Quote Competition in Corporate Bonds

TERRENCE HENDERSHOTT, DAN LI, DMITRY LIVDAN,
NORMAN SCHÜRHOFF, KUMAR VENKATARAMAN*

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Abstract

We demonstrate the importance of dealer quotes in corporate bonds for trading volume and execution costs, despite being indicative. Dealers strategically use quotes to manage inventories and attract client order flow. Higher quoting activity increases trading volume, with dealers offering the best quotes executing trades at better prices. Conversely, dealers with inferior quotes offer price improvement, indicating clients exploit quote information during negotiations. Unlike in centralized markets, the best quotes may not attract order flow, and trades often occur at prices worse than the best quotes. Our findings suggest that quoting substitutes for relationships and enhances investors' market access.

JEL Classification: G12, G14, G24

Key words: Pre-trade transparency, quotes, corporate bonds, OTC markets, order flow competition

Conflict of Interest Disclosure Statement

Terrence Hendershott provides expert witness services to a variety of clients. He has taught a course for a financial institution that engages in liquidity provision and high-frequency trading activity. He gratefully acknowledges support from the Norwegian Finance Initiative.

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Fixed-income securities such as corporate bonds are typically traded over-the-counter (OTC) (Bessembinder, Spatt, and Venkataraman (2020)). While corporate bond dealers do disseminate indicative quotes on a subset of bonds (called "runs") to their potential institutional customers, OTC markets are generally considered to be opaque with limited or no pre-trade transparency (Weill (2020)), as information on the best available bid and ask quotes are not widely available. The theoretical literature generally views OTC markets as a setting with significant search frictions without modelling dealer quotes (e.g., Duffie, Dworczak, and Zhu (2017)). Quotes are advertisements signaling dealers' interest in trading a bond and can potentially reduce search frictions. Whether quotes are meaningless for investor search or they do matter for trading and pricing in OTC markets is an unexplored empirical question. We provide new empirical evidence on the role of dealers' indicative quotes in the U.S. corporate bond market by studying how quotes relate to order flow and client execution costs.

We find evidence that quotes attract trades from customers. At the level of the individual dealer, the decision to quote, the extent of quotation activity, and the quality of the quotes are positively related to trading volume. Customers who trade with dealers posting better quotes obtain lower trading costs. Thus, consistent with quote competition, dealers have incentives to post better-quality quotes and clients have incentives to search for better quotes.

However, while dealers attract order flow by competing on quotes, they do so imperfectly. First, the best quotes are not observed by all market participants. Often the best quotes fail to attract order flow and trades frequently occur at prices worse than the best quotes. In addition, quotes matter for large trades and not for small trades. Second, clients and dealers appear to exploit quote information from other dealers in their negotiations. We find that dealers with lower-quality quotes compared to their peers improve prices more for clients. Thus, quote leakage leads to price matching which limits dealers' incentives to compete aggressively via quotes.

We find that quotes matter at the aggregate level. Specifically, we construct shift-share instruments (Bartik (1991)) to show that higher quoting activity causes higher aggregate trading activity. Hence, quoting is not a zero-sum game between quoting and non-quoting dealers which is consistent with models that predict quotes lower search frictions which mitigates welfare losses and improves overall market efficiency.

We establish these relations by linking trades and quotes for a subset of dealers. Indicative quotes on corporate bonds are emailed by dealers to customers in "runs" that consist of a list of bonds and the indicative quoted price or yield at which the dealer is willing to buy or sell each bond. Our data is from BondCliQ (CliQ, hereafter), a provider that collects quotes from participating dealers by requesting inclusion on each dealer's distribution list for runs. The CliQ data contains dealer names that we match to the dealer names in the regulatory TRACE dataset to link quoting and trading activity. While many of the largest dealers do not include CliQ on their runs during our October 2019 to May 2020 sample period, CliQ dealers alone provide 8.5 million quotes (bid or ask) on roughly 24,000 bonds. Overall, CliQ dealers provide significant liquidity, averaging about 25% of trading volume in corporate bonds, and their quotations affect trading activity even though they are not the dealers with the largest size and impact.

We study the effect of posting quotes in attracting order flow at the individual dealer level for all participating CliQ dealers. On average each CliQ dealer trades in a bond on 4.1% of days. In regressions with saturated fixed effects (i.e., dealer-day and bond-day fixed effects), the presence of a quote increases the probability of a trade by the dealer in the same bond by 3.9% (extensive margin), a 95% percent increase from the unconditional average. The number of trades by the quoting dealer is 3.5% higher (intensive margin). When the number of quotes increases from one to two, which is the median of quotes per dealer-bond-day, the trade probability is 4.8% higher and the number of trades is 4.3% higher. Because the bond-day fixed effects absorb variation in bond-specific daily trading activity aggregated across all dealers, these results show that dealers who quote/quote more attract order flow at the expense of dealers who do not quote/quote less.

We then examine whether quote competition provides a positive externality on the market. To understand how quoting impacts market-wide trading activity we study whether CliQ dealers' market share increases when CliQ dealers quote and quote more frequently and whether quotes increase aggregate trading volume. Our identification strategy exploits heterogeneity in a bond's importance or/and exposure to different dealers to construct a Bartik (1991)-type instrument for dealers' quote supply at the bond level. We measure such exposure by the dealer's institutional share of trading over the past 10 trading days. The predicted quote supply in a bond is then an institutional-trading-share-weighted average of the market-wide quoting rates of each dealer. Thus, we measure whether dealers quoting more market-wide across all bonds leads to more trading in bonds where dealers have had a higher recent market share. A standard deviation increase in either the intensive or extensive margin of the quote supply results in an additional 0.8% CliQ dealers' market share in this bond on that day. This is consistent with customers substituting towards CliQ dealers when they quote and/or CliQ dealers' quotes attracting customers to trade who would not have traded otherwise. We next examine whether dealer quotes cause higher trading volume. This could occur through quotes lowering search frictions and helping customers direct their search to dealers offering better prices. We find that a standard deviation increase in the intensive/extensive margin of the dealers' quote supply increases the total number of trades by 16.1%/22.8%. Thus quote competition is not a zero-sum game which is important for investor welfare implications.

We next move beyond whether dealers quote and how often they quote to the competitiveness and quality of their quotes. We measure the competitiveness of a dealer's quote relative to the average quote across all dealers in a bond on that day, which we refer to as quote quality. We find that a dealer's quote quality relates to both the dealer's extensive and intensive margins of trading after controlling for the presence of the dealer's quote. Economically, with a one standard deviation improvement in a dealer's quote quality, 22 bps, the trade probability at the dealer-bond-day level is 10.88% higher and the number of dealer's trades is 0.57% higher. Notably, with bond-day fixed effects, these results show that dealers with better quotes attract order flow at the expense of dealers with worse quotes. We also find that order flow is more tightly linked to quote activity and quote quality when VIX is high (including the onset of Covid-19) and for speculative-grade bonds, both pointing to uncertainty as an important driver of the relationship.

The natural underlying mechanism for quotes attracting order flow is that quotes lower search frictions and help customers to trade with dealers quoting better prices (e.g., Duffie, Garleanu, and Pedersen (2005)). While we cannot directly observe the clients' search process, the relation between quoted and trade prices provides empirical support for this mechanism. If there is no relation between the price a dealer quotes and the price at which a dealer trades then quotes are not meaningful. We find that dealers with better quotes execute trades at better prices, implying that indicative quotes are meaningful signals of the clients' execution quality.

However, we find that the quote competition is imperfect, as the best quotes often fail to attract order flow and trades frequently occur at prices worse than the best indicative quotes, which does not occur in centralized equity markets (Stoll and Schenzler (2006)).[1] The best quoting CliQ dealer only attracts 15% of CliQ-dealer trades and more than 30% of trades with CliQ dealers not quoting the best price occur at prices worse than the best quote. The way in which quotes relate to trades in corporate bonds differs from equities due to several structural differences in market structure. In the U.S., stock quotes are firm and publicly disseminated and Reg NMS defines inter-market linkages with best execution rules that prohibit trade throughs. Corporate-bond dealers have no quoting obligations and what quotes they do disseminate only go to a select list of potential clients. There are no formal market linkages and much weaker best execution rules. These differences in market structure imply that quotes may play a fundamentally different role in bonds than stocks.

We explore two explanations for why quote competition works imperfectly in corporate bonds. The first explanation is the limited pre-trade transparency where the best quotes are imperfectly observed and used by all market participants. Because retail customers do not directly receive CliQ quotes, we expect that, if better quotes attracts order flow, the relation should be stronger for institutional trades than retail trades. Indeed, we find for small trades (trade size $<$ \$100k) that quote quality does not relate to the extensive and intensive margin of trading, while for large trades(trade size $\geq$ \$100K), the relation is statistically and economically significant. The best-quoting dealer is significantly more likely to attract the next large trade than small trade, 20% versus 6.4%. We find that uncertainty affects the sensitivity of institutional order flow to quotes but not the sensitivity of retail order flow to quotes. Further, the link between quote quality and client execution quality is larger for large trades.

The second explanation is that clients and competing dealers exploit quote information from other dealers in their bilateral negotiations. We find evidence of significant asymmetry in how quote quality impacts execution prices. Dealers with the very best quotes offer little improvement over their quotes when executing trades while dealers with worse quotes offer significant price improvement over their quotes. This could arise from customers using better quotes to negotiate better prices from their relationship dealers who may not be offering the best quotes. On the one hand, these results suggest that, consistent with quote competition, dealers respond to other dealers' quotes and that customers benefit from the competition. On the other hand, quote leakage limits dealers' incentives to compete aggressively and offer

[1]Harris (2015) refers to these as trade throughs.

better quotes in the first place (Godek (1996), Dutta and Madhavan (1996)).

Trading and quoting are not frequent in corporate bonds, so much of our analysis is done daily. A concern with this level of aggregation is that unobserved factors could affect both trading and quoting in a bond on a certain day, thus limiting the ability to establish a causal link. However, the dealer-level analyses that link trading activity to whether a dealer quotes, how often a dealer quotes, and how aggressively a dealer quotes, are done with bond-day and dealer-day fixed effects. Unobserved factors that could potentially affect both trades and quotes would need to be active at the dealer-bond-day level, not just the bond-day or dealer-day level. Further, for unobserved factors to explain the asymmetry based on trade size, the factors would need to be active at the dealer-bond-day level for large trades, but not for small trades. Another approach to examining causality exploits the pattern that dealer runs occur more in the morning while trading peaks in the afternoon. Here we split the trading day into the morning and afternoon sessions and examine the lead-lag relationship between quotes and trades. We find that a dealer's trading in the afternoon is higher when the dealer quotes more in the morning after controlling for saturated fixed effects and the dealer's trading activity in the morning.

Our results that institutional clients benefit from quote competition in the form of lower trading costs point to the importance of broader availability of the best bid and ask quotes. Green, Hollifield and Schürhoff (2007) predict that fragmentation and lack of transparency create opportunities for dealers to profit from less-sophisticated investors.[2] Future research should consider the implications of our results for market design, i.e., whether the wider availability of dealer quotations should arise endogenously in the marketplace, or whether it is necessary for a regulator to mandate pre-trade transparency?

Related literature. The literature on OTC markets has not generally considered dealer quotes. By linking individual dealers' quotes and trades we show that quote competition exists, but is far from perfect. Dealers use indicative quotes to broadcast their desire to trade a list of bonds. We document that trading activity is positively related to quoting activity

[2]Consistent with this, the literature has shown that smaller trades have higher trading costs than larger trades in corporate bonds. See, among others, Schultz (2001, 2017), Bessembinder, Maxwell and Venkataraman (2006), Edwards, Harris and Piwowar (2007), Goldstein, Hotchkiss and Sirri (2007), Friewald, Jankowitsch, and Subrahmanyam (2012), Hendershott, Li, Livdan and Schürhoff (2020), Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018), Bao, O'Hara and Zhou (2018), Trebbi and Xiao (2019). Trade costs declining in trade size can also arise from fixed costs and relationships.

and quote quality, suggesting that customers respond to dealers' signals of trading interest. Better-quoted prices are passed through to trade prices received by clients. However, while quotes matter, trades often go to dealers not quoting or quoting inferior prices. These trades often execute at prices worse than the best quotes, but at prices improved over dealers' inferior quotes. While this price improvement helps individual customers receive better prices, it can lower the incentive to offer better quotes in the first place.

Our study also relates to the literature on pre-trade transparency in electronic bond platforms. The majority of electronic trading occurs on request-for-quotations (RFQs) venues, where dealers respond with firm quotes to a client's inquiry. One distinction is that dealer quotes on RFQs are shown only to the enquiring client while dealer "runs" are broadcast more broadly to all potential institutional customers. Hendershott and Madhavan (2015) show that RFQ usage is higher for recently issued, investment-grade, large-issue-size bonds while O'Hara and Zhou (2021) conclude that electronic trading improved the market for both customers and dealers. Some studies (e.g., Harris (2015), Kozora et al. (2020), Kim and Nguyen (2021)) have examined dealer quotation data from corporate bond ATS venues. As O'Hara and Zhou (2021) note, electronic trading remains fairly small and segmented, catering mainly to retail clients and smaller institutional trades, while the traditional OTC dealer market dominates trading in the round lot of $1 million or more. Mattmann (2021) finds that electronic quotes in a limit order book for corporate bonds reduce transaction costs during normal times but customers providing electronic quotes got picked off during the onset of the Covid-19 pandemic.

Stoll and Schenzler (2006) note that every client would prefer to trade at the best quote rather than outside the quote and that the way in which the market mechanism operates can affect the client's trading costs. The differences between the U.S. corporate bond market, where trade-throughs are observed, and the U.S. equity market, where trade-throughs are infrequent, could be systematically related to the features of the market mechanism.

In the U.S. equity market, each exchange generally provides a firm quote in (all) stocks in which they make a market to the Consolidated Quotation System (CQS), which consolidates and transmits quotes continuously to all participants (see Blume and Goldstein (1997)). Stock trading is governed by Reg NMS which defines inter-market linkages with best execution rules that prohibit trade-throughs.[3] The importance of quote competition

[3]The rules require that a market order submitted to any market must be executed at a price no worse

among market centers has been studied extensively in equity markets.[4] Christie and Schultz (1994), Godek (1996), Huang and Stoll (1996), and Barclay, Christie, Harris, Kandel, and Schultz (1999), among others, examine the importance of better quotes attracting order flow for competition on Nasdaq.[5]

In the U.S. corporate bond market, each dealer operates as a separate market center with no obligation to quote a bond. Each dealer selects the list of potential clients that receive their indicative quotes. In particular, less-sophisticated participants, such as retail investors, have limited or no direct access to dealer quotes. Thus, the lack of publicly disseminated quotes and a system that consolidates and transmits quotes implies that many participants do not see the best available prices. There are no intermarket linkages that govern the routing of an order to another market for execution and trade-throughs are not prohibited by rules. Therefore, a dealer offering good quotes may be passed over in favor of competitors offering inferior quotes, discouraging better quotes from being offered in the first place (Godek (1996) and Madhavan and Dutta (1997)). [6] Bessembinder et al. (2020) note that such best execution requirements are less clearly defined in the corporate bond market, potentially further reducing the incentives for quote competition. Harris (2015) examines quotation data consolidated across several electronic bond trading venues and shows that execution prices are often worse than the best quote, consistent with the lack of best execution.

While the literature on OTC markets generally does not consider dealer quotes, Duffie, Dworczak, and Zhu (2017) theoretically examine pre-trade transparency in OTC markets in the form of a single market-wide benchmark.[7] If individual dealer quotes are informative

than the best price that is displayed on CQS. While our discussions focus on exchange trading, equities also trade in a variety of other venues which often use exchange quotes in their pricing mechanism.

[4]Cao, Ghyssels, and Hatheway (2000) study price discovery via indicative quotes by Nasdaq dealers prior to the official opening of the regular trading day. Stoll and Schenzler (2006) examine how firm Nasdaq quotes were in general. Bessembinder (2003) examines quotes competition in NYSE-listed stocks across exchanges while Boehmer, Saar and Yu (2005) examine competition among traders on the NYSE via the introduction of NYSE's OpenBook service that provides limit-order book information to off-exchange traders. Battalio, Hatch, and Jennings (2004) examine quote competition among option exchanges.

[5]Barclay et al. (1999) note that "dealers could not obtain this order flow by competing more aggressively using quoted prices [...] dealers faced a disincentive to improve the posted quotes, for they would likely fail to attract significant new order flow but would reduce the profits on orders that they (and other dealers) were already receiving."

[6]Foucault and Menkveld (2008) study the Dutch equity market and show that protecting limit orders against trade-throughs is important for encouraging liquidity provision.

[7]Cereda, Chague, De-Losso, and Giovannetti (2021) examine the introduction of such a benchmark in

about potential terms of trade then quotes provide pre-trade transparency beyond a benchmark by fostering quote competition. We document quote competition in corporate bonds by showing that higher quote quality (better-priced quotes) attracts more order flow and that heightened uncertainty raises the order flow sensitivity to quotes.

1 Data and Empirical Design

1.1 Data

Our analysis covers the period from October 1, 2019, to May 1, 2020, including the period of stress in the fixed-income markets at the onset of the Covid-19 pandemic. During our sample period, dealers broadcast indicative bids and offers on lists of bonds to potential institutional clients, typically using Bloomberg's messaging system. Institutions also receive quotes directly for a limited set of bonds through Alternative Trading Systems (ATSs), although electronic trading of bonds remains a relatively small part of the overall market. Institutions can solicit quotes for a specific bond through electronic Request-for-Quote (RFQ) platforms (e.g., MarketAxess), or by directly contacting dealers via instant messaging or phone. Larger institutions have built proprietary technology to aggregate quote information that they receive from many sources while smaller institutions either purchase a similar technology (e.g., ALGOMI Alpha) or use Bloomberg to parse quotes for their watch list of bonds. Clients can then complete a bilateral trade by contacting the dealer, or trade using Bloomberg's functionality.

Our bond quotes are from BondCliQ, a company trying to create a centralized, consolidated quote system for U.S. corporate bonds. BondCliQ collects quotes from participating dealers by requesting inclusion in each dealer's distribution list for runs.[8] BondCliQ plans on making its data available to both dealers and institutions but did not provide quote data to dealers during our sample period. This setting allows to study the relevance of quotes for institutions without any confounding effect from BondCliQ on dealers. Many large dealers had not yet joined BondCliQ during our sample period potentially because they view their

the Brazilian stock lending market.

