	(-1.14)	(-3.85)	(-2.41)	(-2.26)
Dealer FE	Yes	Yes	Yes	Yes
Bond-Day-Size FE	Yes	Yes	Yes	Yes
Observations	20,063	58,869	59,484	219,523
R^2	0.44	0.65	0.58	0.71

Figure 1. Growth of electronic trading in the corporate bond markets

Panel A presents the annual average daily share of dealer to customer trades that are executed on MarketAxess, both in terms of number of trades and total par amount traded. Panel B presents the share of electronic trading in total volume separately for investment-grade and high-yield bonds.

Panel A. Share of electronic trading over 2010-2017



Panel B. Share of electronic trading in volume over 2010-2017: investment-grade vs. high-yield

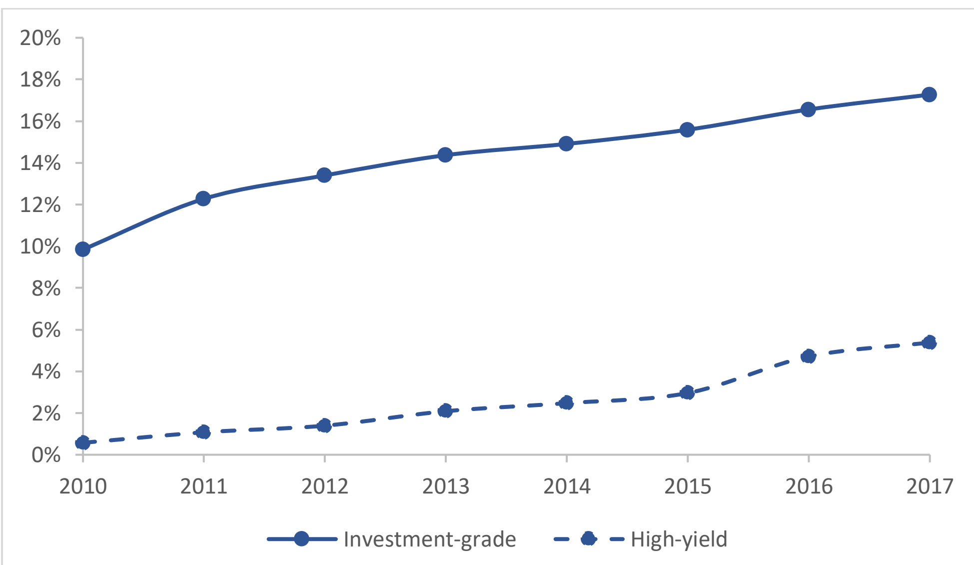
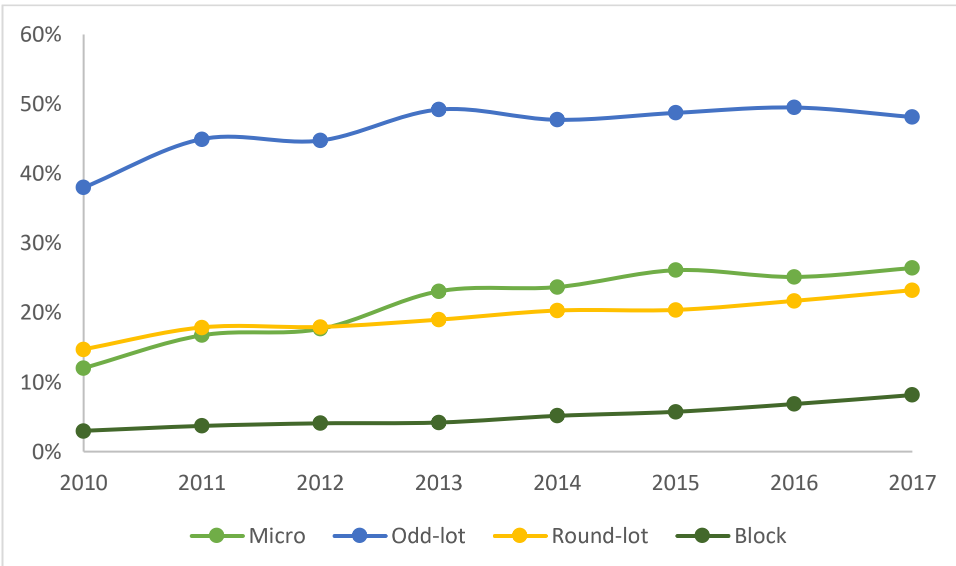


Figure 2. Share of electronic trading across trade size categories

This figure presents the share of electronic trade volume out of total trade volume for trades with different sizes. Trades are classified into four size categories based on their par amount: Micro ($1 to $100,000), Odd-lot ($100,000 to $1,000,000), Round-lot ($1,000,000 to $5,000,000), and Block (above $5,000,000). Panels A and B present the annual average daily share of electronic trading in each of the four size categories separately for investment-grade and high-yield bonds.