[8]Conversations with market participants suggest that institutional clients undergo a rigorous vetting process focused on potential business benefits to a dealer before being added to a distribution list of runs. Clients receiving runs typically have a strong trading relationship with the dealers providing quotes.

quotes as being the most valuable and prefer to limit their distribution. Our study only relies on BondCliQ as a data source and does not examine BondCliQ's role in enhancing quote competition among dealers. While we have no reason to believe that quote competition amongst dealers who joined BondCliQ differs from dealers who did not, this is not something we can test. Our results are directly applicable to the BondCliQ (in short, CliQ) dealers.

The raw quote data contains 8.5 million quotes (bid or ask) on roughly 24,000 bonds. We rely on the Mergent Fixed Income Securities Database (FISD) data to identify securities that are corporate bonds with known features, and thus require the bond to be in the FISD. We then apply a series of filters to select bonds with well-defined features relating to the bond type, optionality, offering date, offering size, maturity date, and coupon type. Table A.1 in Appendix A details the steps involved in filtering the BondCliQ data on dealer quotes. After filtering, 4,160,948 quotes on 8,077 bonds remain. Since bid-side quotes and ask-side quotes are often quoted by the same dealer for the same bonds at the same time, we can collapse the sides of the quotes and call each unique quote by the same dealer on the same bond at a unique timestamp a "run". This yields 2,462,193 run observations (one-sided or two-sided). Each quote is in terms of absolute *price* or as a *spread* from the Treasury benchmark yield, and sometimes in both. We convert quotes in spread to prices when only the spread is available. The details of this procedure are documented in Appendix B.

Data on corporate bond transactions are obtained from the supervisory TRACE database from FINRA. The supervisory TRACE data contains unmasked dealer IDs that allow us to link quotes to trades of the same dealer. We apply similar filters in terms of bond characteristics to the TRACE data. In addition, since we are mainly interested in comparing quoting behavior and trading behavior of the same dealer, in the main analysis in the paper, we further narrow our trade sample to trades that involve at least one CliQ dealer.[9] This yields a sample of 884,030 trades.

Our final data combines the quotes and trades data and include a total of 9,617 bonds that have been quoted or traded by one of the 35 CliQ dealers over the 146 trading days.

[9] For trades between client and dealer, this means the dealer is one of the 35 CliQ dealer firms. For interdealer trades, at least one side needs to be a CliQ dealer. FINRA Rule 6730(a) requires dealers to report to TRACE transactions in corporate bonds within 15 minutes of the time of execution. Our conversations with market participants suggest that reporting delays greater than 15 minutes are uncommon. We use the trade timestamps from TRACE and quote timestamps from CliQ.

We maintain two versions of this data, one at the micro-level with each quote and trade as a unique observation and another version collapsed at the dealer-bond-day level. The latter is a three-dimensional dataset, where each observation is identified through unique combinations of dealer-bond-days in the quote and trade data. We first identify the dealer-bond pairs. There are 94,300 such pairs (out of 336,595 possible dealer-bond pairs) where the dealer quotes or trades the bond at least once during the sample period. We then balance the panel in the time dimension by setting the variables that capture trading or quoting activity to zero on days without any quote or trade. This creates a panel that is balanced in time with 13,767,800 observations. Only one-third of quotes have indicative sizes associated with them. For those quotes with size, 83% of quotes are for over $1 million while only 15% of client-dealer trades are for more than $1 million. Hence, quote size has limited relevance for most trades, and is unlikely to be binding even for the larger trades. Therefore, we focus on whether a dealer quotes and the price of their quotes.

During our sample periods, CliQ dealers were mid-tier dealers in the corporate bond market. The largest dealers also quote but they do not provide their quotes to CliQ during our sample period. Our results are thus conservative about the relation between quotes and trades. The largest CliQ dealer ranks among the top 10 of all TRACE dealers by trading volume, while 19 CliQ dealers rank among the top 50 of all TRACE dealers. The daily market share of all CliQ dealers averages about 25% of the total TRACE (dealer to client) volume with the range spanning 15% to 40% depending on the calendar day. There is no significant change in the daily market share of CliQ dealers in late March 2020.

Using the precise timestamp for each quote, we are able to infer the set of bond quotes sent in the same run message by the dealer to the clients. As shown in Table 1, a median message contains 7 bonds, but this number varies substantially across dealers and days. At the 5% and 95% tails, a message contains 1 and 42 bonds, respectively. Dealers send out many of these lists of quotes throughout the day. The frequency that dealers send out such messages also varies substantially across dealers and across days. A median dealer sends out 13.5 such messages a day. At the 5% and 95% tails, dealers send out 1 and 236 such messages a day, respectively.

1.2 Measuring quoting and trading activity

Most of our analysis is conducted on quotes and trades at the dealer-bond-day level. Our main variables of interest relate to the extensive and intensive margin of trading activity, client execution quality in terms of the transaction cost that they face, and dealers' price improvement over quoted prices. We relate these outcome variables to individual dealers' quoting activity at the extensive and intensive margin and the quality of a dealer's quoted prices relative to its peers.

We define all variables at the transaction level or aggregated at the dealer-bond-day level for dealer d and bond b on the day t. To characterize the extensive margins of quoting and trading activity at the dealer-bond-day level, we construct the quote indicator $\text{HasQuote}_{d,b,t}$ and the trade indicator $\text{HasTrade}_{d,b,t}$. $\text{HasQuote}_{d,b,t} = 1$ indicates that the dealer quotes the bond on the day, and $\text{HasQuote}_{d,b,t} = 0$ otherwise. We define $\text{HasOnlyAskQuote}_{d,b,t}$, $\text{HasOnlyBidQuote}_{d,b,t}$, and $\text{HasAskAndBidQuote}_{d,b,t}$ correspondingly when we explore the direction of the quote. $\text{HasTrade}_{d,b,t} = 1$ if the dealer trades the bond on the day, and $\text{HasTrade}_{d,b,t} = 0$ otherwise.

To characterize the intensive margins of quoting and trading, we construct the natural log-transformed number of quotes $\text{LogNumQuotes}_{d,b,t} = \log(\text{NumQuotes}_{d,b,t} + 1)$ and trades $\text{LogNumTrades}_{d,b,t} = \log(\text{NumTrades}_{d,b,t} + 1)$ by dealer d in bond b on the day t, respectively, where we add one to the number under the log to ensure these measures are well defined when the number of quotes or trades, or both, is zero.

In the analysis, we link trading activity and client execution quality to quoting activity and quote quality. Our measure $\text{ClientExecutionQuality}_{d,b,t}$ compares the trade price to a reference price at the time of the trade. We use two alternative benchmark prices on each transaction in Section 4. In our base case, we use the Bank of America Merrill Lynch (BAML) end-of-day quote on the same bond on the day prior to the transaction. Alternatively, following Hendershott and Madhavan (2015), we use the price on the last interdealer trade prior to the transaction. $\text{ClientExecutionQuality}_{d,b,t}$ is essentially the negative of trading costs, with higher execution quality indicating lower transaction costs.

1.3 Descriptive statistics about dealer quotes and trades

Each quote provides the time stamp, quoting dealer ID/name, quoted price (either bid or ask) if the quote is one-sided or both bid and ask prices if the quote is two-sided, bond CUSIP number, and the quantity for some quotes. The information on quotes is limited to the CliQ dealers. We use all trades, both by CliQ and non-CliQ dealers, which we obtain from FINRA supervisory TRACE and match them to the CliQ data by dealer ID and bond CUSIP number. Each trade has the transaction price, dealer buy/sell indicator, and bond characteristics.

Table 1 provides descriptive statistics about individual dealer quotes and trades. Results are presented separately for quotes (Panel A), CliQ trades (Panel B), and a balanced panel at the dealer-bond-day level (Panel C). We start with the quote data. On average, 27 dealers quote per day, and 2 dealers quote per day per bond. The 95th percentile has 31 dealers quoting per day and 4 dealers quoting per day per bond. For the 5% most quoted bonds, the number of quoting dealers varies over time between less than five and more than 15. About 30% of the quotes are one-sided quotes with the bid side quoted less than the ask side, particularly during stress periods.

On a typical day, 4,325 bonds are quoted on CliQ, and 310 bonds are quoted per dealer. At the 95th percentile, 5,387 bonds are quoted on CliQ per day and 1,171 bonds are quoted per day per dealer. The quoted bid-ask spread is winsorized at 0.5% and its average/median value is 74bps/56bps, and it can be as high as 2%. The average and median quote quality are both 0bps (standard deviation of 13bps) when using the average quote as a benchmark, and it is -22bps/-12bps (standard deviation of 28bps) when using the best quote as a benchmark.

Panel B of Table 1 reports descriptive statistics for CliQ dealer trades. On average, 34 CliQ dealers trade per day. An average number of 1.54 CliQ dealers trade a given bond per day. The average/median client execution quality is -37bps/-15bps when using the BAML quote as a benchmark, and it is -29bps/-8bps when using the interdealer benchmark. A higher number indicates better client execution quality because it is associated with lower transaction costs. Finally, the average/median price improvement is 7bps/3bps. Price improvement ranges from -75bps (5th percentile) to 89bps (95th percentile).

Panel C of Table 1 reports descriptive statistics for quotes and trades for the pooled data in a dealer-bond-day balanced panel. The average value of $\text{HasQuote}_{d,b,t}$/$\text{HasTrade}_{d,b,t}$ is the unconditional probability of a quote/trade on a day in a bond by a dealer, which equals 9%

Table 1: Descriptive statistics

The table provides descriptive statistics about individual dealer quotes and trades, the number per day, frequency, quality, and intraday timing. Variables with (w) are winsorized at 0.5% and 99.5%.

	N	Mean	SD	5%	25%	50%	75%	95%
Panel A: Quotes by CliQ dealers								
No. dealers quoting per day	146	27.03	2.75	22	26	27	29	31
No. dealers quoting per day per bond	631,435	1.93	1.23	1	1	2	2	4
No. bonds quoted per day	146	4,324.90	950.95	2,499	3,781	4,711	5,034	5,387
No. bonds quoted per day per dealer	3,946	309.62	412.08	6	41	153	413	1,171
No. bonds quoted per message	179,531	13.71	25.57	1	3	7	16	42
No. messages per day per dealer	3,946	45.50	81.58	1	5	13.50	40	236
Quoted bid-ask spread (w)	1,931,288	0.74	0.65	0.09	0.26	0.56	1.00	2.00
Quote quality (w):								
BenchmarkQuote = Avg. $\text{quote}_{b,t}$	1,098,617	0.00	0.13	-0.21	-0.01	0.00	0.02	0.18
BenchmarkQuote = Best $\text{quote}_{b,t}$	1,098,617	-0.22	0.28	-0.76	-0.35	-0.12	0.00	0.00
Quote time-of-day (hour)	2,462,193	10.64	3.10	7.25	8.32	9.85	12.57	16.42
Panel B: Trades by CliQ dealers								
No. dealers trading per day	146	33.89	1.13	32	33	34	35	35
No. dealers trading per day per bond	363,006	1.54	0.92	1	1	1	2	3
No. bonds traded per day	146	2,486.34	336.13	1,859	2,356	2,548	2,683	2,862
No. bonds traded per day per dealer	4,948	112.85	164.91	2	14	44	138	536
Client execution quality (w):								
BAML $\text{benchmark}_{d,b,t}$	417,512	-0.37	1.75	-2.87	-0.64	-0.15	0.13	1.43
Interdealer $\text{benchmark}_{d,b,t}$	452,235	-0.29	1.18	-2.00	-0.46	-0.08	0.03	0.81
$\text{PriceImprovement}_{d,b,t}$ (w)	40,844	0.07	0.75	-0.75	-0.04	0.03	0.19	0.89
Trade time-of-day (hour)	917,754	12.98	2.42	8.97	11.12	13.22	15.00	16.40
Panel C: Quotes and trades at dealer-bond-day level, balanced panel								
$\text{HasQuote}_{d,b,t}$	13,767,800	0.09	0.28	0.00	0.00	0.00	0.00	1.00
$\text{HasTrade}_{d,b,t}$	13,767,800	0.04	0.20	0.00	0.00	0.00	0.00	0.00
$\text{LogNumQuotes}_{d,b,t}$	13,767,800	0.08	0.30	0.00	0.00	0.00	0.00	0.69
$\text{LogNumTrades}_{d,b,t}$	13,767,800	0.04	0.19	0.00	0.00	0.00	0.00	0.00

for quotes and 4% for trades.

The last row in Panel A shows that quotes arrive on average in the morning hours, with a mean between 10AM and 11AM. The last row in Panel B shows that trades take place on average in the afternoon hours, with a mean at about 1PM. Figure 1 documents the distribution of quotes and trades during the day. The left plot shows that quoting activity is slow in the early morning. Quoting spikes up to 17% at 7AM right before trading starts to

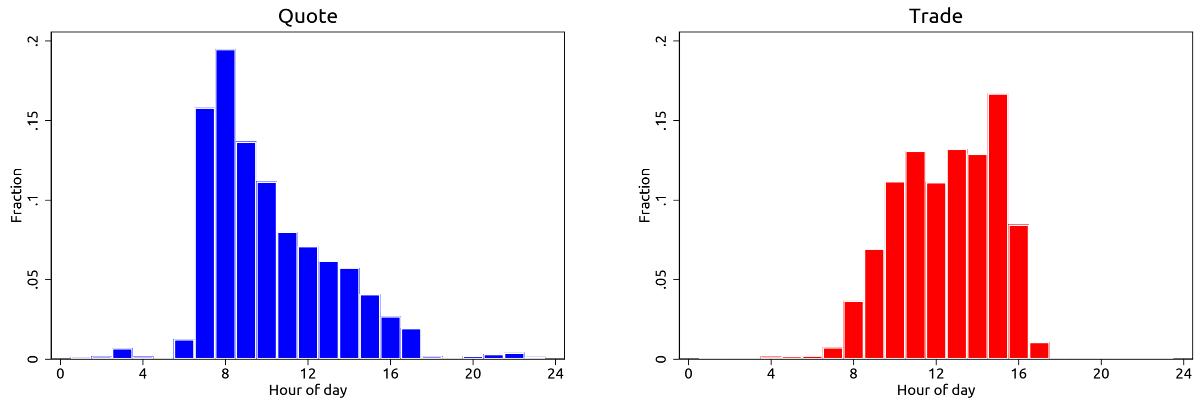

Figure 1: Distribution of quotes and trade during the day

The figure documents the distribution of trades and quotes during the day. We pool all dealer-bond-days and plot the fraction of the quotes (left) and trades (right) that arrive during a given hour.

pick up (right plot). The peak of quoting activity is at 8AM when nearly 20% of all quotes arrive. Quoting activity gradually declines thereafter and hits its lowest simultaneously with the lowest for trading activity at 6PM. Only around 3% of daily quotes arrive at 3PM when the highest fraction of trades take place. The right plot shows that trading is slow between 4AM and 8AM, then it picks up and plateaus at about 12%-13% of daily trades, staying at this level until 3PM when the fraction of daily trades jumps to its highest value of 17%, before declining dramatically after 4PM. These results are indicative of the lead-lag intraday relation between quotes, which lead, and trades, which lag.

2 Do Dealer Quotes Matter for Trading?

Dealer quotes are indicative and as such non-binding and may not matter for trading.

Dealers' quoting activity can reduce clients' search costs by directing them to dealers who compete via quoting to signal their willingness to trade, and it can allow dealers to better manage their inventory risk by attracting orders when needed. Such quote competition relies on dealer quotes attracting trades, which we investigate in this section at daily and intraday frequencies. If quoting is based on superior information by the dealers, this asymmetric information channel suggests, in turn, that quoting may reduce trading activity. We explore the relation between quoting activity and extensive, the trade probability, and intensive, the number of trades, margins of trading activity at the individual dealer level.

2.1 Daily relation between quotes and trades

We start with a univariate analysis of quoting and trading within the CliQ dealers. To examine quoting and trading within the CliQ dealers, we estimate the probability of having a trade depending on quoting activity in the same bond on the same day by the same dealer using the balanced panel of 13,767,800 dealer-bond-day observations. We calculate the daily trade probability in the same bond on the same day by dealer conditional on that dealer having/not having a quote. We separate institutional and retail trades using trade size as a proxy and splitting the sample into small, $<$\$100K, and large, $\geq$\$100K, trades. We examine risk by splitting the sample into investment grade and high-yield bonds.

Table 2 reports dealer-level results. Trade is more likely to take place on days with quoting activity, 5.7% than on days without quoting activity, 3.9%, although the difference, 1.8%, is significant only at 10% level. The split by trade size reveals that all of the effect is driven by large trades, as one would expect if quotes are available only to institutional investors. Large trades are more likely to take place on days with quoting activity, 4.0% than on days without quoting activity, 1.9%, and the difference, 2.1%, is statistically significant at the 1% level. By contrast, the coefficient on having a quote is not statistically significant for small trades. Finally, both IG and HY bonds are more likely to be traded on days with quoting activity, 5.5%/8.9%, than on days without quoting activity, 3.6%/4.9%, and the difference, 1.9%/3.9%, is significant again at the 10% level. The impact of having a quote on the trade probability is greater for HY than IG bonds, likely because HY bonds are harder to price and trade less than IG bonds.

Overall, these results are consistent with the hypothesis that quoting facilitates trading at the individual dealer level. Importantly, all of the effect derives from institution-sized trades. We next use multivariate analysis to further understand the link between quoting and trading at the individual dealer level. We are specifically interested in whether the provision of a dealer quote is related to the likelihood the quoting dealer subsequently has higher trading activity on both the extensive, trade probability and the intensive, number of trades, margins. Our multivariate specifications include dealer-day and bond-day fixed effects.

Table 2: Individual quoting and trading activity

The table documents the relationship between individual dealers' quoting activity and trading activity. We disaggregate quotes and trades by each CliQ dealer at the bond–day level. Standard errors are robust to heteroskedasticity. Significance levels are *** 1%, ** 5%, * 10%.