Panel A. Investment-grade bonds



Panel B. High-yield bonds

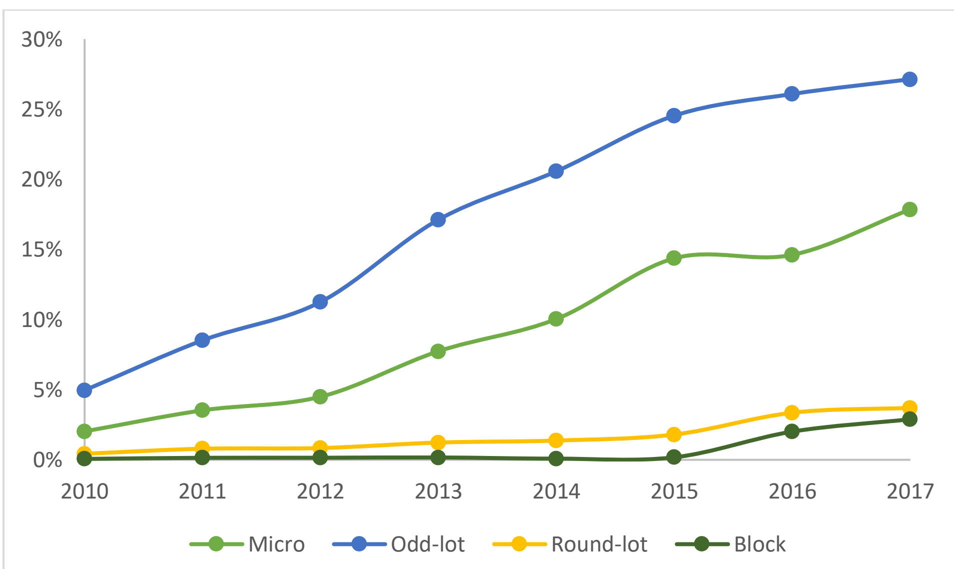
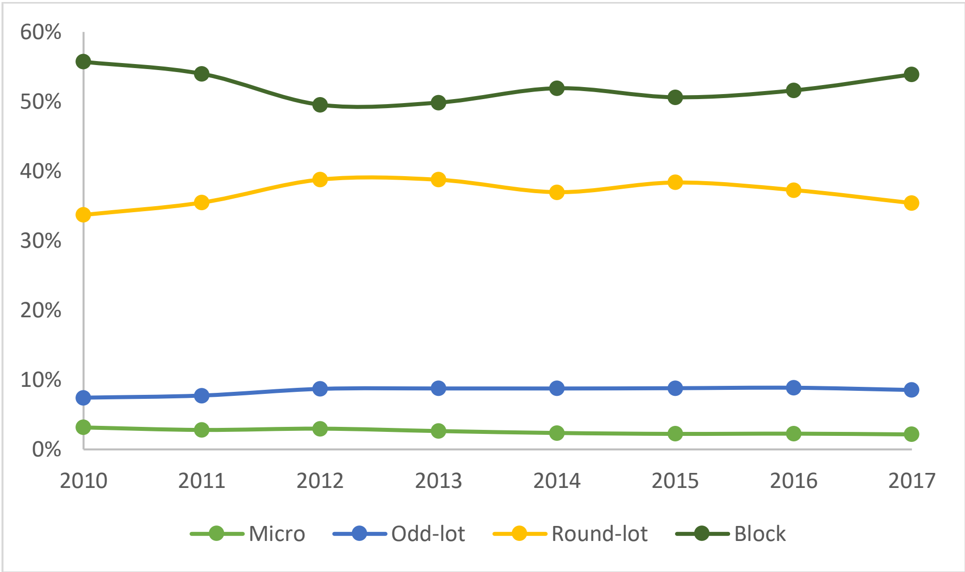


Figure 3. Distribution of bond trades across size categories

This figure shows how corporate bond trades are distributed across different size categories. Trades are classified into four size categories based on their par amount: Micro ($1 to $100,000), Odd-lot ($100,000 to $1,000,000), Round-lot ($1,000,000 to $5,000,000), and Block (above $5,000,000). Panels A and B present the annual average daily share of volume in each of the four size categories separately for investment-grade and high-yield bonds.

Panel A. Invest-grade bonds



Panel B. High-yield bonds

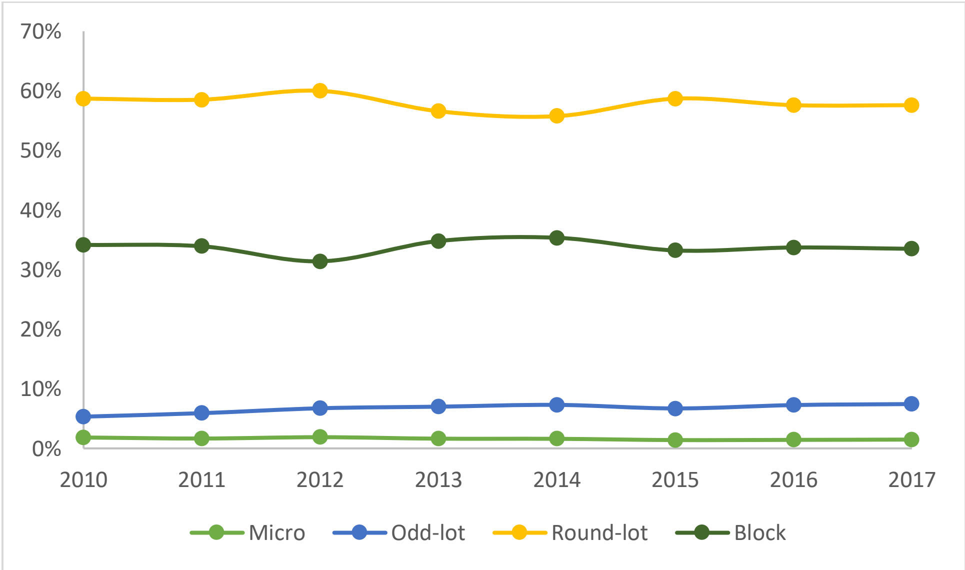


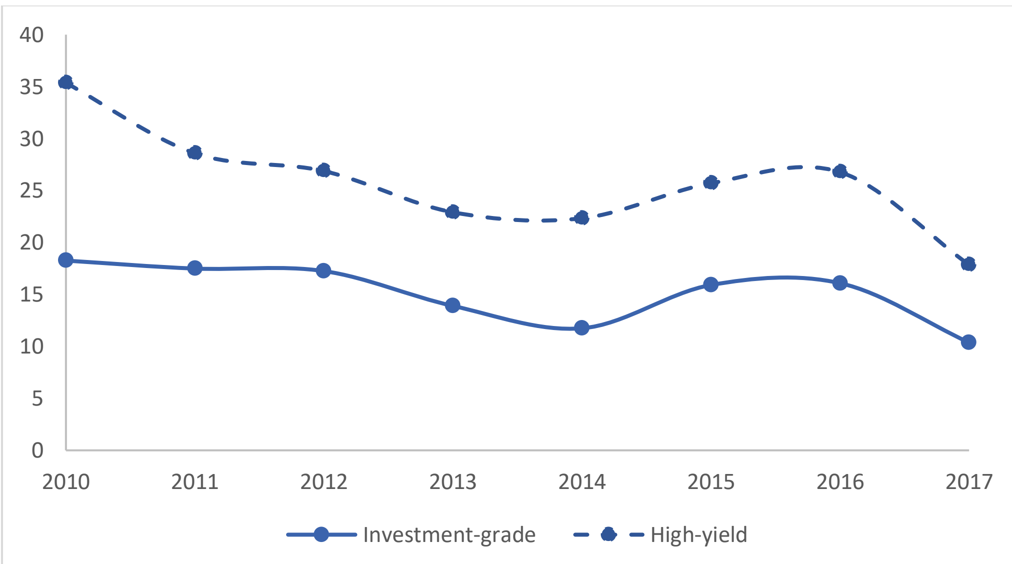
Figure 4. Transcation costs in electronic trading and voice trading

This figure presents the annual average transaction cost separately for electronic trades (Panel A) and voice trades (Panel B). Transaction cost is estimated for each trade as in Hendershott and Madhavan (2015):

$$Cost_j = ln\left(Trade\ Price_j / Benchmark\ Price_j\right) \times Trade\ Sign_j,$$

where $Trade\ Price_j$ refers to the transaction price for trade j, $Benchmark\ Price_j$ is the transaction price of the last trade in that bond in the interdealer market, and $Trade\ Sign_j$ is an indictor variable for trade direction. $Trade\ Sign_j$ takes the value of +1 for an investor purchase and -1 for an investor sale. We multiple $Cost_j$ by 10,000 to compute transaction cost in basis points of value. We first estimate a bond-day level *Cost* measure by averaging $Cost_j$ across trades in the same bond on the same day. We then average the bond-day level *Cost* measure across bonds to get a daily measure for market. Finally, the daily measure is averaged across days to get an annual estimate, which is plotted in the figure.