		Probability of trade by dealer d in bond b on the day t			
	N	All dealer-bond-days	$\text{HasQuote}_{d,b,t} = 0$	$\text{HasQuote}_{d,b,t} = 1$	Δ
$\text{HasTrade}_{d,b,t}$	13,767,800	4.1%	3.9%	5.7%	1.8%*
$\text{HasTrade}_{d,b,t}$, split by:					
Trade size≥\$100K	13,767,800	2.1%	1.9%	4.0%	2.1%***
Trade size<\$100K	13,767,800	2.3%	2.3%	2.3%	0.0%
IG rated	11,100,026	3.8%	3.6%	5.5%	1.9%*
HY rated	2,667,774	5.0%	4.9%	8.9%	3.9%*

Extensive margin of trading activity. We start by estimating a linear probability model for how the occurrence of trades depends on quote provision.[10] The dependent variable of interest is the indicator $\text{HasTrade}_{d,b,t}$, and the explanatory variable of interest is the indicator $\text{HasQuote}_{d,b,t}$. Alternatively, we use $\text{LogNumQuotes}_{d,b,t}$ as the explanatory variable to capture quoting intensity.[11] Quote competition at the dealer level leading to more trading is best identified by dealer quotes in a specific bond and trading with that dealer relative to other dealers. This requires controlling for unobserved factors that may jointly cause dealers to quote more bonds and lead to a higher volume across all dealers. Thus to capture all demand and supply variation that is specific to a given dealer as well as to a given bond traded on any given day, our specifications are panel regressions with saturated fixed effects, i.e., interactions of dealer fixed effects α_d and day fixed effects α_t with bond fixed effects α_b, as follows:

$$\text{HasTrade}_{d,b,t} = \alpha_d \times \alpha_t + \alpha_b \times \alpha_t + \beta \times \left\{ \begin{array}{c} \text{HasQuote}_{d,b,t} \\ \text{LogNumQuotes}_{d,b,t} \end{array} \right\} + \epsilon_{d,b,t}, \qquad (1)$$

Standard errors are robust to clustering at the dealer, bond, and day levels.

Table 3, Panel A illustrates how an individual dealer's quoting activity relates to her trading activity at the extensive margin. Columns 1 through 4 report results for four variants of specification (1) all of which share the same fixed effects, but use the indica-

[10]Probit and logit results are similar and available upon request.
[11]The distribution of the number of quotes is highly right-skewed.

Table 3: Dealer's quoting activity and order flow

The table documents the determinants of dealer trades. In Panel A, the dependent variable equals one if dealer d trades bond b on the day t, and zero otherwise. In Panel B, the dependent variable equals the natural logarithm of the number of trades plus one by dealer d in bond b on the day t. Estimates are obtained from panel regressions with saturated fixed effects at the dealer–day and bond–day levels. Standard errors are triple clustered at the dealer, bond, and day levels. The lower number of observations compared to Table 1 is due to singletons 67,014 being dropped due to saturated fixed effects. Significance levels are *** 1%, ** 5%, * 10%.

Panel A: Dealer's trading activity, extensive margin				
	(1)	(2)	(3)	(4)
Dependent variable:	$\text{HasTrade}_{d,b,t}$	$\text{HasTrade}_{d,b,t}$	$\text{HasTrade}_{d,b,t}$	$\text{HasTrade}_{d,b,t}$
$\text{HasQuote}_{d,b,t}$	0.039***		0.032***	
	(0.008)		(0.006)	
$\text{LogNumQuotes}_{d,b,t}$		0.048***		0.039***
		(0.008)		(0.006)
$\text{HasQuote}_{d,b,t-1}$			0.221***	0.219***
			(0.011)	(0.011)
fe	Saturated	Saturated	Saturated	Saturated
r2	0.147	0.149	0.189	0.190
N	13,700,786	13,700,786	13,606,945	13,606,945

Panel B: Dealer's trading activity, intensive margin				
	(1)	(2)	(3)	(4)
Dependent variable:	$\text{LogNumTrades}_{d,b,t}$	$\text{LogNumTrades}_{d,b,t}$	$\text{LogNumTrades}_{d,b,t}$	$\text{LogNumTrades}_{d,b,t}$
$\text{HasQuote}_{d,b,t}$	0.035***		0.027***	
	(0.008)		(0.006)	
$\text{LogNumQuotes}_{d,b,t}$		0.043***		0.034***
		(0.007)		(0.005)
$\text{LogNumQuotes}_{d,b,t-1}$			0.264***	0.263***
			(0.016)	(0.016)
fe	Saturated	Saturated	Saturated	Saturated
r2	0.155	0.157	0.214	0.215
N	13,700,786	13,700,786	13,606,945	13,606,945

tor $\text{HasQuote}_{d,b,t}/\text{LogNumQuotes}_{d,b,t}$ alone in Columns 1 and 2 and with lagged variable $\text{HasQuote}_{d,b,t-1}$ in Column 3 and 4. The regression coefficient on $\text{HasQuote}_{d,b,t}$, β, captures the difference in the trade probability when the same dealer is quoting in the same bond.[12]

Column 1 of Panel A shows the estimate of β is 0.039, which is statistically significant at the 1% level. This is more than twice as high as its univariate counterpart from Table 2 which is equal to 0.018. This is because unlike the change in the *unconditional* trade probability reported in Table 2, β captures the change in the trade probability *conditional* on the

[12]Table A.1 in the Appendix explores dealers' quoting activity and order flow using alternative specifications with triple fixed effects at dealer, bond, and day level. The coefficient estimates are consistent with Table 3.

saturated fixed effects. The estimate of β in Column 3, with the lagged quote indicator included in specification (1), is 0.032 (statistically significant at the 1% level). Economically, these estimates imply that when dealer d quotes in bond b on the day t dealer d's trade probability in the same bond on the same day is 3.9%/3.2% higher.

When $\text{LogNumQuotes}_{b,t}$ is the explanatory variable instead of $\text{HasQuote}_{b,t}$, its regression coefficient is 0.048/0.039 (Column 2/4), significant at the 1% level. Economically these imply that doubling[13] the number of quotes by dealer d in bond b on the day t translates into the trade probability being 4.8%/3.9% higher for the same dealer in the same bond on the same day. In summary, bonds with quotes are more likely to be traded than bonds without quotes on the same day by the quoting dealer even after controlling for past trading. The magnitude of the difference is both economically and statistically significant.

Intensive margin of trading. We next examine the intensive trading margin through the relation between quoting and the number of trades by the quoting dealer. The dependent variable of interest is $\text{LogNumTrades}_{d,b,t}$ which is defined as the natural logarithm of the number of trades by dealer d in bond b on the day t plus one, given that the dealer trades. Similar to the extensive margin of trading, our base specifications for the intensive margin of trading are panel regressions with saturated fixed effects. Standard errors are robust to clustering at the dealer, bond, and day levels. Once again, in specifications (3) and (4), we include the lagged quote variable as an additional control to account for persistence in quoting behavior.

Panel B of Table 3 has the same layout as Panel A and shows that quoting relates to the dealer's trading activity at the intensive margin. Column 1 of Panel B shows the estimate of β is 0.035 and it is statistically significant at the 1% level. Economically, it implies that when dealer d quotes in bond b on the day t dealer d's number of trades in the same bond on the same day is 3.5% higher. The estimate of β in Column 3, with the lagged trade indicator included in specification (1), is 0.027 and it is statistically significant at the 1% level.

When $\text{LogNumQuotes}_{b,t}$ is used as the explanatory variable instead of $\text{HasQuote}_{b,t}$, its regression coefficient is 0.043/0.034 (Column 2/4), statistically significant at the 1% level. Economically it implies that doubling the number of quotes by dealer d in bond b on the day t translates into the number of trades by the same dealer being 4.3%/3.4% higher in the

[13]Panel C of Table 1 shows the average number of quotes by dealer d in bond b on date t is 1.

same bond on the same day.

These findings establish a strong relation between daily quoting activity and daily trading activity for an individual dealer on a bond-day. When dealers decide whether to quote or not, they jointly set the aggressiveness of their quotes. Therefore, we next explore the impact of quote aggressiveness on trading activity.

2.2 Quote quality, trade size and order flow

Given that dealers trade more when they quote, we next study whether dealers trade more when they quote more aggressively. This is because for quote competition to be effective, more aggressive quotes should attract more order flow. We analyze this relation by examining the quality of dealers' quotes within a bond and relate it to dealers' order flow. We also explore how quotes affect trading for different size. Large trades are typically done by institutions and they have access to quotes. In contrast, small trades are often done by retail investors and they do not have direct access to quotes.

Measuring quote quality. To capture the quality of a dealer's quoted prices relative to other dealers in bond b on day t, let $\text{BidQuote}_{d,b,t}$ and $\text{AskQuote}_{d,b,t}$ be the quoted price at which dealer d quotes a willingness to buy and sell, respectively. We compare the dealer's ask and bid quotes to a benchmark. $\text{BenchmarkAskQuote}_{b,t}$ and $\text{BenchmarkBidQuote}_{b,t}$ are benchmark quotes derived from aggregating the quotes of all dealers in bond b on the day t. We use two alternative benchmarks in the empirical implementation: the average dealer ask or bid quotes (our baseline quote quality measure) and the best offer (BO) or best bid (BB).

We define the bid and ask quote quality of dealer d in bond b on the day t relative to the quotes of all other dealers in the same bond on the same day:

$$\text{QuoteQuality}_{d,b,t} = \begin{cases} \text{BidQuoteQuality}_{d,b,t} = \text{BidQuote}_{d,b,t} - \text{BenchmarkBidQuote}_{b,t}, \\ \text{AskQuoteQuality}_{d,b,t} = \text{BenchmarkAskQuote}_{b,t} - \text{AskQuote}_{d,b,t}. \end{cases} \tag{2}$$

$\text{QuoteQuality}_{d,b,t}$ is a measure of the price aggressiveness of dealer d's quotes relative to the respective benchmark quotes across all CliQ dealers. A positive $\text{QuoteQuality}_{d,b,t}$ means that the dealer d's quote is at a better price than the benchmark quote in bond b on the day t. When we examine how quote quality relates to order flow, we average the $\text{BidQuoteQuality}_{d,b,t}$ and $\text{AskQuoteQuality}_{d,b,t}$ from the same dealer on the same day. When the dealer provides multiple quotes on the same day, we average across quotes on the same side of the market. When one side is missing, we use the side that is not missing. When we quantify price improvement, we use the last quote prior to the trade. $\text{QuoteQuality}_{d,b,t}$ is set to zero when $\text{BenchmarkBid/AskQuote}_{b,t}$ are undefined or when the dealer does not provide a quote on a bond-day.

To analyze whether the order flow of dealer d quoting in bond b on date t increases with quote quality, we estimate the following specifications with saturated fixed effects:

$$\left\{ \begin{array}{c} \text{HasTrade}_{d,b,t} \\ \text{LogNumTrades}_{d,b,t} \end{array} \right\} = \alpha_d \times \alpha_t + \alpha_b \times \alpha_t + \beta_1 \times \text{QuoteQuality}_{d,b,t} + \\ + \beta_2 \times \left\{ \begin{array}{c} \text{HasQuote}_{d,b,t} \\ \text{LogNumQuotes}_{d,b,t} \end{array} \right\} + \epsilon_{d,b,t}, \quad (3)$$

with standard errors robust to clustering at the dealer, bond, and day levels. To control for variation in quoting activity, we include explanatory variables that capture quoting activity by dealer d in bond b on date t.

We start with the relationship between quote quality and the extensive margin of trading. Panel A of Table 4 shows that the regression coefficient on $\text{QuoteQuality}_{d,b,t}$ is 0.028 and statistically significant at the 5% level. Economically, it implies that if dealer d's quote quality in bond b on the day t is one standard deviation (22bps from Panel A of Table 1) higher, then the probability of trading by that dealer in that bond on that day is 0.0062 higher. The dealer-level probability of trading conditional on quoting is 0.057 (5.7%) from Panel B of Table 2, implying that a dealer with one standard deviation better quote quality has a higher trade probability at the dealer-bond-day level of 10.88% (0.0062/0.057=0.1088). Because the mean $\text{QuoteQuality}_{d,b,t}$ is zero in bond b on the day t, the coefficient on $\text{HasQuote}_{d,b,t}$ is 0.039, which is the same as the coefficient from Column 1 of Panel A of Table 3.

Column 2 investigates the relationship between quote quality and the intensive margin of trading. The regression coefficient on $\text{QuoteQuality}_{d,b,t}$ is 0.026 and statistically significant at the 1% level. Economically, it implies that a dealer d having one standard deviation (22bps) better quote quality in bond b on the day t has 0.57% more trades in that bond on that day.

Quoting and large vs. small trades. Given that quotes are sent to institutional clients only, we further refine the hypothesis by focusing on trades of different sizes as a proxy for institutional trading as opposed to retail trading. Our hypothesis is that quoting increases institutional order flows but not retail orders. Retail-sized trades can thus be used as a control group under our maintained hypothesis. Accordingly, we estimate specification (3) on the whole sample and on sub-samples of large (trade size $\geq$ \$100K) and small (trade size $<$ \$100K) trades.[14]

Panels B and C of Table 4 show that the positive relationship between quote quality and trade probability at the dealer-bond-day level is due to large trades (trade size $\geq$ \$100K, Column 2). While the regression coefficients on $\text{QuoteQuality}_{d,b,t}$ are positive in both panels, only the former is economically and statistically significant. For large trades, the estimate of 0.030 means economically that if dealer d has one standard deviation better quote quality in bond b on the day t, the probability of executing a large trade is 0.66% higher. The dealer-level probability of a large trade conditional on quoting is 0.04 (4.0%) from Panel B of Table 2, implying that a one standard deviation improvement in quote quality results in a 16.5% (0.0066/0.04=0.165) higher probability of a large trade at the dealer-bond-day level.

Column 2 confirms that the relation between quote quality and the intensive margin is due to large trades (Panel B) for whom $\beta_1 = 0.027$ is positive and statistically significant at the 1% level. In contrast, β_1 for small trades (Panel C) is equal to -0.001 and it is not statistically significant. Comparing Panel B and C, the coefficients on $\text{HasQuote}_{d,b,t}/\text{LogNumQuotes}_{d,b,t}$ are about three times larger for institutional sized trades than retail trades. Thus, quote quality is important mostly for large trades. As a robustness check, Table A.2 in the Appendix reports these findings using the distance of the best quote as a measure of quote quality. The main results are quite similar to the results reported in Table 4.

In summary, our findings suggest that dealers use quotes to compete for order flow and advertise their willingness to trade. Dealers with better quotes trade more at the extensive and intensive margin at the dealer-bond-day level. The relation of both quote *quantity* and *quality* to order flow is concentrated primarily in large trades. For small trades, having

[14]We selected the trade size threshold of \$100K to account for order splitting by institutions. Our conclusions are similar when the threshold for identifying large trades is (trade size$\geq$\$1 million). The higher threshold makes it more likely that the client is an institution.

Table 4: Importance of quote quality for order flow

The table documents the importance of quote quality for order flow. The dependent variable captures the trading activity by dealer d in bond b on the day t by $\text{HasTrade}_{d,b,t}$ or $\text{LogNumTrades}_{d,b,t}$. Quote quality is the distance to the average quote. Estimates are obtained from panel regressions with saturated fixed effects at the dealer–day and bond–day levels. The lower number of observations compared to Table 1 is due to singletons 67,014 being dropped due to saturated fixed effects. Standard errors are triple clustered at the dealer, bond, and day levels. Significance levels are *** 1%, ** 5%, * 10%.

	(1)	(2)
	$\text{HasTrade}_{d,b,t}$	$\text{LogNumTrades}_{d,b,t}$
Panel A: Impact of quote quality on dealer's trading activity		
$\text{QuoteQuality}_{d,b,t}$	0.028**	0.026***
	(0.011)	(0.009)
$\text{HasQuote}_{d,b,t}$	0.039***	
	(0.008)	
$\text{LogNumQuotes}_{d,b,t}$		0.043***
		(0.007)
fe	Saturated	Saturated
r2	0.147	0.157
N	13,700,786	13,700,786
Panel B: Impact of quote quality on large trades (trade size ≥\$100K)		
$\text{QuoteQuality}_{d,b,t}$	0.030***	0.027***
	(0.009)	(0.008)
$\text{HasQuote}_{d,b,t}$	0.031***	
	(0.006)	
$\text{LogNumQuotes}_{d,b,t}$		0.034***
		(0.005)
fe	Saturated	Saturated
r2	0.133	0.154
N	13,700,786	13,700,786
Panel C: Impact of quote quality on small trades (trade size <\$100K)		
$\text{QuoteQuality}_{d,b,t}$	0.001	-0.001
	(0.005)	(0.005)
$\text{HasQuote}_{d,b,t}$	0.013***	
	(0.004)	
$\text{LogNumQuotes}_{d,b,t}$		0.011***
		(0.003)
fe	Saturated	Saturated
r2	0.132	0.135
N	13,700,786	13,700,786

a quote is associated with a higher trade probability and a higher quoting frequency is associated with a greater trading activity; however, for small trades quote quality is related to neither trade probability nor trading intensity.

2.3 Do Indicative Quotes Increase Trading Volume, or Just Redistribute Order Flow?

We next examine whether bond-day quoting activity provides a positive externality by attracting higher aggregate trading activity, or whether quoting simply leads to a redistribution of order flow from non-quoting dealers to quoting dealers. Dealers' advertising of quotes diminishes search frictions for investors which, according to search-based theories of OTC trading (e.g., Duffie, Garleanu, and Pedersen (2005)), can increase trade surplus and trading volume. Quote competition allows investors to access the market more easily, regardless of their relationships with dealers. In turn, small and mid-tier dealers can more readily compete with large established dealers.

Specifically, we investigate how quoting and competition impact trading by non-CliQ dealers. Intuitively, quoting lowers search frictions thus improving aggregate trading volume, consistent with predictions from the search literature (e.g., Duffie, Garleanu, and Pedersen, 2005). While quoting by non-CliQ dealers is not directly observable in the data, it is possible to analyze whether the aggregate trading volume, trading volume by CliQ dealers, and the market share of CliQ dealers are all higher when CliQ-dealers provide quotes.

To examine daily trading at the bond level we construct for bond b on the day t the number of CliQ trades, $\text{CliQNumTrades}_{b,t} = \sum_d \text{NumTrades}_{d,b,t}$, where the summation is over all CliQ dealers $d = 1, ..., D$, the total number of trades, $\text{TotalNumTrades}_{b,t} = \text{CliQNumTrades}_{b,t} + \text{non-CliQNumTrades}_{b,t}$, where $\text{non-CliQNumTrades}_{b,t}$ is the number of non-CliQ trades in bond b on date t, and the market share of CliQ dealers, $\text{CliQTradeShare}_{b,t} = \frac{\text{CliQNumTrades}_{b,t}}{\text{TotalNumTrades}_{b,t}}$.[15]

We define quote supply in bond b on day t as:

$$\begin{aligned} \text{QuoteSupply}_{b,t}^{ext} &= \textstyle\sum_d \text{w}_{d,b,t} \times \text{HasQuote}_{d,b,t}, \\ \text{QuoteSupply}_{b,t}^{int} &= \textstyle\sum_d \text{w}_{d,b,t} \times \text{NumQuotes}_{d,b,t}, \end{aligned} \tag{4}$$

where $\text{w}_{d,b,t}$ captures the dealers' activity shares and $\text{HasQuote}_{d,b,t}$ and $\text{NumQuotes}_{d,b,t}$ are the extensive and intensive margins of dealer d's bond-specific quoting activity, respectively. $\text{QuoteSupply}_{b,t}^{ext/int}$ capture the market-wide quote activity for bond b on date t.