Panel A. Transaction costs in electronic trading



Panel B. Transaction costs in voice trading

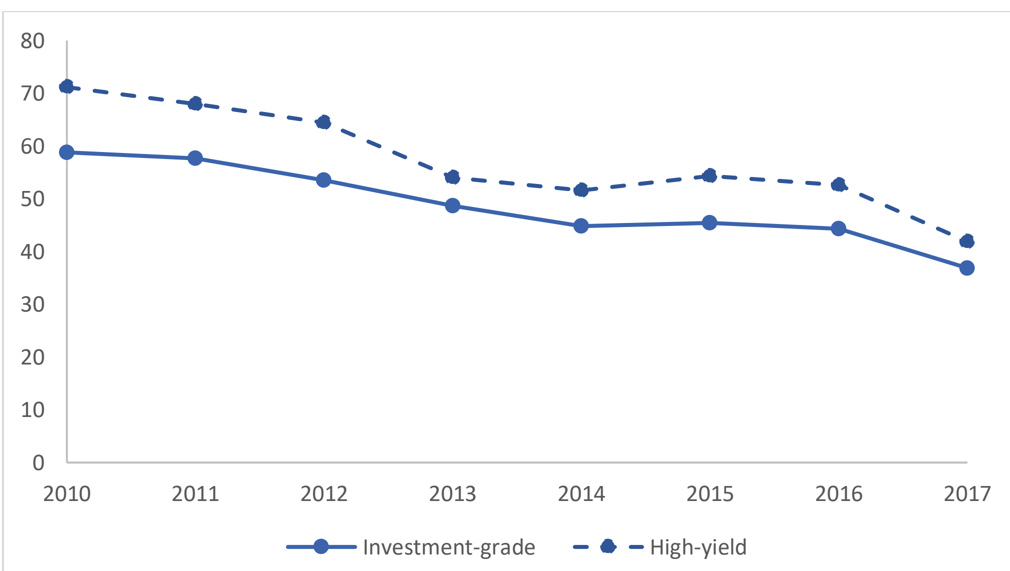


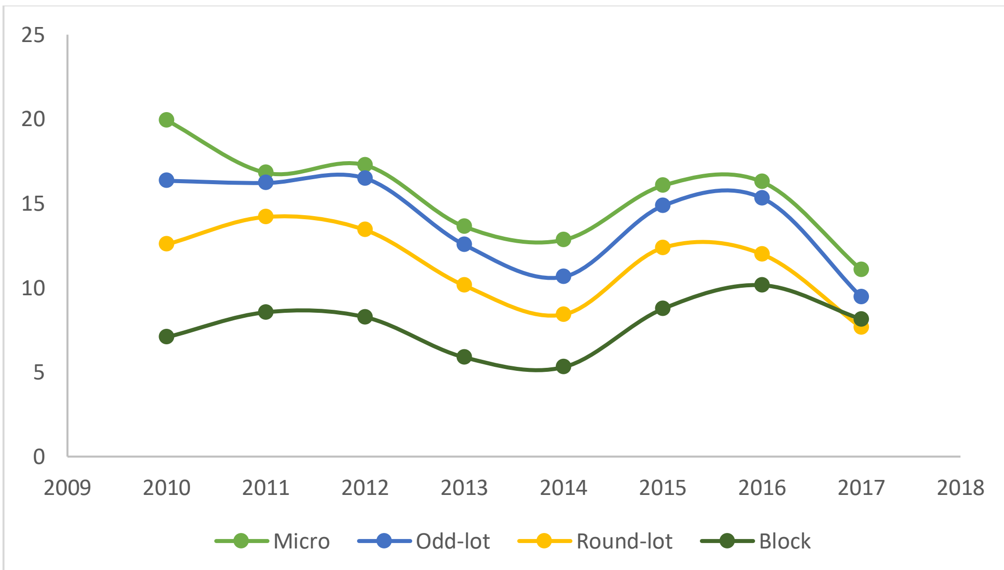
Figure 5. Transaction cost across size categories

This figure presents the annual average transaction cost for both electronic and voice trades with different sizes. Transaction cost is estimated for each trade as in Hendershott and Madhavan (2015):

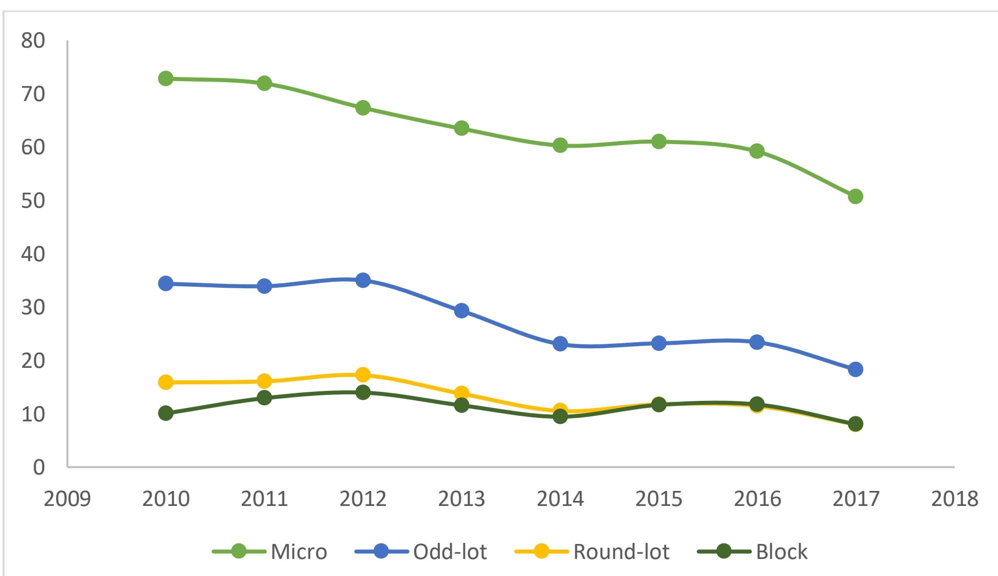
$$Cost_j = ln(Trade\ Price_j / Benchmark\ Price_j) \times Trade\ Sign_j,$$

where $Trade\ Price_j$ refers to the transaction price for trade j, $Benchmark\ Price_j$ is the transaction price of the last trade in that bond in the interdealer market, and $Trade\ Sign_j$ is an indictor variable for trade direction. $Trade\ Sign_j$ takes the value of +1 for an investor purchase and -1 for an investor sale. We multiple $Cost_j$ by 10,000 to compute transaction cost in basis points of value. We first estimate a bond-day-trade size level *Cost* measure by averaging $Cost_j$ across trades in the same bond on the same day and within the same trade size category. We then average the measure across bonds to get a daily measure for each size category. Finally, the daily measure is averaged across days to get an annual estimate for each size category, which is plotted in the figure.

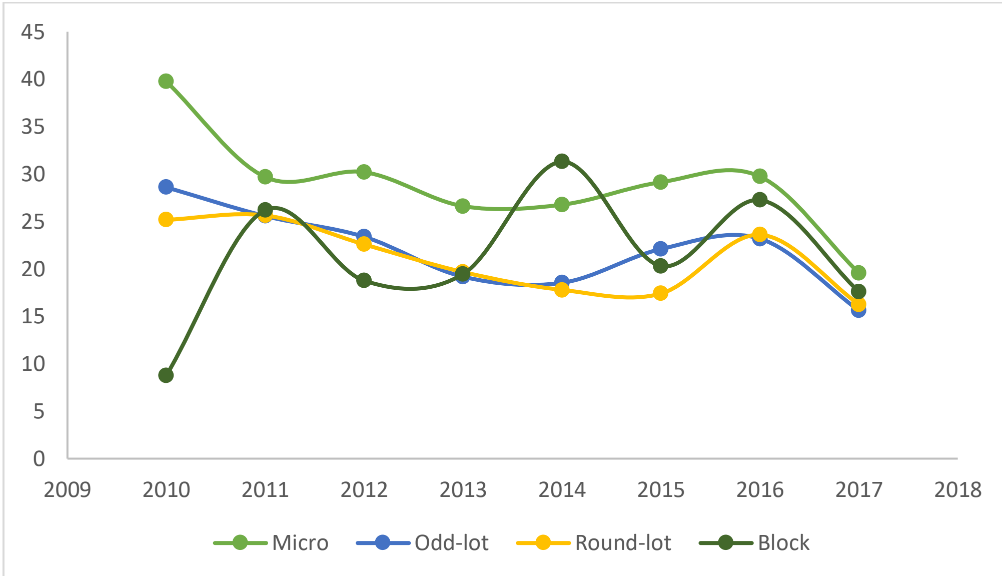
Panel A. Electronic trades in investment-grade bonds



Panel B. Voice trades in investment-grade bonds



Panel C. Electronic trades in high-yield bonds



Panel D. Voice trades in high-yield bonds

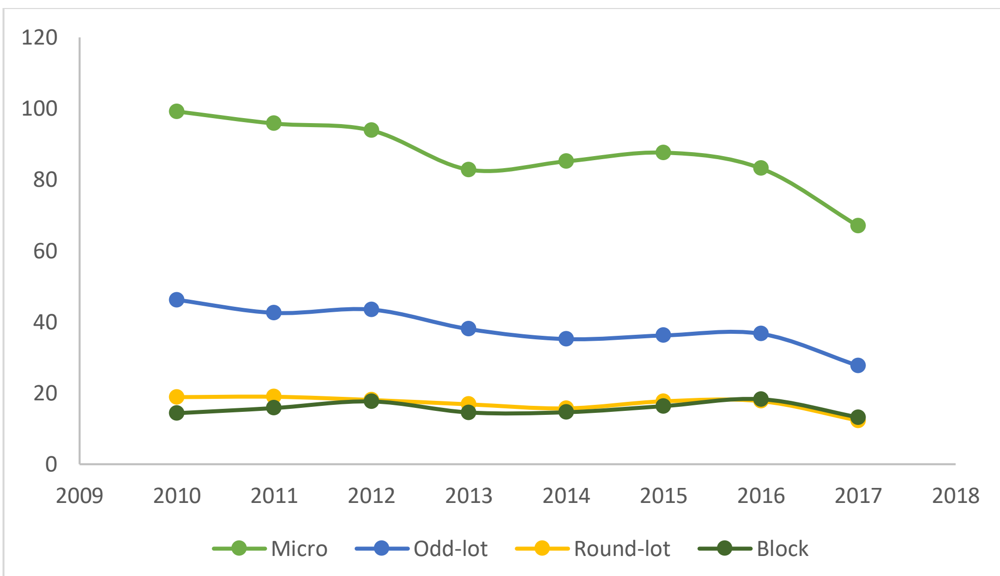


Figure 6. Inter-dealer trading in the corporate bond markets

This figure plots annual average daily share of inter-dealer trade volume out of total market volume (i.e., the summation of inter-dealer and dealer-customer trade volume) for all bonds, as well as for investment-grades and high-yield bonds separately.