[15]This sample is not restricted to bonds quoted or traded by CliQ dealers, thus adding 17 bonds for a total of 1,406,564 bond-day observations.

A potential concern with explaining aggregate trading activity by $\text{QuoteSupply}_{b,t}^{ext/int}$ is that common shocks can affect both a bond's trading activity and dealers' incentives to quote. To identify an instrument for quoting activity and/or quote quality that is unrelated to a dealer's willingness to trade, one potential approach is to use exogenous shocks that affect dealers' quoting behavior but are unrelated to their trading incentives. In the spirit of the Bartik (1991) shift-share instrument, we can use the granular nature of our quoting data to isolate variation in quoting activity due to differential impact of common shocks on dealers with distinct predetermined exposures from dealer-specific incentives to quote and trade certain bonds on certain days. A natural way to do this is to exploit the heterogeneity in the prior propensity of dealers to trade certain bonds due to information, issuer-dealer relationships, dealer-client relationships, and other factors.

Appendix C provides a detailed discussion of our Bartik construction. Our choice of lagged weights/exposures $\text{w}_{d,b,t-1}$, in constructing the Bartik-IV, $\widehat{\text{QuoteSupply}}_{b,t}^{ext/int}$, is based on the observation that dealer institutional shares vary across bonds and these shares are relevant for dealers' incentives to quote (Goldsmith-Pinkham et al., 2020). Following Borusyak, Hull, Jaravel (2022), we aggregate $\text{HasQuote}_{d,b,t}$ and $\text{NumQuotes}_{d,b,t}$ over all bonds $b = 1, ..., B$ to capture the extensive and intensive margins of dealer d's total quoting activity on day t replacing the dealer-bond-day level variables in expression (4). The predicted quote supply in a bond is then a weighted average of the market-wide quoting rates of each dealer ("the shift"), with weights depending on the past distribution of the trading activity ("the shares"). The exclusion restriction is that the quoting dealers' share of past trading in institutional sizes is uncorrelated with the bond's quote demand shock at time t.

Our specification to check if quote supply affects trading is a bond-day 2SLS regression with bond, α_b, and day, α_t, fixed effects:

$$y_{b,t} = \alpha_b + \alpha_t + \beta \times \widehat{\text{QuoteSupply}}_{b,t}^{ext/int} + \epsilon_{b,t}. \tag{5}$$

The dependent variable, $y_{b,t}$, is either the number of trades in bond b on the day t by CliQ dealers natural log-transformed, $\log(\text{CliQNumTrades}_{b,t})$, or the market/trade share of CliQ dealers in bond b on the day t, $\text{CliQTradeShare}_{b,t}$, or the total number of trades in bond b on the day t by CliQ and non-CliQ dealers natural log-transformed, $\log(\text{TotalNumTrades}_{b,t})$.

The explanatory variable of interest is the extensive/intensive margin of the aggregate quote supply in bond b on date t, $\text{QuoteSupply}_{b,t}^{ext/int}$, instrumented by $\widehat{\text{QuoteSupply}}_{b,t}^{ext/int}$ as defined in Appendix C. Variation explained by bond characteristics and market conditions is controlled for by bond fixed effects α_b and day fixed effects α_t. Standard errors are robust to clustering at the bond and day levels.

Table 5 summarizes the results from specification (5) for trades by CliQ dealers (Panel A), the market share of trades by CliQ dealers (Panel B), and all trades (Panel C). Columns 1 and 2 report results from specification (5) for $\text{QuoteSupply}_{b,t}^{int/ext}$ based on $\text{NumQuotes}_{d,b,t}$ and/or $\text{HasQuote}_{d,b,t}$. We perform underidentification tests using the Anderson LM statistic and weak identification tests based on the Cragg-Donald Wald F-statistic and Stock-Yogo critical values. For comparison, Columns 3 and 4 report OLS estimates from specification (5) for $\text{QuoteSupply}_{b,t}^{int/ext}$ based on $\text{LogNumQuotes}_{b,t}/\text{HasQuote}_{b,t}$.

Panel A of Table 5 shows that quoting increases the number of trades by CliQ dealers as the regression coefficients on the intensive and extensive margins of quote supply, equal to 0.014 and 0.513 respectively, are positive and statistically significant at the 1% level. Economically the regression coefficient on the intensive margin of the aggregate quote supply implies that a standard deviation increase in $\text{QuoteSupply}_{b,t}^{int}$ results in 8.8% increase in the number of trades by CliQ dealers in this bond on that day. For comparison, the OLS regression coefficient on $\text{LogNumQuotes}_{b,t}$ is equal to 0.121 (statistically significant at the 1% level) thus implying that a 10% increase in the number of quotes leads to a 1.21% increase in the number of trades by CliQ dealers in this bond on that day. The regression coefficient on the extensive margin of the aggregate quote supply implies that a standard deviation increase in $\text{QuoteSupply}_{b,t}^{ext}$ results in 11.8% increase in the number of trades by CliQ dealers in this bond on that day. Once again, for comparison, the OLS regression coefficient on $\text{HasQuote}_{b,t}$ is equal to 0.128 (statistically significant at the 1% level) meaning that having a quote increases the number of trades by CliQ dealers by 12.8% in this bond on that day. While the point estimates are quantitatively different between the IV and OLS specifications, they result in somewhat similar economic implications for the number of CliQ trades.

Panel B of Table 5 shows that the market share of trades by CliQ dealers in bond b on date t is also higher when they quote this bond on that day. The regression coefficients on the intensive and extensive margins of quote supply, equal to 0.001 and 0.049 respectively, are positive and statistically significant at the 1% level. Economically the regression coefficient on the intensive margin of the aggregate quote supply implies that a standard deviation

Table 5: Quote supply and aggregate trading activity

The table documents the relationship between CliQ dealers' quote supply and trading activity by CliQ dealers and non-CliQ dealers. We split trades by CliQ dealers versus non-CliQ dealers and collapse all trades at the bond-day level. In columns (1) and (2), we use the share of institutional-sized trades over the window [-20,-1] as our measure of dealers' exposure and the dealer's aggregate quotes from (C.3) as quote activity on the day t to construct our instrument. Estimates are obtained from panel regressions with bond and day fixed effects. Standard errors are double clustered at the bond and day levels. Significance levels are *** 1%, ** 5%, * 10%.

	IV				OLS	
	(1)	(2)	(3)	(4)	(5)	(6)
	1^{st} stage	2^{nd} stage	1^{st} stage	2^{nd} stage		
Panel A: Impact of quote supply on CliQ dealer trading activity						
Dependent variable: $\log(\text{CliQNumTrades}_{b,t})$						
$\widehat{\text{QuoteSupply}}^{ext}_{b,t}$	5.191***					
	(0.135)					
$\text{QuoteSupply}^{ext}_{b,t}$		0.117***			0.041***	
		(0.005)			(0.002)	
$\widehat{\text{QuoteSupply}}^{int}_{b,t}$			0.444***			
			(0.008)			
$\text{QuoteSupply}^{int}_{b,t}$				0.440***		0.255***
				(0.018)		(0.006)
fe	Bond, Date	Bond, Date	Bond, Date	Bond, Date	Bond, Date	Bond, Date
r2	0.103	-0.001	0.127	0.017	0.433	0.435
Underidentification LM-test	988.91 (p=0.00)		1565.86 (p=0.00)			
Weak identification F-test	1485.87 (p=0.00)		2991.58 (p=0.00)			
N	1,406,564		1,406,564		1,406,564	1,406,564
Panel B: Impact of quote supply on CliQ dealer market share						
Dependent variable: $\text{CliQTradeShare}_{b,t}$						
$\widehat{\text{QuoteSupply}}^{ext}_{b,t}$	5.644***					
	(0.157)					
$\text{QuoteSupply}^{ext}_{b,t}$		0.018***			0.011***	
		(0.001)			(0.001)	
$\widehat{\text{QuoteSupply}}^{int}_{b,t}$			0.426***			
			(0.008)			
$\text{QuoteSupply}^{int}_{b,t}$				0.066***		0.084***
				(0.006)		(0.002)
fe	Bond, Date	Bond, Date	Bond, Date	Bond, Date	Bond, Date	Bond, Date
r2	0.099	0.004	0.116	0.007	0.101	0.103
Underidentification LM-test	833.62 (p=0.00)		1385.59 (p=0.00)			
Weak identification F-test	1291.86 (p=0.00)		2690.29 (p=0.00)			
N	796,294		796,294		796,294	796,294
Panel C: Impact of quote supply on aggregate trading activity						
Dependent variable: $\log(\text{TotalNumTrades}_{b,t})$						
$\widehat{\text{QuoteSupply}}^{ext}_{b,t}$	5.191***					
	(0.135)					
$\text{QuoteSupply}^{ext}_{b,t}$		0.227***			0.047***	
		(0.010)			(0.003)	
$\widehat{\text{QuoteSupply}}^{int}_{b,t}$			0.444***			
			(0.008)			
$\text{QuoteSupply}^{int}_{b,t}$				0.846***		0.307***
				(0.035)		(0.010)
fe	Bond, Date	Bond, Date	Bond, Date	Bond, Date	Bond, Date	Bond, Date
r2	0.103	-0.002	0.127	0.024	0.614	0.614
Underidentification LM-test	988.91 (p=0.00)		1565.86 (p=0.00)			
Weak identification F-test	1485.87 (p=0.00)		2991.58 (p=0.00)			
N	1,406,564		1,406,564		1,406,564	1,406,564

increase in $\text{QuoteSupply}_{b,t}^{int}$ results in an additional 0.8% CliQ dealers' market share in this bond on that day. For comparison, the OLS regression coefficient on $\text{LogNumQuotes}_{b,t}$ is equal to 0.021 (statistically significant at the 1% level) thus implying that a 10% increase in the number of quotes leads to an additional 0.21% CliQ dealers' market share in this bond on that day. The regression coefficient on the extensive margin of the aggregate quote supply implies that a standard deviation increase in $\text{QuoteSupply}_{b,t}^{ext}$ also results in an additional 0.8% CliQ dealers' market share in this bond on that day. Once again, for comparison, the OLS regression coefficient on $\text{HasQuote}_{b,t}$ is equal to 0.021 (statistically significant at the 1% level) meaning that having a quote adds 2.1% to the CliQ dealers' market share in this bond on that day. This evidence is consistent with customers substituting towards CliQ dealers when they quote and/or CliQ dealers' quotes attracting customers to trade who would not have traded otherwise.

Panel C of Table 5 shows that the total number of trades in bond b on date t increases when it is quoted on that day. The regression coefficients on the intensive and extensive margins of quote supply, equal to 0.027 and 0.939 respectively, are positive and statistically significant at the 1% level. Economically the regression coefficient on the intensive margin of the aggregate quote supply implies that a standard deviation increase in $\text{QuoteSupply}_{b,t}^{int}$ results in 16.1% increase in the total number of trades in this bond on that day. For comparison, the OLS regression coefficient on $\text{LogNumQuotes}_{b,t}$ is equal to 0.193 (statistically significant at the 1% level) thus implying that a 10% increase in the number of quotes leads to a 1.93% increase in the total number of trades in this bond on that day. The regression coefficient on the extensive margin of the aggregate quote supply implies that a standard deviation increase in $\text{QuoteSupply}_{b,t}^{ext}$ results in 22.8% increase in the total trading volume in this bond on that day. Once again, for comparison, the OLS regression coefficient on $\text{HasQuote}_{b,t}$ is equal to 0.235 (statistically significant at the 1% level) meaning that having a quote increases the total number of trades by 23.5% in this bond on that day.

Overall, consistently across specifications, more active quoting by CliQ dealers causes higher aggregate trading activity, more trading by CliQ dealers, and a higher share of trades by CliQ dealers. Thus, quote competition is not a zero-sum game which is important for investor welfare considerations.

2.4 Intraday lead-lag relation between quotes and trades

A concern with the prior analysis may be that quotes and trades overlap. To address this potential issue, we now take the lead-lag structure between quotes and trades explicitly into account. We first show that most of the quotes are sent out before trading picks up. Figure 1 shows that the quoting activity peaks at 8AM and then gradually declines through the rest of the day until 6pm when it almost stops. Therefore, a large proportion of quotes were sent out before noon. The arrival times of trades are typically later. Trading activity is low at 8AM and then increases between 8AM and 11AM then plateaus between 11AM and 3PM, spikes at 3PM and then winds down by 5PM. A larger share of trades happens after noon.

Panel A of Table 6 provides additional statistics for AM (before noon) and PM (afternoon) quotes and trades. The average AM/PM number of quotes is 0.127/0.052 while the average AM/PM number of trades is 0.024/0.042. Overall these results are indicative of the lead-lag intraday relation between quotes and trades to examine the lead-lag relation.

Our specification is a VAR for the extensive trading, $\text{HasTrade}_{d,b,t}$, and quoting, $\text{HasQuote}_{d,b,t}$, margins with saturated fixed effects:

$$\begin{pmatrix} \text{HasTrade}^{PM}_{d,b,t} \\ \text{HasQuote}^{PM}_{d,b,t} \end{pmatrix} = \alpha_d \times \alpha_t + \alpha_b \times \alpha_t + \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix} \begin{pmatrix} \text{HasTrade}^{AM}_{d,b,t} \\ \text{HasQuote}^{AM}_{d,b,t} \end{pmatrix} + \begin{pmatrix} \epsilon^1_{d,b,t} \\ \epsilon^2_{d,b,t} \end{pmatrix}, \tag{6}$$

and we also estimate the same VAR specification for the intensive quoting, $\text{LogNumQuotes}_{d,b,t}$, and trading, $\text{LogNumTrades}_{d,b,t}$, margins. Our main test is whether morning quotes predict afternoon trades after controlling for morning trades. In addition, we test whether morning trades predict afternoon quotes after controlling for morning quotes.

Panel B of Table 6 reports our findings from specification (6). Columns 1/2 and 3/4 present results for the extensive/intensive margin. Having an AM *quote* by dealer d in bond b increases the PM trade probability by the same dealer in the same bond on the same day by 0.022 (by 2.2%, Column 1). The result is statistically significant at the 1% level. Having AM *trade* by dealer d in bond b increases the PM trade probability by the same dealer in the same bond on the same day by 0.209 (20.9%, Column 1). Increasing the number of AM *quotes* by dealer d in bond b from one to two increases the number of PM trades by the same dealer in the same bond on the same day by 2.5% (Column 2). The result is also statistically

Table 6: Predicting PM trades and PM quotes

The table documents the predictability of PM trades and PM quotes by AM quotes and AM trades. Panel A provides summary statistics. In Panel B, estimates are obtained from panel regressions with saturated fixed effects (i.e., dealer-day and bond-day fixed effects) as specified in the respective column. Standard errors are triple clustered at the dealer, bond, and day levels. The lower number of observations compared to Table 1 is due to 67,014 singletons being dropped due to saturated fixed effects. Significance levels are *** 1%, ** 5%, * 10%.

Panel A: Number of trades and quotes AM and PM

Variable	Obs	Mean	Std. Dev.	Min	Max
No. trades AM	13,767,800	0.024	0.251	0	204
No. trades PM	13,767,800	0.042	0.526	0	316
No. quotes AM	13,767,800	0.127	0.601	0	28
No. quotes PM	13,767,800	0.052	0.440	0	28

Panel B: VAR

	(1)	(2)	(3)	(4)
Dependent variable:	$\text{HasTrade}^{PM}_{d,b,t}$	$\text{LogNumTrades}^{PM}_{d,b,t}$	$\text{HasQuote}^{PM}_{d,b,t}$	$\text{LogNumQuotes}^{PM}_{d,b,t}$
$\text{HasQuote}^{AM}_{d,b,t}$	0.022***		0.221***	
	(0.005)		(0.038)	
$\text{HasTrade}^{AM}_{d,b,t}$	0.209***		0.022**	
	(0.009)		(0.008)	
$\text{LogNumQuotes}^{AM}_{d,b,t}$		0.025***		0.364***
		(0.004)		(0.061)
$\text{LogNumTrades}^{AM}_{d,b,t}$		0.255***		0.013*
		(0.013)		(0.007)
fe	Saturated	Saturated	Saturated	Saturated
r2	0.155	0.173	0.291	0.411
N	13,700,786	13,700,786	13,700,786	13,700,786

significant at the 1% level. Increasing the number of AM *trades* by dealer d in bond b from one to two increases the number of PM trades by the same dealer in the same bond on the same day by 25.5% (Column 2). Therefore, AM quotes facilitate PM trading by the same dealer in the same bond on the same day even after controlling for trade persistence.

Having an AM *quote* by dealer d in bond b increases the PM quote probability by the same dealer in the same bond on the same day by 0.221 (22.1%, Column 3). The result is statistically significant at the 1% level. Having an AM *trade* by dealer d in bond b increases the PM trade probability by the same dealer in the same bond on the same day by 0.022 (2.2%, Column 3). Increasing the number of AM *quotes* by dealer d in bond b from one to two increases the number of PM quotes by the same dealer in the same bond on the same day by 36.4% (Column 4). The result is also statistically significant at the 1% level. Increasing the number of AM *trades* by dealer d in bond b from one to two increases the number of

PM quotes by the same dealer in the same bond on the same day by 1.3% (Column 4). Therefore, AM trades facilitate PM quoting by the same dealer in the same bond on the same day even after controlling for quote persistence.

Overall, the results show that there exists a strong lead-lag intraday relation between quotes and trades. Quotes are more prevalent in the morning than in the afternoon and tend to facilitate the afternoon trades by the same dealer in the same bond on both the extensive and intensive margins even after controlling for trade persistence.

3 Dealers' Motives for Quoting

Exploring why dealers quote bid and ask prices in the corporate bond market is a first step in understanding their impact on trading activity, price discovery, and market quality. Quoting bid and ask prices may serve several purposes for dealers and investors. The basic channels of bid-ask quotes that we explore are:

- *Advertising:* Dealers act as market makers by signaling they are willing to buy and sell bonds at quoted prices. Dealers' quoting activity reduces clients' search costs and directs them to dealers who signal their willingness to trade. Quoting thus facilitates trading by matching buyers with sellers and ensuring that investors can buy or sell bonds at any given time. By offering attractive bid and ask quotes, dealers increase their own trading volume potentially at the expense of other dealers.

- *Information asymmetry:* Dealers may possess more information about market conditions, including the demand for and credit quality of specific bonds, than individual investors. By quoting bid and ask prices, dealers may exploit information asymmetry and gain from superior information vis-a-vis other market participants. This may diminish trust and confidence in the market, leading to reduced trading activity.

- *Inventory and risk management:* Dealers quote bid and ask prices as part of their risk management and inventory management strategies. By updating prices based on market conditions, dealers can manage their inventory levels and exposure to various bonds. Dealers may also strategically quote depending on the inventory of their connected dealers, competing with them or supporting them.

- *Access to market:* Quoting bid and ask prices allows investors to access the market more easily, regardless of their preexisting relationships with dealers. In turn, smaller dealers by quoting can more readily compete with larger, more established dealers. Hence, investors can trade with any dealer offering competitive prices, expanding smaller dealers' market reach and investors' market access and reducing the markets' dependence on individual client-dealer relationships.

Overall, while these motives are not mutually exclusive they suggest that quoting bid and ask prices in the corporate bond market may serve multiple economic purposes. Each of these channels contributes differently to the functioning of the bond market and benefits investors and dealers differently.

3.1 Role of quoting in market making and risk management

To test these hypotheses, we start by exploring the determinants of dealers' quoting activity. The market making hypothesis implies that, if bid and ask prices reflect dealers' willingness to trade, then dealers with special expertise in the bond, such as the bond's lead underwriter, should exhibit a higher propensity to quote specific bonds than other dealers. The information asymmetry hypothesis implies that, if bid and ask prices reflect dealers' private information about market conditions, then changes in quoting activity should precede new information becoming public. To test this hypothesis, we focus on whether changes in bid-ask activity anticipates (or follows) the release of market-moving information such as rating changes. The inventory management hypothesis implies that, if bid and ask prices are used for risk management and inventory control, then dealers' quoting behavior should be influenced by factors related to their inventory levels and risk exposure. The testable hypothesis is that bid-ask activity varies with changes in inventory turnover, bond maturity, and credit rating. Dealers with larger inventories or higher risk exposure may increase quoting activity to mitigate risk.

Table 7 presents the determinants of dealers' decision to quote at the ask or bid, ask only, and bid only in the corporate bond market. The dependent variables are $\text{HasQuote}_{d,b,t}$, an indicator variable representing whether a dealer has quoted a price for a particular bond on a specific date, $\text{HasAskQuote}_{d,b,t}$, an indicator variable representing whether a dealer has quoted an ask price for a particular bond on a specific date, $\text{HasBidQuote}_{d,b,t}$, an indicator

Table 7: Determinants of quoting

The table documents the determinants of dealers' decision to quote at the ask or bid, ask only, and bid only. Standard errors are robust to clustering at the dealer and bond level. Significance levels are *** 1%, ** 5%, * 10%.

	(1)	(2)	(3)
Dependent variable:	$\text{HasQuote}_{d,b,t}$	$\text{HasAskQuote}_{d,b,t}$	$\text{HasBidQuote}_{d,b,t}$
Dealer type:			
Lead Underwriter	0.027**	0.026**	0.027**
	(0.011)	(0.010)	(0.011)
Underwriter	0.015	0.015	0.015
	(0.010)	(0.011)	(0.010)
Bond type:			
Rating	-0.006***	-0.005***	-0.005***
	(0.002)	(0.001)	(0.002)
Log Years to Mature	0.012*	0.014*	0.014**
	(0.007)	(0.007)	(0.007)
Log Age of Bond Yr	0.008***	0.008***	0.008***
	(0.002)	(0.002)	(0.002)
Log Size of Issuance	0.009***	0.009***	0.006**
	(0.003)	(0.003)	(0.003)
MTN	0.004	0.003	0.002
	(0.007)	(0.006)	(0.007)
Rule 144a Bond	0.009	0.008	0.010*
	(0.006)	(0.006)	(0.006)
Private Placement	0.005	0.008	0.008
	(0.013)	(0.013)	(0.013)
Log No. of Institutional Investors	-0.000	-0.001	0.001
	(0.006)	(0.005)	(0.005)
Private information event:			
Rating Change in next 5 days	-0.010	-0.009	-0.008
	(0.006)	(0.006)	(0.006)
Dealer risk management:			
Inventory Change	0.005***	0.005***	0.003**
	(0.002)	(0.002)	(0.001)
Inventory Change, Connected Dealer	-0.001	-0.001	-0.001
	(0.003)	(0.003)	(0.003)
Constant	-0.013	-0.026	-0.000
	(0.041)	(0.039)	(0.039)
fe	Dealer, Date	Dealer, Date	Dealer, Date
r2	0.128	0.130	0.130
N	14,031,768	14,031,768	14,031,768

variable representing whether a dealer has quoted a bid price for a particular bond on a specific date. The explanatory variables are split into four categories: Dealer type indicates whether the dealer is a lead underwriter or underwriter; bond type includes indicators for types of bonds such as Medium Term Note (MTN), Rule 144a Bond, and Private Placement. Bond characteristics include factors like bond rating, years to maturity, age of bond in years, size of issuance, and number of institutional investors holding the bond. For the private information events, we include an indicator for the time period prior to a rating change in the next 5 days. To capture dealers' risk management, we include variables related to inventory changes in the bond at the dealer and whether the dealer is connected to an inventory change by another dealer. The coefficients represent the effect of each independent variable on the likelihood of a dealer quoting a price, either at the bid or ask, or both based on the following panel linear probability specification with standard errors that are robust to clustering at the dealer and bond levels:

$$\begin{aligned} \text{HasQuote}_{d,b,t} = \alpha_d + \alpha_t + \beta_1 \times \text{Dealer type}_{d,b} + \beta_2 \times \text{Bond type}_{b,t} + \\ + \beta_3 \times \text{Info event}_{d,t} + \beta_4 \times \text{Dealer risk management}_{d,b,t} + \epsilon_{d,b,t}. \end{aligned} \quad (7)$$

Table 7 reports the β coefficients which provide insights into the factors influencing dealers' quoting behavior in the corporate bond market, including dealer characteristics, bond characteristics, private information events, and dealer risk management strategies. Lead underwriters exhibit a higher likelihood of quoting bid and ask prices compared to underwriters, suggesting that dealers with more prominent roles in bond issuance are more active in providing liquidity by quoting. Among bond characteristics, higher bond ratings and longer time to maturity are associated with an increased likelihood of quoting bid and ask prices, while older bonds and larger issuances also increase the likelihood of quoting. Rule 144a bonds exhibit a slightly higher probability of bid quoting, indicating potential differences in liquidity provision for these types of bonds. Interestingly, private information events, such as anticipated rating changes, do not significantly influence dealers' quoting decisions, suggesting that exploiting private information about bond fundamentals is not a major concern for quoting. Regarding risk management, changes in dealer inventory positively impact quoting behavior, particularly bid quoting, suggesting dealers adjust their quoting activity based on inventory levels. When we test whether dealers quote strategically in response to connected dealers' inventory changes, we find a negative but statistically insignificant effect, potentially indicating the lack of power.

Overall, these results document the importance of dealer characteristics, bond attributes, and risk management strategies in shaping quoting behavior, highlighting the importance of liquidity provision for investors and risk management considerations for dealers.

3.2 Do dealer quotes substitute for relationships?

To test the market access hypothesis, we pursue a different approach and collect additional data on insurance companies trading with dealers. The prior literature has shown that insurance companies often possess long-term relationships with a small number of bond dealers and these client-dealer relationships matter for client execution quality. H4 suggests that dealer quotes can substitute for relationships in the corporate bond market. Dealer quotes provide transparent pricing information, allowing investors to compare prices without relying solely on relationships with specific dealers. This reduces the need for relationships to obtain pricing information. In addition, quotes allow investors to access the market more broadly, irrespective of their relationships with individual dealers. Investors can trade with any dealer offering competitive prices, reducing dependence on specific relationships for market access. Finally, quote competition encourages dealers to offer better prices and improve their services to attract trading volume. This competition benefits investors by providing better execution prices and tighter bid-ask spreads, reducing the reliance on relationships for obtaining favorable terms. However, while dealer quotes can substitute for some aspects of relationships, relationships still play a significant role in the bond market.

To test this channel, we define the relationship dealer for each insurer as being the top half counterparties of the same insurer over the period from Jan 1, 2019 to Sep 30, 2019. We define non-relationship dealers as the remainder for each insurer. We define an indicator Trade with non-relationship CliQ $\text{dealer}_{i,b,t}$ that equals one if insurer i trades bond b on date t with a non-relationship CliQ dealer, and zero if the trade occurs with a relationship CliQ dealer. We then perform the following logit regression for the probability of trading with a non-relationship CliQ dealer (1) as opposed to a relationship CliQ dealer (0):

$$\text{Trade with non-relationship CliQ dealer}_{i,b,t} = \alpha + \beta \times \text{HasQuote}_{i,b,t} + \delta' \mathbf{X}_{i,b,t} + \epsilon_{i,b,t}. \quad (8)$$

Table 8 summarizes the results and provides evidence for the hypothesis that dealer quotes substitute for relationships. The table presents evidence on whether dealer quoting affects insurers' choice to trade with relationship or non-relationship dealers in the corporate bond market. Panel A provides univariate tabulations of trades between insurers and CliQ dealers, categorized by whether the dealer is a relationship dealer or a non-relationship dealer and whether the dealer quotes or not. The results first confirm that a higher percentage of trades occur with relationship dealers when compared to non-relationship dealers, regardless of quoting activity. However, the results also show that a higher percentage of trades occurs with non-relationship dealers when they quote.

Panel B of Table 8 presents the multivariate logit regression results for the probability of trading with a non-relationship CliQ dealer versus a relationship CliQ dealer. The coefficients indicate the effect of dealer quoting behavior on insurers' trading decisions, controlling for various bond and market characteristics. The results suggest that the presence of dealer quotes, particularly bids and asks simultaneously, increases the likelihood of trading with non-relationship dealers compared to relationship dealers. This finding suggests that dealer quotes may substitute for established relationships in facilitating bond trades, highlighting the importance of quoting behavior in shaping trading patterns in the corporate bond market.

3.3 Quoting alters client-dealer matching

A concern with the analysis in Table 8 is that it focuses exclusively on insurers' choice among CliQ dealers while ignoring non-CliQ dealers which may attenuate the quotes' effect on switching being estimated. To overcome this issue, we study insurers' trade choices more broadly. Insurers can trade with their relationship dealer or a non-relationship dealer irrespective of whether the (non-)relationship dealer is in CliQ. To model insurer i's trade choice $Y_{i,b,t}$ in bond b on date t, we consider four possibilities with CliQ relationship dealers being the baseline: relationship CliQ dealer ($Y_{i,b,t} = 0$), non-relationship CliQ dealer ($Y_{i,b,t} = 1$), non-relationship non-CliQ dealer ($Y_{i,b,t} = 2$), relationship non-CliQ dealer ($Y_{i,b,t} = 3$).

In a multinomial choice model of insurer-dealer matching, we estimate a set of coefficients, β_d, $d = 1, 2, 3$, corresponding to each outcome relative to the baseline:

$$\Pr(\text{Trade with } Y_{i,b,t} = d) = \frac{e^{\beta_d' \mathbf{X}_{i,b,t}}}{1 + \sum_{\mathbf{d}=1,2,3} e^{\beta_{\mathbf{d}}' \mathbf{X}_{i,b,t}}}, \qquad d = 1, 2, 3. \tag{9}$$

We estimate (9) using multinomial logit and report the β_d coefficients in Table 9. Since $\Pr(\text{Trade with } Y_{i,b,t} = 0) = 1/(1 + \sum_{\mathbf{d}=1,2,3} e^{\beta_{\mathbf{d}}' \mathbf{X}_{i,b,t}})$, the relative probability of $Y_{i,b,t} = d$ to the base outcome is the relative risk,

$$\frac{\Pr(\text{Trade with } Y_{i,b,t} = d)}{\Pr(\text{Trade with } Y_{i,b,t} = 0)} = e^{\beta_d' \mathbf{X}_{i,b,t}}. \tag{10}$$

Table 8: Dealer quotes substitute for relationships

The table document whether dealer quoting affects insurers' choice to trade with a relationship or non-relationship CliQ dealers. Panel A tabulates the dealer type, relationship CliQ dealer vs. non-relationship CliQ dealer, against an indicator of whether the CliQ dealer quotes on that bond or not. The sample consists of all trades between insurers and CliQ dealers. Relationship dealer is defined as being the top half counterparties of the same insurer over the period from Jan 1, 2019 to Sep 30, 2019. Panel B documents logit regression results for the probability of trading with a non-relationship CliQ dealer (1) as opposed to a relationship CliQ dealer (0). All results are conditional on the dealer being a CliQ dealer. Standard errors are robust to heteroskedasticity. Significance levels are *** 1%, ** 5%, * 10%.

Panel A: Insurer trades with relationship vs. non-relationship CliQ dealers, univariate

	Relationship dealer	Non-relationship dealer	Total
NoQuote	84,821	11,763	96,584
%	*87.82%*	*12.18%*	100.00%
HasQuote	8,633	3,164	11,797
%	*73.18%*	*26.82%*	*100.00%*
Total	93,454	14,927	108,381
%	*86.23%*	*13.77%*	*100.00%*

Panel B: Insurer trades with relationship vs. non-relationship CliQ dealers, logit analysis

	(1)	(2)	(3)
Dependent variable:	Trade with non-relationship CliQ dealer	Buy from non-relationship CliQ dealer	Sell to non-relationship CliQ dealer
HasQuote	0.896***		
	(0.127)		
HasOnlyAskQuote		1.277***	0.616***
		(0.184)	(0.212)
HasOnlyBidQuote		1.091***	0.931***
		(0.339)	(0.299)
HasAskAndBidQuote		0.850***	0.600***
		(0.170)	(0.145)
Controls	Yes	Yes	Yes
Pseudo R^2	0.046	0.057	0.038
N	107,499	84,144	23,355

	(1)	(2)	(3)
HasQuote	0.879***		
	(0.130)		
HasOnlyAskQuote		1.282***	0.614***
		(0.184)	(0.212)
HasOnlyBidQuote		1.089***	0.933***
		(0.345)	(0.299)
HasAskAndBidQuote		0.818***	0.600***
		(0.179)	(0.146)
Dealer Quote Quality	0.964**		
	(0.397)		
Dealer Ask Quote Quality		0.543**	0.269**
		(0.223)	(0.119)
Dealer Bid Quote Quality		0.301	-0.054
		(0.321)	(0.387)
Controls	Yes	Yes	Yes
Pseudo R^2	0.046	0.057	0.038
N	107,499	84,144	23,355

Table 9 summarizes the multinomial logit estimates examining insurers' dealer choices in the corporate bond market. Column (1) shows the effect of dealer quoting behavior on insurers' choice of counterparties. The coefficient for HasQuote is statistically significant and positive, indicating that the presence of dealer quotes increases the likelihood of insurers trading with non-relationship CliQ dealers compared to relationship CliQ dealers. The coefficient 2.479 indicates that quoting increases the baseline probability more than 11 fold ($e^{2.479} = 11.93$). Columns (2) and (3) present additional factors influencing insurers' trade choices, including trade size, bond characteristics, market volatility (VIX), and the number of relationship dealers. These results highlight the impact of dealer quoting behavior on insurer-dealer matching decisions in the corporate bond market, emphasizing the important role of dealer quotes in shaping trading counterparties.

We repeat the estimation in Panels B and C of Table 9 separately for insurer buys from dealers (Panel B) and insurer sells to dealers (Panel C). To capture the effect of CliQ dealers' quotes on insurers' choices, we replace HasQuote with all three possibilities: HasOnlyAskQuote which equals one if the dealer provides an ask quote only, and zero otherwise, HasOnlyBidQuote which equals one if the dealer provides a bid quote only and zero otherwise, and HasAskAndBidQuote which equals one if the dealer provides both an ask and bid quote and zero otherwise. The results corroborate the notion that quoting by CliQ dealers alters insurer-dealer matching in their favor.

4 Do Clients Benefit from Indicative Quoting?

The previous sections show that consistent with quote competition being important, a dealer's order flow and bond-level trading volume are higher in the presence of quoting. Next, we investigate the relationship between dealer quotes and client execution quality.

4.1 Measuring client execution quality

To more systematically examine the relationship between quotes and trade prices, we explore the link between quoting, quote quality, and client execution quality. We define client execution quality with dealer d in bond b on date t in terms of the transaction cost that the client faces on the trade. Lower transaction costs are tantamount to better client execution

Table 9: Quoting alters client-dealer matching

The table documents estimates from a multinomial logit model for insurers' trade choices. We consider four possibilities with CliQ relationship dealers being the baseline: relationship CliQ dealer ($Y_{i,b,t} = 0$), non-relationship CliQ dealer ($Y_{i,b,t} = 1$), non-relationship non-CliQ dealer ($Y_{i,b,t} = 2$), relationship non-CliQ dealer ($Y_{i,b,t} = 3$). We only report coefficients for the relevant category non-relationship CliQ dealer, $Y_{i,b,t} = 1$. The sample includes all trades between insurers and dealers during the period when we have CliQ quote information for the subset of bonds in our CliQ sample. Standard errors are robust to heteroskedasticity. Significance levels are *** 1%, ** 5%, * 10%.