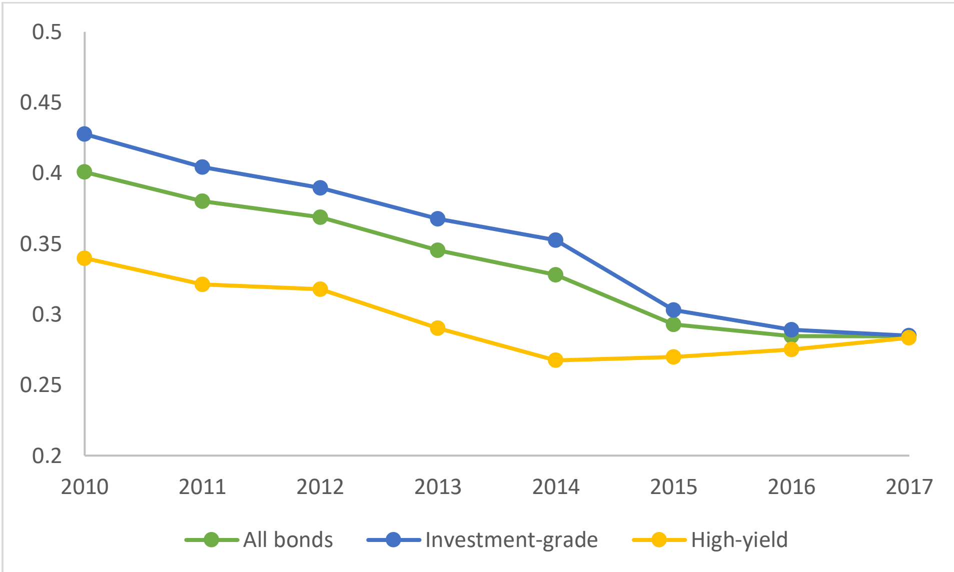
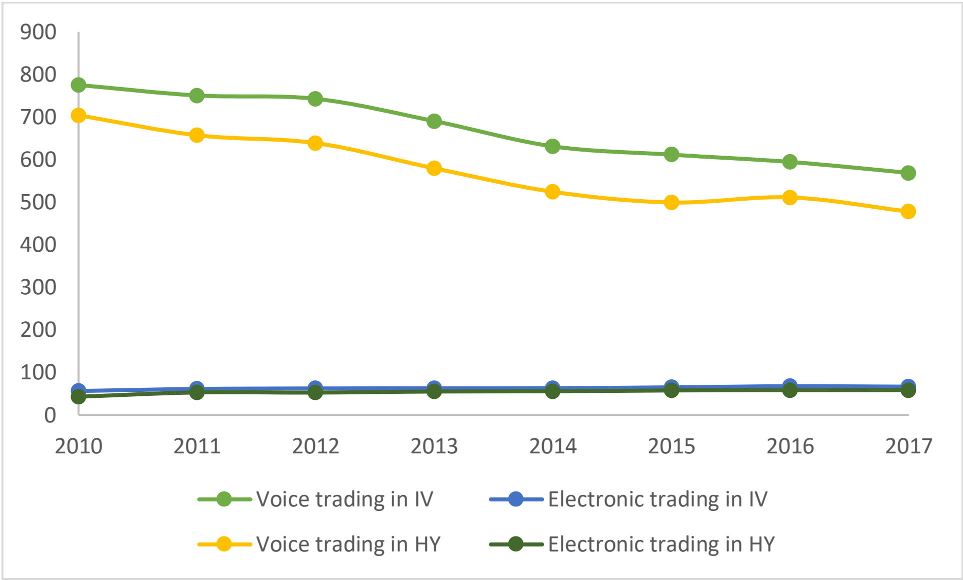


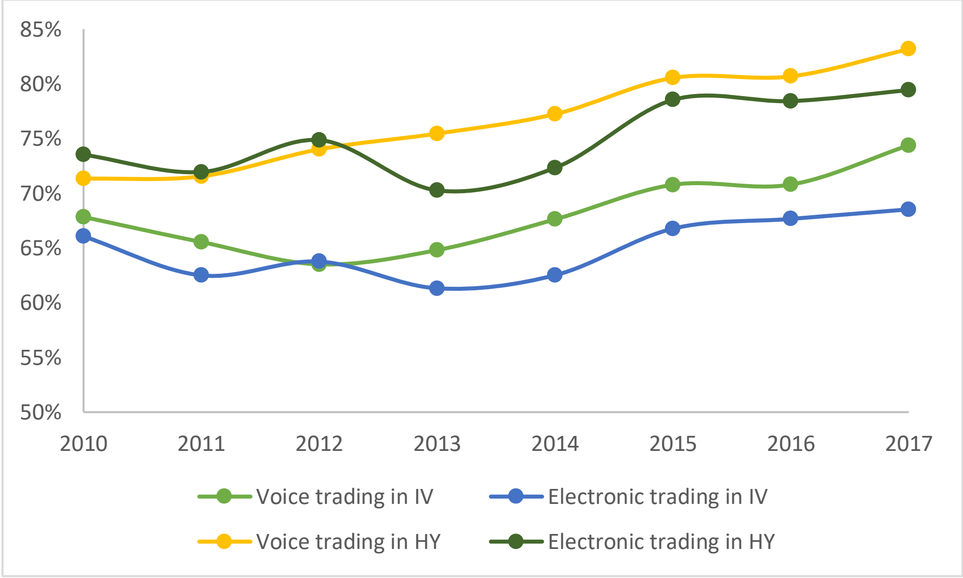
Figure 7. Market Concentration

This figure presents measures of market concentration for electronic trading and voice trading in investment-grade (IV) and high-yield (HY) bonds. Panel A shows the annual market share of the top 10 dealers. Panel B shows the annual average daily Herfindahl index. Panel C shows the annual total number of active dealers.

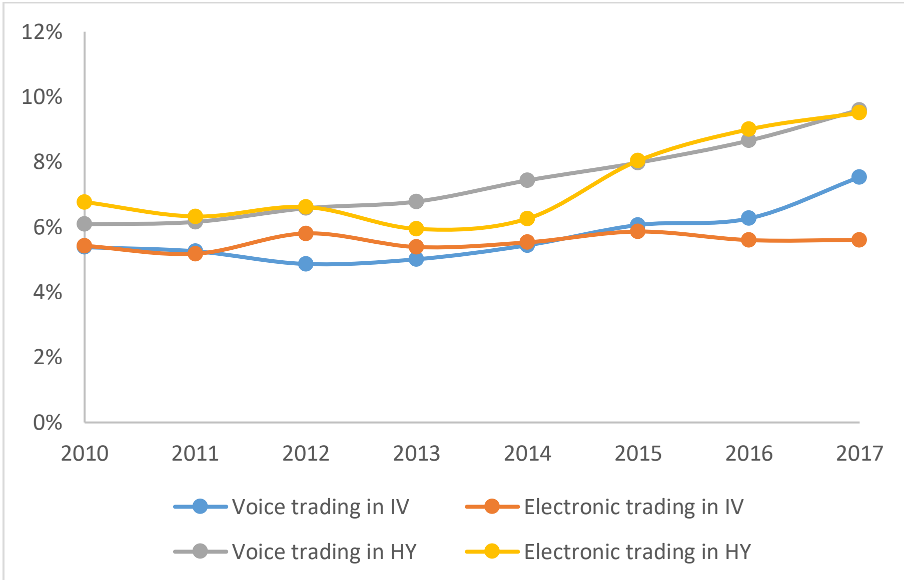
Panel A. Number of active dealers



Panel B. Market share of top 10 dealers



Panel C. Herfindahl index

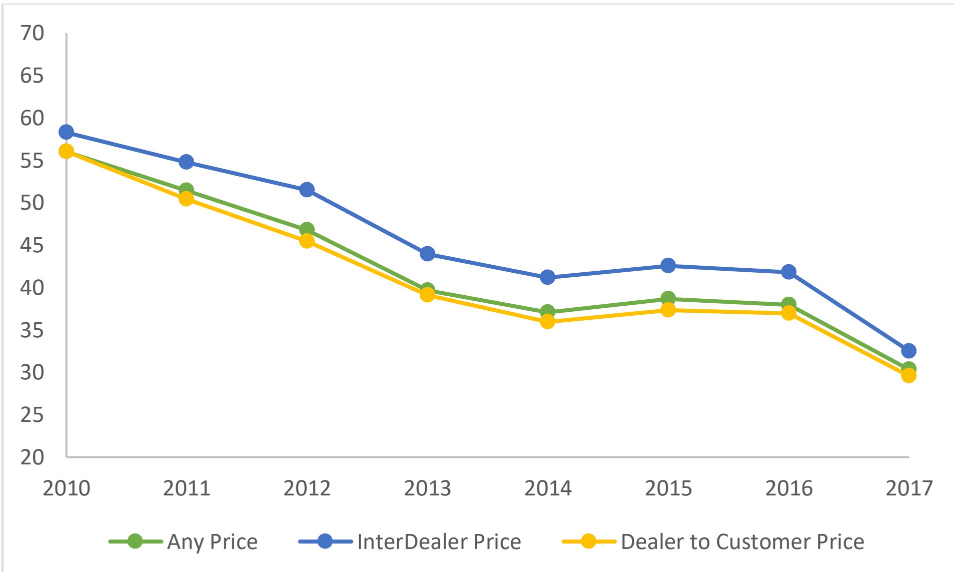


Appendix 1. Transaction cost estimated from using alternative benchmark prices

This figure compares the annual average transaction cost estimated from using alternative benchmark prices. Transaction cost is estimated for each trade following the model used in Hendershott and Madhavan (2015):

$$Cost_j = ln\left(Trade\ Price_j / Benchmark\ Price_j\right) \times Trade\ Sign_j,$$

where $Trade\ Price_j$ refers to the transaction price for trade j, and $Trade\ Sign_j$ is an indictor variable for trade direction. We use three alternative approaches to estimate $Benchmark\ Price_j$: the transaction price of the last inter-dealer trade, the last dealer-customer trade, or any trade in that bond. We multiple $Cost_j$ by 10,000 to compute transaction cost in basis points of value. We first estimate a bond-day level *Cost* measure by averaging $Cost_j$ across trades in the same bond on the same day. We then average the bond-day level *Cost* measure across bonds to get a daily measure for market. Finally, the daily measure is averaged across days to get an annual estimate, which is plotted in the figure.