	(1)	(2)	(3)
Dependent variable:	Trade with non-relationship CliQ dealer	Buy from non-relationship CliQ dealer	Sell to non-relationship CliQ dealer
HasQuote	2.479***		
	(0.106)		
HasOnlyAskQuote		2.814***	2.165***
		(0.178)	(0.226)
HasOnlyBidQuote		2.672***	2.607***
		(0.313)	(0.276)
HasAskAndBidQuote		2.426***	2.244***
		(0.139)	(0.143)
Controls	Yes	Yes	Yes
N	471,462	371,711	99,751

	(1)	(2)	(3)
Dependent variable:	Trade with non-relationship CliQ dealer	Buy from non-relationship CliQ dealer	Sell to non-relationship CliQ dealer
HasQuote	2.459***		
	(0.108)		
HasOnlyAskQuote		2.819***	2.163***
		(0.177)	(0.226)
HasOnlyBidQuote		2.669***	2.608***
		(0.321)	(0.277)
HasAskandBidQuote		2.391***	2.245***
		(0.145)	(0.143)
Dealer Quote Quality	1.078***		
	(0.417)		
Dealer Ask Quote Quality		0.615**	0.241**
		(0.240)	(0.115)
Dealer Bid Quote Quality		0.333	-0.079
		(0.334)	(0.388)
Controls	Yes	Yes	Yes
N	471,462	371,711	99,751

quality. To compute client execution quality, we compare the traded price to a benchmark price:

$$\text{ClientExecutionQuality}_{d,b,t} = \begin{cases} \text{Price}_{d,b,t} - \text{BenchmarkPrice}_{b,t}, & \text{for dealer buy trades,} \\ \text{BenchmarkPrice}_{b,t} - \text{Price}_{d,b,t}, & \text{for dealer sell trades.} \end{cases} \tag{11}$$

We compare the trade price $\text{Price}_{d,b,t}$ to a reference price at the time of the trade denoted by $\text{BenchmarkPrice}_{b,t}$ in order to measure client execution quality.[16] We use two alternative proxies for the benchmark price on the transaction. In our base case, we define $\text{BenchmarkPrice}_{b,t}$ as the Bank of America Merrill Lynch (BAML) end-of-day quote on the same bond on the day prior to the transaction.[17] Alternatively, following Hendershott and Madhavan (2015), we define $\text{BenchmarkPrice}_{b,t}$ as the price on the last interdealer trade prior to the transaction.[18] We require the last interdealer trade to be no more than 3 calendar days before the trade.

Client execution quality as defined in expression (11) is essentially the negative of trading costs, with higher execution quality indicating lower transaction costs. While two alternate benchmarks are used to construct $\text{ClientExecutionQuality}_{d,b,t}$, for ease of exposition we report in this section results only for the benchmark based on the BAML end-of-day quote on the same bond on the day prior to the transaction; Table A.3 in the Appendix provides results for the alternate benchmark. Panel B of Table 1 provides basic descriptive statistics for $\text{ClientExecutionQuality}_{d,b,t}$ and Panel A of Table 10 supplements these with additional descriptive statistics for client execution quality split by trade size and credit rating.

The average/median execution quality is -37bps/-15bps. The standard deviation of 1.75% implies a large dispersion in execution quality. Smaller trades receive on average worse execution quality than larger trades, -54bps versus -24bps. The execution quality for IG bonds is on average slightly better than that for speculative-grade bonds, -36bps versus -40bps. Overall, consistent with the prior literature (e.g., Edwards, Harris and Piwowar

[16]For convenience, here we use the same subscripts as before, although technically there could be multiple transactions by the same dealer on the same day in the same bond. This could be accommodated by adding a fourth subscript.

[17]Because BAML end-of-day quotes are available only for the bid side, we add 15bps (equal to half of the sample average effective spread) to the benchmark level to make the bid- and ask-sides comparable. Hendershott et al. (2020) provide a detailed description of BAML quotes.

[18]In case the dealer has multiple trades in the bond, the interdealer benchmark may vary over the day. While we use a benchmark price specific to the transaction, our notation suppresses this for ease of notation.

(2007)), there exists significant heterogeneity in the execution quality across different trade sizes and bond credit ratings.

4.2 Impact of dealer quotes on client execution quality

We proceed to use multivariate analysis to link execution quality to quoting using the following specification:

$$\text{ClientExecutionQuality}_{ijt} = \alpha_i + \alpha_j + \alpha_t + \beta \times \text{HasQuote}_{ijt} + \delta \times \text{QuoteQuality}_{ijt} + \\ + \gamma \times \text{QuoteUpdate}_{jt} + \epsilon_{ijt}, \quad (12)$$

where $\text{QuoteQuality}_{ijt}$ is defined in (2) and QuoteUpdate_{jt} is defined in (16). In specification (12), the coefficients β and δ capture the degree to which a dealer's quotes relate to the prices at which the dealer executes a trade. XXX Define QUOTEUPDATE

Panel B of Table 10 documents results from specification (12) on how a dealer's quote quality relates to client execution quality. Results are reported for the pooled sample (Column 1), large trades (Column 2), and small trades (Column 3). In column 1, the coefficient δ is positive suggesting that clients obtain better executions when they trade with the dealer posting a better quote. It also shows that 68% of quote quality is passed through to the execution quality (Column 1), with most of the effect driven by the large trades for whom the pass-through is 93.1% (Column 2), while it is equal to only 17.2% for small trades (Column 3), which is not statistically significant. To the extent that a small trade size proxies for retail investors, the results suggests that indicative quotes do not benefit retail investors to the same extent as institutional investors. This likely reflects that less sophisticated participants such as retail investors do not have access to dealer quotes. The results also suggest that, even for institutional clients, quotes are meaningful but not completely firm.

Identity (15) lends itself to estimating the degree to which dealer quotes matter for client execution quality. Quotes matter if they are good or/and lead to bilateral negotiations between dealer and client. We, therefore, split $\text{QuoteQuality}_{d,b,t}$ defined in (2) into its positive,

Table 10: Client execution quality and dealer quotes

The table documents the relationship between the client execution quality of dealer quotes and quote quality. Estimates are obtained from panel regressions with saturated fixed effects at the dealer–day and bond–day levels, and day fixed effects interacted with a buy-sell indicator $\text{DealerSellTrade}_{d,b,t}$ indicator (not reported for space consideration). Standard errors are triple clustered at the dealer, bond, and day levels. Significance levels are *** 1%, ** 5%, * 10%.

Panel A: Descriptive statistics on $\text{ClientExecutionQuality}_{d,b,t}$

	N	Mean	SD	5%	25%	50%	75%	95%
$\text{ClientExecutionQuality}_{d,b,t}$	417,512	-0.37	1.75	-2.87	-0.64	-0.15	0.13	1.43
$\text{ClientExecutionQuality}_{d,b,t}$, split by:								
Trade size≥$100K	233,106	-0.24	1.79	-2.72	-0.53	-0.12	0.19	1.81
Trade size<$100K	184,406	-0.54	1.67	-3.02	-0.81	-0.19	0.07	0.85
IG rated	303,876	-0.36	1.69	-2.71	-0.55	-0.13	0.12	1.16
HY rated	113,636	-0.40	1.88	-3.18	-0.88	-0.22	0.16	2.09

Panel B: Impact of dealer's quote quality on client execution quality

	Dependent variable: $\text{ClientExecutionQuality}_{d,b,t}$		
	(1)	(2)	(3)
	All trades	Trade size≥$100K	Trade size<$100K
$\text{HasQuote}_{d,b,t}$	0.319***	0.318***	0.135***
	(0.055)	(0.054)	(0.036)
$\text{QuoteQuality}_{d,b,t}$	0.680***	0.931***	0.172
	(0.139)	(0.148)	(0.151)
$\text{QuoteUpdate}_{b,t}$	0.880***	0.954***	0.475***
	(0.074)	(0.076)	(0.086)
fe	Saturated	Saturated	Saturated
r2	0.463	0.302	0.786
N	270,050	124,847	99,647

Panel C: Asymmetric impact of quote quality on client execution quality

	Dependent variable: $\text{ClientExecutionQuality}_{d,b,t}$		
	(1)	(2)	(3)
	All trades	Trade size≥$100K	Trade size<$100K
$\text{HasQuote}_{d,b,t}$	0.251***	0.230***	0.117**
	(0.049)	(0.049)	(0.048)
$\text{QuoteQuality}^{+}_{d,b,t}$	1.520***	1.862***	0.440
	(0.199)	(0.230)	(0.302)
$\text{QuoteQuality}^{-}_{d,b,t}$	-0.381	-0.321	-0.135
	(0.259)	(0.326)	(0.405)
$\text{QuoteUpdate}_{b,t}$	0.888***	0.960***	0.479***
	(0.074)	(0.075)	(0.085)
fe	Saturated	Saturated	Saturated
r2	0.463	0.302	0.786
N	270,050	124,847	99,647

$\text{QuoteQuality}^{+}_{d,b,t}$, and negative, $\text{QuoteQuality}^{-}_{d,b,t}$, parts:

$$\begin{aligned}\text{QuoteQuality}_{d,b,t} = {} & \text{QuoteQuality}^{+}_{d,b,t} \times \mathbb{1}\{\text{QuoteQuality}_{d,b,t} \geq 0\} + \\ & + \text{QuoteQuality}^{-}_{d,b,t} \times \mathbb{1}\{\text{QuoteQuality}_{d,b,t} < 0\},\end{aligned}$$

where $\mathbb{1}\{\cdot\}$ is the indicator function. $\text{QuoteQuality}^{+/-}_{d,b,t}$ captures quotes that are better/worse than the benchmark quote. The following specification to estimate how quote quality relates to execution quality is then used:

$$\begin{aligned}\text{ClientExecutionQuality}_{d,b,t} = {} & \alpha_d \times \alpha_t + \alpha_b \times \alpha_t + \beta \times \text{HasQuote}_{d,b,t} + \\ & + \delta^{+} \times \text{QuoteQuality}^{+}_{d,b,t} + \delta^{-} \times \text{QuoteQuality}^{-}_{d,b,t} + \\ & + \gamma_1 \times \text{QuoteUpdate}_{b,t} + \gamma_2 \times \alpha_t \times \text{DealerSellTrade}_{d,b,t} + \epsilon_{d,b,t},\end{aligned} \tag{13}$$

To control for possible asymmetries due to the trade direction during stress periods, we include day fixed effects interacted with a buy-sell indicator, $\text{DealerSellTrade}_{d,b,t}$, that equals one if dealer d sells bond b on the day t and zero otherwise.

In specification (13), the coefficients δ^{+} and δ^{-} capture the sensitivity of prices at which the dealer executes a trade to the dealer's quote quality. If $\delta^{+} = \delta^{-} = 0$, then client execution quality is unrelated to quote quality and quotes are not meaningful for prices, and, according to relation (15), all of the execution quality comes from price improvement. The hypothesis $H_0 : \delta^{+} = \delta^{-} = 0$ thus provides a test for whether quotes affect client execution quality. If $\delta^{+} = \delta^{-} = 1$, then quotes are firm and, according to relation (15), all of the execution quality comes from quote quality. The hypothesis $H_0 : \delta^{+} = \delta^{-} = 1$ thus provides a test for whether quotes are firm.

An asymmetry between δ^{+} and δ^{-} indicates that dealers respond differently to good and bad quotes. For positive quote quality, $\delta^{+} > 1$ implies that dealers indicate trade interest with good quotes and offer even better prices via negotiation. $\delta^{+} \in (0, 1)$ implies that dealers also indicate trade interest with good quotes but not all of the quote quality is passed through to execution quality. For negative quote quality, $\delta^{-} < 0$ again implies that quotes are not entirely firm and dealers improve execution quality via price improvement in bilateral negotiations. In this case, price improvement compensates more than one-to-one for a dealer's bad quotes. In the limit when $\delta^- = 0$ the client execution quality is determined entirely by good quotes. $\delta^- > 0$ would mean that investors trade with dealers despite their poor quote quality and price improvement only partially offsets the dealers' bad quotes.

Results in Panel C Table 10 points to a striking difference between the effect of high- and low-quality quotes on execution quality. For pooled trades (Column 1), the coefficient δ^+ equals 1.520, which is significantly different from zero at 1%. Economically, it means that one standard deviation (13bps) increase in quote quality results in a 19.8bps improvement in execution quality. The coefficient δ^- equals -0.381, which is not statistically significant. This indicates that inferior quotes are not relevant for execution quality as dealers compensate for bad quotes via price improvement. When the sample is split between large (Column 2) and small (Column 3) trades, once again almost all of the effect derives from large trades. The coefficient δ^+ for large trades equals 1.862, which is significantly different from zero at 1%, while the coefficient δ^+ equals 0.440 for small trades and it is neither statistically nor economically significant. The coefficient δ^- for large trades equals -0.321 and equals -0.135 for small trades, with both coefficients being neither statistically nor economically significant.

The coefficient on $\text{HasQuote}_{d,b,t}$ equals 0.251 and is statistically significant at the 1% level for all trades pooled (Column 1). Economically it means that the average execution quality is 25.1bps higher on bond days when dealer d quotes bond b versus days when not quoting that bond. When we split the sample between large (Column 2) and small (Column 3) trades, we find that the coefficient γ_1 on $\text{HasQuote}_{d,b,t}$ for large trades equals 0.230 and is statistically significant at the 1% level, while γ_1 for small trades equals 0.117. These results imply that for small trades having any quote matters for the execution quality, but quote quality does not. The regression coefficients on $\text{DealerSellTrade}_{d,b,t}$ are neither statistically nor economically significant across all specifications.

In summary, quotes matter for trades and the competition between dealers on quotes relates to trade outcomes. The aggressiveness of quotes (quote quality) by the transacting dealer translates into better prices for large trades. However, quote quality does not translate to better execution quality for small trades.

To further understand the "price improvement" channel of execution quality, we next investigate the determinants of price improvement over quotes.

4.3 Trade throughs and client execution quality

To understand the firmness of dealer quotes and the conditions when they are not firm, we investigate the relation between the trade price and the best-quoted prices. Figure 2 plots the fraction of trades that occur at a price worse than the best dealer quote that is less than one hour old. Consistent with our prior trade size findings, quotes matter more for large trades as large trades are significantly less likely to occur at prices worse than the best quote for all dealer types. The best-quoting dealer trades at or better than the best price significantly more often than other dealers. Other dealers trade at worse prices than the best quote roughly 30% of the time. Finally, within the sample of CliQ-dealer trades in Figure 2 the best-quoting dealer attracts the next trade 15.4% of the time, 20.3% for large trades, and 6.5% for small trades.[19] Overall, unlike in a frictionless market, trades frequently occur at prices worse than the best-quoted price and often occur with dealers not quoting the best price. While Figure 2 shows quote competition is far from perfect, Figure 2 still shows that the best quote leads to better trade prices, which could explain why dealers with better quotes get more order flow.

While better quotes attract order flow and improve client execution quality on average, we find that they do so imperfectly.

4.4 Price improvement from quotes

The previous section documents that quoted prices differ from traded prices. Here we analyze if dealers trade at better or worse prices than their quotes. Dealer quotes can affect client execution quality for at least three reasons. Dealers compete for order flow by updating their quotes over the benchmark price. Dealers attract order flow by posting more aggressive quotes relative to their peers, as captured by QuoteQuality. Dealers improve bilaterally negotiated prices over their quoted prices to the extent that quotes are not entirely firm.

To check if and when clients can negotiate better prices than dealers' quotes (Hendershott et al., 2020), we construct a price improvement measure that captures the improvement of the trade price over the last available quote. We first match each trade to the last quote prior to the trade by the same dealer on the same day for the same bond on the same side of the trade. We require that either $\text{BidQuote}_{d,b,t}$ or $\text{AskQuote}_{d,b,t}$ arrives before the

[19] These findings are similar to those in Harris (2015).

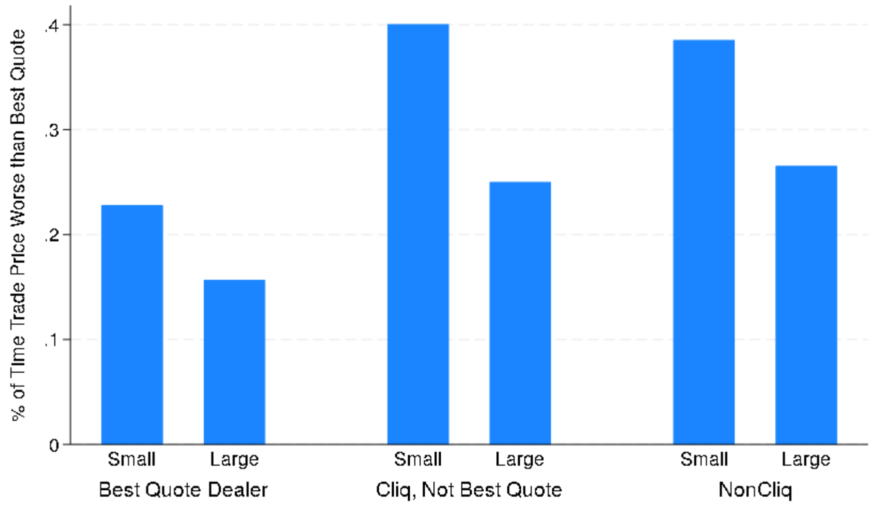

Figure 2: Fraction of trades occurring at prices worse than best quote

The figure documents the fraction of trades that occur at a price worse than the best dealer quote that is less than one hour old. Fractions are calculated by small ($< \$100,000$) and large ($\geq \$100,000$) trade sizes for the best-quoting dealer, CliQ dealers who are not quoting or quoting at an inferior price, and non-CliQ dealers.

trade. Roughly 8% of all trades can be matched to such a quote. For each quote-trade pair, following Petersen and Fialkowski (1994) we define $\text{PriceImprovement}_{d,b,t}$ depending on whether it is a dealer sell or buy:

$$\text{PriceImprovement}_{d,b,t} = \begin{cases} \text{Price}_{d,b,t} - \text{BidQuote}_{d,b,t}, & \text{for dealer buy trades,} \\ \text{AskQuote}_{d,b,t} - \text{Price}_{d,b,t}, & \text{for dealer sell trades.} \end{cases} \quad (14)$$

Price improvement is one potential channel for why dealers' quotes are not entirely firm. A positive $\text{PriceImprovement}_{d,b,t}$ means that the client executed at a price better than the last available quote.

Relations (2)–(14) for $\text{QuoteQuality}_{d,b,t}$, $\text{ClientExecutionQuality}_{d,b,t}$, and $\text{PriceImprovement}_{d,b,t}$, respectively, allow for a convenient decomposition of the client's execution quality by dealer d in bond b on the day t into three components: the price improvement negotiated with the dealer after establishing contact, quote quality of the dealer in the bond at the time of contact, and the aggregate quote update over the benchmark price (e.g., yesterday's BAML quote) for the bond on the same day:

$$\text{ClientExecutionQuality}_{d,b,t} = \text{PriceImprovement}_{d,b,t} + \text{QuoteQuality}_{d,b,t} + \text{QuoteUpdate}_{b,t}. \tag{15}$$

In decomposition (15), the first term captures the impact of price negotiations on clients' transaction costs, the second term captures the relative quote aggressiveness of the transacting dealer, and the third term captures the quote updating behavior in aggregate across all CliQ dealers:

$$\text{QuoteUpdate}_{b,t} = \begin{cases} \text{BenchmarkBidQuote}_{b,t} - \text{BenchmarkPrice}_{b,t}, & \text{for dealer buy trades,} \\ \text{BenchmarkPrice}_{b,t} - \text{BenchmarkAskQuote}_{b,t}, & \text{for dealer sell trades.} \end{cases} \tag{16}$$

By comparing quotes across all CliQ dealers to the benchmark price, $\text{QuoteUpdate}_{b,t}$ allows us to capture updates to the midquote together with any systematic widening or narrowing of quoted spreads across dealers.