Appendix 2. Summary information on samples constructed for various measures of market quality and dealer behavior

Panel A provides summary information on the sample constructed based on the availability of the bond-day-trade size level transaction cost measure for voice trades ($Cost^{v}_{i,t,s}$). We first estimate the transaction cost for each voice trade as in Hendershott and Madhavan (2015). We then average the estimate across trades executed in the same bond *i*, on the same trading day *t*, and within the same size category *s* to get $Cost^{v}_{i,t,s}$. *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same bond-day-trade size level as $Cost^{v}_{i,t,s}$.

Panel B provides summary information on the sample constructed based on the availability of the measure of price difference across dealers for voice trading ($PriceDiff^{v}_{i,t,s,B/S}$), estimated at the dealer-day-trade size-trade direction level. For trades with the same trade direction (i.e., whether the investor is buying (B) or selling (S)), executed in the same bond *i*, on the same trading day *t*, within the same size category *s*, we first calculate the average price for each dealer *d*. We then calculate the difference between the highest and the lowest average prices across dealers to get $PriceDiff^{v}_{i,t,s,B/S}$. *E-share* is the share of dealer-customer trade volume that occurs onMarketAxess. It is calculated at the same bond-day-trade size-trade direction level as $PriceDiff^{v}_{i,t,s,B/S}$.

Panel C provides summary information on the sample constructed based on the availability of the share of inter-dealer trade out of total trade, calculated at the bond-day-trade size level ($InderDealerShare_{i,t,s}$). For trades executed in the same bond *i*, on the same trading day *t*, and within the same size category *s*, we calculate the aggregate volumes for those between a dealer and a customer, and those between two dealers. $InterDealerShare_{i,t,s}$ is defined as the ratio of inter-dealer volume and the total trade volume (the sum of inter-dealer volume and dealer-customer volume). *E-share* is the share of dealer-customer trade volume that occurs on MarketAxess. It is calculated at the same bond- -day-trade size level as $InderDealerShare_{i,t,s}$.

Credit Rating refers to the lower of Moody's and S&P's ratings. A numeric value is assigned to each notch of Moody’s (S&P’s) credit rating, with 1, 2, 3,… denoting Aaa (AAA), Aaa1(AA+), Aa2(AA) …, respectively. For bonds rated by both Moody’s and S&P, we keep the lower of the two credit ratings. *Time to Maturity* is the number of years between a bond’s offering date and its maturity date. *Outstanding Amount* is the total par amount outstanding for a bond, denominated in $ millions. *Industry Distribution* provides the distribution of each sample across three broad industries, industrial, financial, and utility, based on FISD’s classification. *Trade Size distribution* provides the distribution of each sample across four size categories: Micro ($1 to $100,00), Odd-lot ($100,000 to $1, 000,000), Round-lot ($1,000,000 to $5,000,000) and Block (above $5,000,000). *Trade Size distribution* provides the distribution of each sample across customer buys and customer sells.

Panel A: Transaction Cost Sample

	N	Mean	Std. Dev.	Median

Cost (bps)	8,067,056	50	84	27
E-Share (%)	8,067,056	21	37	0
Credit Rating	8,067,056	9	4	9
Time to Maturity (Year)	8,067,056	8	9	6
Outstanding Amount ($ Million)	8,067,056	948	927	700
		Industrial	**Financial**	**Utility**
Industry Distribution (%)		56.05	38.4	5.55
	Retail	**Odd-lot**	**Round-lot**	**Block**
Trade Size Distribution (%)	56.13	23.94	15.46	4.48

Panel B: Dealer Competition Sample

	N	**Mean**	**Std. Dev.**	**Median**
Price Dispersion (bsp)	4,934,180	49	68	16
E-Share (%)	4,934,180	14	25	0
Credit Rating	4,934,180	9	4	9
Time to Maturity (Year)	4,934,180	8	9	6
Outstanding Amount ($ Million)	4,934,180	1,100	1,080	750
		Industrial	**Financial**	**Utility**
Industry Distribution (%)		55.5	40.08	4.42
	Retail	**Odd-lot**	**Round-lot**	**Block**
Trade Size Distribution (%)	70.77	14.64	12.48	2.11
	Customer Buy		**Customer Sell**	
Trade Direction Distribution (%)	56.77		43.23	

Panel C: Inter-dealer Share Sample

	N	**Mean**	**Std. Dev.**	**Median**
Inter-dealer Share (%)	12,955,236	33	34	22
E-Share (%)	12,955,236	26	40	0
Credit Rating	12,955,236	9	4	9
Time to Maturity (Year)	12,955,236	9	9	6
Outstanding Amount ($ Million)	12,955,236	849	855	600
		Industrial	**Financial**	**Utility**
Industry Share (%)		55.44	37.25	7.31
	Retail	**Odd-lot**	**Round-lot**	**Block**
Trade Size Share (%)	53.27	25.41	16.75	4.58