For dealer d in bond b on date t, price improvement captures the improvement of the trade price over the last available quote offered by the dealer, given by expression (14). Trades that are not preceded by a quote from the same dealer in the same bond on the same day are eliminated as we cannot compute price improvement. By identity (15) price improvement is one of several components of the client execution quality studied in the previous section.

Table 11 reports price improvement overall, by trade size, by bond credit rating, and by quote quality. The sample average/median price improvement across all trades reported in Panel A is 7bps/3bps with a standard deviation of 75bps. The sample average price improvement of 7bps is economically significant compared to the average execution quality of -37bps. The price improvement can be as high/low as 89bps/-75bps for some trades. Most of the price improvement occurs for large trades. The average/median price improvement for large trades is 12bps/4bps with a standard deviation of 71bps, while for small trades it is -11bps/0bps with a standard deviation of 83bps. This is not surprising since retail investors, who are mostly responsible for small trades, are unlikely to receive quotes. In contrast, institutions are more likely to receive quotes and thus also benefit from quote competition in the form of price improvement. IG and HY bonds have similar price improvements. The average/median price improvement for IG bonds is 7bps/3bps with a standard deviation of

Table 11: Price improvement over quote

The table documents the price improvement over the dealer's quote defined in (14) at the dealer-bond-day level. We use the last quote provided by the dealer as the relevant dealer quote. Trades that are not preceded by a quote from the same dealer in the same bond on the same day are eliminated since we cannot compute price improvement.

Panel A: Descriptive statistics on $\text{PriceImprovement}_{d,b,t}$								
	Mean	SD	5%	25%	50%	75%	95%	N
$\text{PriceImprovement}_{d,b,t}$ (\$)	0.07	0.75	-0.75	-0.04	0.03	0.19	0.89	40,844
$\text{PriceImprovement}_{d,b,t}$ (\$), split by:								
Trade size≥\$100K	0.12	0.71	-0.45	-0.02	0.04	0.21	0.95	31,567
Trade size<\$100K	-0.11	0.83	-1.63	-0.12	0.00	0.12	0.74	9,277
IG rated	0.07	0.74	-0.72	-0.04	0.03	0.18	0.88	37,516
HY rated	0.08	0.75	-1.09	-0.03	0.05	0.25	1.03	3,328
Panel B: $\text{PriceImprovement}_{d,b,t}$, split by $\text{QuoteQuality}_{d,b,t}$								
Quartile of $\text{QuoteQuality}_{d,b,t}$	Mean	SD	5%	25%	50%	75%	95%	N
Low	0.18	0.87	-0.81	-0.02	0.09	0.34	1.27	8,230
2	0.04	0.60	-0.44	-0.03	0.02	0.11	0.52	6,277
3	0.05	0.36	-0.20	-0.02	0.02	0.10	0.43	8,012
High	-0.01	0.83	-1.29	-0.12	0.02	0.21	0.86	8,654
Panel C: $\text{PriceImprovement}_{d,b,t}$, split by VIX_t								
Quartile of VIX_t	Mean	SD	5%	25%	50%	75%	95%	N
Low	0.02	0.37	-0.45	-0.03	0.02	0.12	0.50	10,394
2	0.04	0.38	-0.38	-0.02	0.03	0.14	0.54	10,111
3	0.06	0.71	-0.67	-0.04	0.03	0.19	0.76	10,332
High	0.16	1.20	-1.41	-0.09	0.06	0.40	1.91	10,007

74bps, while for HY bonds it is 8bps/5bps with a standard deviation of 75bps.

Panel B of Table 11 splits $\text{PriceImprovement}_{d,b,t}$ into quartiles by $\text{QuoteQuality}_{d,b,t}$.[20] The univariate sort on the transacting dealer's quote quality shows that better-quality quotes are associated with less improvement of the transaction price over the quoted price. This holds true at the mean, median, and right tail. Dealers thus improve their negotiated prices when they offer poor-quality quotes (18bps/9bps at mean/median for quartile 1). At the other extreme, dealers with very attractive quotes offer little to no price improvement (-1bps/2bps at mean/median for quartile 4).

Overall, price improvement is particularly high for large trades and when a dealer's quote quality is low. These results further support our findings from the previous section. Dealers with good quotes improve transaction prices over their quotes less than dealers with bad

[20]The unequal number of observations in each quartile is due to overdispersion at zero.

quotes. This is consistent with the coefficient δ^+ in specification (12) being greater than one and statistically significant and the coefficient δ^- in the same specification being insignificant.

5 Bond-Day Quote Behavior of Dealers

It is also useful to study not just the quoting decision of individual dealers at the dealer-bond-day level but also the behavior of quotes at the bond-day level. For example, from what bond characteristics are associated with more or better quotes? (Size? Rating? Uncertainty? Recent volume, quotes, or spreads?) Can we learn anything interesting from the dynamics of, say, spreads or the number of dealers providing quotes for a bond?

5.1 Quoting activity over time

Figure 3 provides time-series evidence on aggregate quoting activity over time.[21] Panel A of Figure 3 documents the time series of the daily average number of quoted bonds. One notable observation is that the average number of quoted bonds, the extensive margin of quoting, the average number of daily quotes per bond in Panel B of Figure 3, the intensive margin of quoting, and the average number of dealers quoting in Panel B of Figure 3 all decline around year-end, bottoming out on December 26, 2019, and then rebound back to their pre-holiday levels. Excluding the holiday period, the average number of quoted bonds ranges between 4,500 in late November 2019 and 5,500 in mid-February 2020. The number of quoted bonds decline in late February 2020 right after CDC declares that Covid-19 is heading toward pandemic status. It hits its lowest number on March 20, 2020, when the Federal Reserve expands its program of support for the flow of credit, and then starts climbing back up, reaching around 4,300 in early May 2020.

Panel B of Figure 3 graphs the daily sample average number of quotes per bond. Between October 2019 and late December 2019, the daily average number of quotes per bond fluctuates between 2.8 and 4.5. Quotes rebound to 5 quotes in mid-January 2020 and then decline to 4.5 quotes by late February 2020. Quotes steadily decline with the onset of Covid-19, bottoming out at 2.8 quotes on March 20, 2020. Note that this number is still larger than the number of quotes, 2, on December 26, 2019. The number of quotes per bond slowly increases

[21] Figure A.1 in the Appendix provides additional time-series evidence on quoting and trading activity.

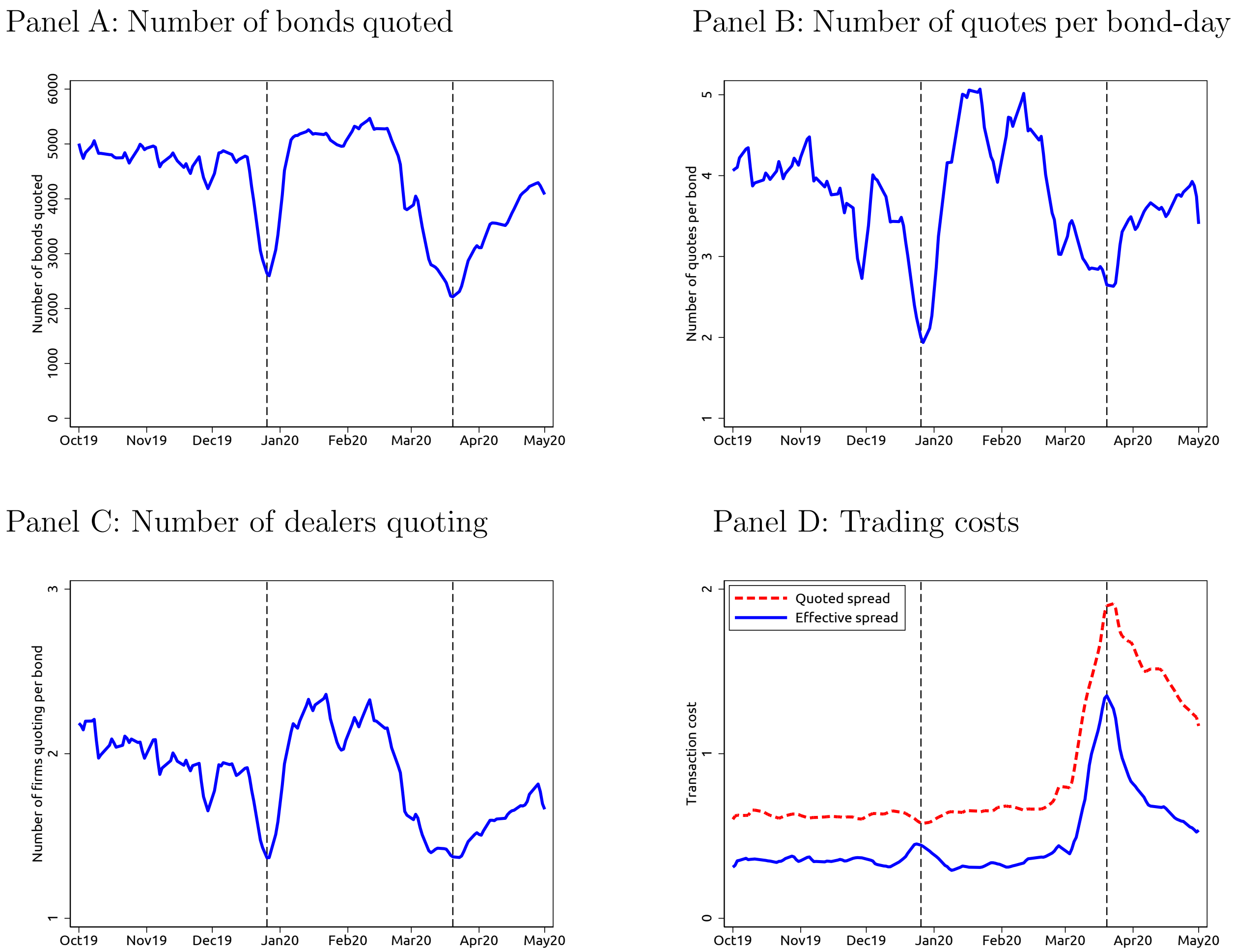

Figure 3: Times series behavior of quoting activity and trading cost

The figure documents the times series of quoting and trading activity. Each line corresponds to the daily sample average. The daily statistics are smoothed using locally weighted regression. The dotted vertical lines correspond to December 26, 2019, and March 20, 2020, respectively.

between March 20, 2020, and late April 2020, reaching 3.5 quotes. Panel C of Figure 3 plots the daily sample average number of dealers quoting per bond. Following a time trend as in Panels A and B, the average number of quoting dealers declines from 2.2 in October 2019 to 1.9 in late December 2019 and drops sharply to 0.4 during the 2019 New Year holidays. The average number of quoting dealers rebounds to its sample high value of 2.5 in late January 2020 and then declines to 0.4 by March 20, 2020. The average number of quoting dealers slowly increases between March 20, 2020, and late April 2020, reaching 1.7.

Panel D of Figure 3 plots the average quoted spread (quoted ask minus quoted bid, dashed line) and effective spread (the negative of the sum of customer buy execution quality and customer sell execution quality, solid line).[22] With the exception of the period around the 2019 New Year holidays, both the effective and quoted spreads are quite flat between October 2019 and March 2020, approximately 40bps and 60bps, respectively. Both spreads rise sharply at the onset of Covid-19 in March 2020 and peak on March 20, 2020, at 1.5% for the effective spread and 1.9% for the quoted spread. After peaking the spreads decline sharply to 50bps for the effective spread and 1.3% for the quoted spread.

Figure 3 shows that stressful market periods are associated with fewer bonds quoted, fewer quotes per bond, fewer dealers quoting, and wider quoted and effective spreads.[23] The previous sections also document that quotes are an important factor for client order flow to a dealer. Does the importance of quotes in attracting client orders decline or rise during stress periods when dealers' intermediation capacity becomes a limiting factor? This helps address whether market liquidity declines during stress periods because dealers across the board reduce their intermediation activity or some dealers reduce their quoting activity while others are able to attract more order flow with the same level of quoting activity and quote quality. Quotes could thus buffer the increase in search frictions for obtaining good prices when volatility is high, as they channel order flow to the dealers willing to trade. It also suggests that quoting activity acts as a proxy for a dealer's liquidity supply, especially during crisis periods.

5.2 Uncertainty and order flow sensitivity to quotes

We first examine how the relation between quoting activity and trading intensity varies with quote quality, bond type, and market-wide uncertainty. We do so by interacting the provision of quotes with the dealer's daily average quote quality, bond type, and market conditions. To simplify notation define

$$Z_{d,b,t} \equiv \{\text{QuoteQuality}_{d,b,t}, \text{Bond type}_{b,t}, \text{Market condition}_t\}.$$

[22]This is equivalent to the difference between average dealer sell prices and dealer buy prices.

[23]Figure A.1 in the Appendix provides additional time series evidence on the decline in quoting activity while trading activity remains stable or increases during market stress.

Table 12: Determinants of order flow sensitivity to quotes

The table documents the determinants of order flow sensitivity to quotes. The dependent variable captures the trading activity by dealer d in bond b on the day t by $\text{HasTrade}_{d,b,t}$ or $\text{LogNumTrades}_{d,b,t}$. Estimates are obtained from panel regressions with triple fixed effects at the dealer, bond, and day levels. Standard errors are triple clustered at the dealer, bond, and day levels. Regression coefficients on VIX_t and IG $\text{rating}_{b,t}$ are omitted for space considerations. Significance levels are *** 1%, ** 5%, * 10%.

	Extensive margin: $\text{HasTrade}_{d,b,t}$			Intensive margin: $\text{LogNumTrades}_{d,b,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)
	All trades	Trade size ≥$100K	Trade size <$100K	All trades	Trade size ≥$100K	Trade size <$100K
$\text{LogNumQuotes}_{d,b,t} \times \text{VIX}_t$	0.059***	0.063***	0.001	0.059***	0.061***	0.001
	(0.017)	(0.016)	(0.008)	(0.018)	(0.015)	(0.008)
$\text{LogNumQuotes}_{d,b,t} \times \text{IG Rating}_{b,t}$	-0.037**	-0.029**	-0.012	-0.045**	-0.036**	-0.011
	(0.015)	(0.014)	(0.008)	(0.017)	(0.015)	(0.007)
$\text{LogNumQuotes}_{d,b,t} \times \text{QuoteQuality}_{d,b,t}$	0.188***	0.172***	0.034***	0.175***	0.156***	0.025***
	(0.029)	(0.028)	(0.009)	(0.027)	(0.024)	(0.009)
$\text{LogNoQuote}_{d,b,t}$	0.072***	0.056***	0.024**	0.074***	0.057***	0.022**
	(0.017)	(0.015)	(0.009)	(0.019)	(0.017)	(0.008)
$\text{QuoteQuality}_{d,b,t}$	-0.127***	-0.112***	-0.027***	-0.119***	-0.102***	-0.021**
	(0.023)	(0.021)	(0.009)	(0.020)	(0.017)	(0.008)
fe	Triple	Triple	Triple	Triple	Triple	Triple
r2	0.058	0.036	0.053	0.057	0.035	0.053
N	13,767,800	13,767,800	13,767,800	13,767,800	13,767,800	13,767,800

As above, we study both the extensive, $\text{HasTrade}_{d,b,t}$, and intensive, $\text{LogNumTrades}_{d,b,t}$, margins of trading when estimating the following balanced panel specifications:

$$\left\{\begin{array}{c}\text{HasTrade}_{d,b,t}\\ \text{LogNumTrades}_{d,b,t}\end{array}\right\} = \alpha_d + \alpha_b + \alpha_t + \beta_1 \times Z_{d,b,t} \times \text{LogNumQuotes}_{d,b,t} + \beta_2 \times Z_{d,b,t} + \\ + \beta_3 \times \text{LogNumQuotes}_{d,b,t} + \epsilon_{d,b,t}, \quad (17)$$

with standard errors robust to clustering at the dealer, bond, and day levels. We estimate specifications (17) on the whole sample and on sub-samples of large (trade size≥$100K) and small (trade size<$100K) trades. To proxy for credit risk, for Bond $\text{type}_{b,t}$ we use the investment-grade indicator, IG $\text{rating}_{b,t}$, equal to one if bond b has an investment-grade rating on the day t and zero otherwise. VIX_t is a proxy for market stress conditions on the day t, Market $\text{condition}_t = \text{VIX}_t$.

Table 12 presents the estimation results. Focusing on the coefficients for the interaction terms, the relation is positive when LogNumQuotes is interacted with VIX and negative when LogNumQuotes is interacted with a dummy for investment-grade bonds. Both of these suggest order flow responds to quote activity more when uncertainty is higher, i.e., when VIX is high and for speculative-grade bonds. The quoting elasticity of trading is statistically significantly different from zero for large trades, consistent with quoting only mattering for institutional-size trades. Because quoting activities tend to decline during market stress, our results suggest that the remaining quotes in the market attract more order flow on average.

We also find that higher quote *quality* is associated with a higher sensitivity of order flow (both extensive and intensive margins). While this is true for trades across all sizes, the magnitude of the coefficients suggests that this effect is stronger for institution-sized trades. Next, we investigate whether dealer quotes relate to client execution quality differently under different market conditions.

5.3 Uncertainty and quote quality relation to execution quality

We now investigate how CliQ dealers' quotes relate to execution quality under different market conditions. To do this we supplement specification (12) with VIX as a proxy for market stress and interact it with quote quality, to yield the following specification:

$$\begin{aligned}\text{ClientExecutionQuality}_{d,b,t} &= \alpha_d + \alpha_b + \delta_1 \times \text{VIX}_t + \delta_2 \times \text{QuoteQuality}_{d,b,t} + \\ &+ \delta_3 \times \text{VIX}_t \times \text{QuoteQuality}_{d,b,t} + \beta \times \text{QuoteUpdate}_{b,t} + \gamma' X_{d,b,t} + \epsilon_{d,b,t}, \quad (18)\end{aligned}$$

where controls, $X_{d,b,t}$, include the quote indicators $\text{HasQuote}_{d,b,t}$ and $\text{DealerSellTrade}_{d,b,t}$. The former is included because VIX is replacing day fixed effects relative to specification (12) and we, therefore, drop day fixed effects interacted with a buy-sell indicator from $X_{d,b,t}$.

Fewer quotes in volatile markets may cause better quality quotes to become more effective at attracting order flow when liquidity demand is high and liquidity supply is low. This hypothesis suggests that $\delta_3 > 0$. Table 13 reports several results. First, client execution quality is lower during market stress periods for all trades, as well as large and small trades. One standard deviation increase in VIX (17.97%) decreases the execution quality by 25bps/17bps/37bps for all/large/small trades. Second, client execution quality is more sensitive to quote quality when VIX is higher for all trades (Column 1), $\delta_3 = 1.405$, and large trades (Column 2), $\delta_3 = 1.425$, with both regression coefficients being statistically significant

Table 13: Client execution quality and dealer quotes under different market conditions

The table documents the relation between the client execution quality of dealer quotes and quote quality under different market conditions. Estimates are obtained from panel regressions with dealer fixed effects, bond fixed effects, and day fixed effects interacted with a buy-sell indicator. Standard errors are triple clustered at the dealer, bond, and day levels. Significance levels are *** 1%, ** 5%, * 10%.

	Dependent variable: $\text{ClientExecutionQuality}_{d,b,t}$		
	(1)	(2)	(3)
	All trades	Trade size≥\$100K	Trade size<\$100K
$\text{VIX}_t \times \text{QuoteQuality}_{d,b,t}$	1.405**	1.425**	-0.112
	(0.625)	(0.674)	(0.874)
VIX_t	-1.369***	-0.929***	-2.058***
	(0.188)	(0.181)	(0.256)
$\text{QuoteQuality}_{d,b,t}$	0.096	0.195	0.166
	(0.184)	(0.170)	(0.250)
$\text{QuoteUpdate}_{b,t}$	0.781***	0.826***	0.608***
	(0.059)	(0.062)	(0.053)
$\text{HasQuote}_{d,b,t}$	0.322***	0.290***	0.205***
	(0.062)	(0.042)	(0.038)
$\text{DealerSellTrade}_{d,b,t}$	0.006	0.025	-0.034
	(0.130)	(0.147)	(0.108)
fe	Double	Double	Double
r2	0.120	0.089	0.223
N	417,292	232,804	183,679

at the 1% level while for small trades, $\delta_3 = -0.112$, is neither statistically nor economically significant. These results are consistent with the idea that retail investors are likely not exposed to dealer quotes and do not benefit from quote competition.[24]

5.4 Uncertainty and price improvement

So far we have established that stressful periods are associated with fewer quotes, fewer dealers quoting, wider bid-ask spreads, and lower client execution quality. To complete the analysis, we examine if the price improvements offered by dealers vary with market conditions.

If quotes are set to reflect the expected bond value conditional on current market conditions, we would not expect the average price improvement to vary significantly with indicators

[24] Panel C of Table A.3 in the Appendix reports the estimates for specification (18) with the last interdealer transaction price as an alternative benchmark. The results are similar to the results reported in Table 13. In particular, the interaction term $\text{QuoteQuality}_{d,b,t} \times \text{VIX}_t$ remains positive and significant for larger trades, confirming that better quality quotes matter for institutional trade quality, particularly in crisis times when VIX is higher.

of stress in the market as they are known at the time of the quote. Alternatively, if dealers do not account for the change in market conditions, more volatile markets may force dealers to lower their price improvement when VIX increases. However, as dealers know that quotes become stale more often in volatile markets, quoted spreads may deteriorate in order to hedge against stale quotes and, as a consequence, price improvement offered by the dealers may increase when VIX increases. Hence, the $\text{PriceImprovement}_{d,b,t}$ of dealer d in bond b on the day t may thus be independent of, fall, or rise with proxies for market volatility.

Panel C of Table 11 splits $\text{PriceImprovement}_{d,b,t}$ into quartiles by VIX_t. The univariate sort on periods of market calm versus stress shows that more stressful periods (with fewer quotes, fewer dealers quoting, and worse quotes) are associated with more improvement of the transaction price over the quoted price. This holds true at the mean, median, and right tail (16bps/6bps at the mean/median for quartile 4 as compared to 2bps/2bps for quartile 1). Price improvement is, hence, particularly high during periods of market stress when VIX is high. This suggests that while there are fewer quotes and fewer dealers quoting during market stress, quotes are set more conservatively which explains the widened quoted spreads and leaves more room for negotiation with the dealer. This interpretation helps explains why quote quality becomes an important determinant of client execution quality during times of stress. Quote competition is thus particularly relevant during stressful periods.

6 Conclusion

Little is known about pre-trade transparency from dealer quotes in OTC markets. We examine the importance of indicative dealer quotes in corporate bonds. At the dealer level in regressions with bond-day and dealer-day fixed effects, the presence of a quote is associated with a higher propensity to trade with more and better quotes associated with more volume. These effects are larger when uncertainty is higher in terms of lower credit ratings and higher volatility, including the onset of Covid-19. Quote competition for order flow is associated with improved execution as clients receive better prices when trading with quoting dealers and even better prices when trading with dealers posting better quotes. Bartik instruments show that market-wide higher quoting activity causes greater trading volume.

These findings establish several results that inform the state of the corporate bond market. First, dealers have incentives to post higher-quality quotes. Second, customers have incentives to search across dealers to find the best price. Both effects are economically significant. While quotes are only indicative, our results suggest quote competition is important in corporate bonds. However, quote competition is imperfect as the best quote often fails to attract order flow and trades often occur at prices worse than the best quote.

Our results suggest a number of ways that theoretical models can incorporate how quotes impact OTC markets. First, directed search models can capture how quotes attract customers to dealers with higher gains from trade who offer better prices. Second, information in quotes can benefit clients even if those clients do not search the dealers with the best quotes as dealers with inferior quotes can offer superior price improvement in negotiations. Third, customers can maintain potential ongoing benefits from their relationship dealers while utilizing quote information. Fourth, the competitive consequences of such cross-dealer effect, e.g., price matching, may be worth modeling.

Our study suggests that institutional clients benefit from quote competition. Indicative quotes used in the study are not generally available to retail investors and smaller institutions. Therefore, we cannot estimate the effects of broadcasting quote data to participants that currently have limited direct access to dealer quotes. However, our results suggest that smaller market participants may not be receiving the trading cost benefits attributable to quote competition. This is consistent with empirical evidence that large trades in corporate bonds have lower trading costs than small trades.

One possibility to level the playing field is to trade bonds on a consolidated and transparent exchange, similar to the mid-1990s Nasdaq market, along with the best execution requirements for routing the order to the dealer posting a better quote, or executing the trade at the best price. Using NYSE data from the 1940s, Biais and Green (2019) present evidence of active trading in corporate bonds on a centralized and transparent exchange. Along similar lines, Abudy and Wohl (2018) report that on the Tel Aviv Stock Exchange corporate bonds trade in a transparent limit order book structure and exhibit high liquidity. While these suggest it is feasible to trade bonds on a transparent exchange, in both instances small retail trades played an important role. For example, Biais and Green (2019) suggest volume moved off-exchange when institutions became more important because institutions and dealers may prefer the OTC structure when trading is infrequent and in larger sizes.

Another possibility is to create a system for consolidating quotes from dealers and electronic platforms and widely disseminate information on the best available bid and ask quotes.

However, many questions arise for such a system. Should dealer-quote reporting be voluntary or mandated? In the current market structure, dealers are endogenously selecting the list of potential institutional customers that receive the quotes, weighing the benefits (e.g., trading relationships and order flow) of sharing potentially valuable information in their quotes against the costs (e.g., adverse selection or information leakage) of doing so. Given this, would mandatory quote disclosure lower trading costs for investors, especially retail investors? Or would mandatory disclosure reduce the production of quotation data that we show benefit institutional clients when disclosures are voluntary?[25]

To mitigate the negative consequences of mandating quote disclosures, one approach is to compensate dealers for the value associated with quote production, potentially via data fees on consolidated National Bid and Offer quotes. This brings up the complex issue of the pricing of market data and the structure of the consolidated quote system. How would the revenue be apportioned among quote providers (a contentious issue under Reg NMS for equity markets)? Who should be covered under mandatory quote disclosure and who should they report to? For mandatory reporting of trades, U.S. SEC-registered broker-dealers and trading platforms are required to report their transactions in Treasury, corporate, and structured bonds to FINRA. One solution could be to adopt an arrangement along the lines of FINRA's TRACE platform, although the issues are more complex for mandatory reporting of quotes. For example, unlike a trade, which is well-defined, regulators need to define a quote that is subject to mandatory disclosure (O'Hara (2010)). Are indicative quotes covered or do quotes need to be firm? Are quotes submitted in response to a client inquiry via an RFQ system covered? What about quotes shared via voice communications or chats between dealers and clients?

[25] Bloomfield and O'Hara (1999) and Madhavan, Porter, and Weaver (2005) find that mandated pre-trade transparency can reduce liquidity.

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Appendix

Appendix A Data filters

Table A.1: BondCliQ data filters

The table documents the steps involved in filtering the BondCliQ data on dealer quotes. Quotes on the bid side and ask side are treated as separate quotes.

Step	No. quotes	No. bonds
Original (Oct 1, 2019–May 1st, 2020)	8,546,249	24,441
In FISD	6,526,786	13,477
Keep bond type "CDEB", "CZ", "CPIK", "CCOV", "CLOC", "UCID", "CMTN", "CMTZ", "EBON", "EMTN"	6,045,106	12,102
Not exchangeable, preferred or convertible	6,042,870	12,091
Drop government type or foreign	4,584,077	9,678
Drop if missing offering date, maturity, offering amt or offering amt<$100K	4,583,478	9,670
Drop floating rate	4,312,326	8,764
Drop maturity<1/1/2021 or maturity>12/31/2070 or payment-in-kind type coupon	4,229,643	8,113
Drop if price=spread	4,187,757	8,101
Drop bond trading holiday	4,183,125	8,101
Drop non-unique observation at timestamp, firm, cusip and quote side	4,170,931	8,101
Keep semi-annual interest payment or zero coupon	4,160,948	8,077

Appendix B Conversion quoted yield spreads to quoted prices

To measure the quality of the quotes, we first need to make sure all quotes are in prices. Many investment-grade bonds are quoted in terms of yield spreads to the benchmark yields. When the bond is quoted in yield-spread space and a price quote is missing, we infer the price from the quoted yield spread. A key step is to identify/match the corresponding benchmark yield (not provided in the data). The steps are:

1. Match the bonds to benchmark securities based on tenor (2, 3, 5, 10, 30 years). We follow market convention in terms of the cutoffs of maturity dates for each tenor bucket.
2. Get intraday benchmark Treasury yields at 5-minute intervals from Bloomberg.
3. Match the bond spread to its benchmark yield based on the quote timestamp and the tenor.
4. Calculate yields by adding the quoted spread and the benchmark yields.
5. Convert yields to prices.
6. For callable bonds, we treat the quoted yields as yield to worst.

Appendix C Instrument construction for dealer shocks

We construct a shift-share instrument (Bartik (1991)) for dealers' quoting activity at the bond level, referred to as $\text{QuoteSupply}_{b,t}$, with the goal of eliminating variation across bonds over time due to endogenous changes in a dealer's activity level, e.g., due to changes in the balance sheet capacity and/or organizational structure of the dealer, and/or endogenous bond-specific trends, e.g., dealer-bond-specific quoting shocks such as inventory management or private information.

We use the dealer's recent institutional market share of trading in the bond as the bond-day's exposure to variation in/shocks to that dealer's aggregate quoting activity that day. This is valid under the assumption that clients only partially substitute or switch with delay to other dealers in response to a reduction in quoting activity by their relationship dealer. Accordingly, a shock to quoting activity to a subset of dealers in a given bond, i.e., the bond's quote supply, will affect aggregate trading in that bond. Intuitively, shocks to dealers quoting across all bonds should affect bonds differently based on dealers' market share in those bonds and the differential shocks across dealers that day. We proceed in three steps.

Step 1: The exposure to shocks in quoting activity is motivated by the fact that dealers send quotes to their institutional clients only. Dealer d's bond-specific activity share, $\mathrm{w}_{d,b,t}$, is the dealer's share of trading in institutional sizes as a fraction of the dealer's total trading over the past 20 (or 10) days:

$$\mathrm{w}_{d,b,t} = \frac{\sum_{l=0}^{19} (\text{NumTrades with size} \geq \$100\text{K})_{d,b,t-l}}{\sum_{\mathbf{d}} \sum_{l=0}^{19} (\text{NumTrades with size} \geq \$100\text{K})_{\mathbf{d},b,t-l}}. \tag{C.1}$$

This choice of shock exposure is based on the observation that dealer institutional shares vary across bonds and that these shares are relevant for dealers' incentives to quote (Goldsmith-Pinkham et al., 2020), with $\sum_d \mathrm{w}_{d,b,t} = 1$.

We define quote supply in bond b on day t as:

$$\begin{aligned} \text{QuoteSupply}_{b,t}^{ext} &= \textstyle\sum_d \mathrm{w}_{d,b,t} \times \text{HasQuote}_{d,b,t}, \\ \text{QuoteSupply}_{b,t}^{int} &= \textstyle\sum_d \mathrm{w}_{d,b,t} \times \text{NumQuotes}_{d,b,t}, \end{aligned} \tag{C.2}$$

where $\text{HasQuote}_{d,b,t}$ and $\text{NumQuotes}_{d,b,t}$ are the extensive and intensive margins of dealer d's bond-specific quoting activity, respectively.

Step 2: Following Borusyak, Hull, Jaravel (2022), aggregating $\text{HasQuote}_{d,b,t}$ and $\text{NumQuotes}_{d,b,t}$ over all bonds $b = 1, ..., B$ captures the extensive and intensive margins of dealer d's total quoting activity on day t, respectively:

$$q_{d,t}^{ext} \equiv \frac{1}{B} \sum_{b=1}^{B} \text{HasQuote}_{d,b,t}, \text{ and } q_{d,t}^{int} \equiv \frac{1}{B} \sum_{b=1}^{B} \text{NumQuotes}_{d,b,t}, \tag{C.3}$$

yielding the dealer-bond-day decompositions $\text{HasQuote}_{d,b,t} = q_{d,t}^{ext} + \varepsilon_{d,b,t}^{ext}$ and $\text{NumQuotes}_{d,b,t} = q_{d,t}^{int} + \varepsilon_{d,b,t}^{int}$. These decompositions isolate the dealer's daily quoting activity from the dealers' incentives to quote a specific bond that day. The mean of $q_{d,t}^{ext}$, i.e., the probability of a dealer having a quote on any given day, is equal to 0.094 with a standard deviation of 0.128. The mean of $q_{d,t}^{int}$ is equal to 0.180, with a standard deviation of 0.30.

Step 3: The quote supply across all dealers in bond b on the day t, $\text{QuoteSupply}_{b,t}^{ext/int}$, is the market-share weighted average of quoting activity across dealers at the bond-day level.[1] Hence, we can instrument

[1]Results are quantitatively similar if dealers' market share of all trades is used in place of institutional market share.

$\text{QuoteSupply}_{b,t}^{ext/int}$ by

$$\widehat{\text{QuoteSupply}}_{b,t}^{ext} = \sum_d \text{w}_{d,b,t-1} \times q_{d,t}^{ext},$$
$$\widehat{\text{QuoteSupply}}_{b,t}^{int} = \sum_d \text{w}_{d,b,t-1} \times q_{d,t}^{int}. \tag{C.4}$$

where $\text{w}_{d,b,t-1}$ are the lagged predetermined activity shares and $q_{d,t}^{ext}$ and $q_{d,t}^{int}$ are the market-wide dealer-specific quoting rates from (C.3), which replace the dealer-bond-specific quoting rates $\text{HasQuote}_{d,b,t}$ and $\text{NumQuotes}_{d,b,t}$. The mean of $\widehat{\text{QuoteSupply}}_{b,t}^{ext/int}$ is equal to 0.039/.084 with a standard deviation of 0.062/0.158. The predicted quote supply in a bond is then a weighted average of the market-wide quoting rates of each dealer ("the shift"), with weights depending on the past distribution of the trading activity ("the shares"). The exclusion restriction here is that the quoting dealers' share of trading in institutional sizes averaged over the period $[t-20, t-1]$ is uncorrelated with the bond's quote demand shock at time t. By construction, endogenous changes of the activity shares or/and endogenous bond-specific trends do not cause a variation in $\widehat{\text{QuoteSupply}}_{b,t}^{ext/int}$ across bonds and over time. We now have a standard 2SLS setup where the first-stage is a regression of quote supply on the controls and the Bartik instrument:

$$\text{QuoteSupply}_{b,t}^{ext/int} = \alpha_b + \alpha_t + \gamma \times \widehat{\text{QuoteSupply}}_{b,t}^{ext/int} + \eta_{b,t}. \tag{C.5}$$

Table A.1: Dealers' quoting activity and order flow—Alternative specifications with triple fixed effects at dealer, bond, and day level

The table documents the determinants of dealer trades. In Panel A, the dependent variable equals one if dealer d trades bond b on the day t, and zero otherwise. In Panel B, the dependent variable equals the natural logarithm of the number of trades plus one by dealer d in bond b on the day t. Estimates are obtained from panel regressions with dealer fixed effects, bond fixed effects, and day fixed effects. Standard errors are triple clustered at the dealer, bond, and day levels. Significance levels are *** 1%, ** 5%, * 10%.

Panel A: Dealer's trading activity, extensive margin				
	(1)	(2)	(3)	(4)
Dependent variable:	$\text{HasTrade}_{d,b,t}$	$\text{HasTrade}_{d,b,t}$	$\text{HasTrade}_{d,b,t}$	$\text{HasTrade}_{d,b,t}$
$\text{HasQuote}_{d,b,t}$	0.040***		0.033***	
	(0.008)		(0.006)	
$\text{LogNumQuotes}_{d,b,t}$		0.049***		0.040***
		(0.007)		(0.006)
$\text{HasTrade}_{d,b,t-1}$			0.221***	0.220***
			(0.011)	(0.011)
fe	Triple	Triple	Triple	Triple
r2	0.055	0.057	0.102	0.103
N	13,767,800	13,767,800	13,767,800	13,767,800

Panel B: Dealer's trading activity, intensive margin				
	(1)	(2)	(3)	(4)
Dependent variable:	$\text{LogNumTrades}_{d,b,t}$	$\text{LogNumTrades}_{d,b,t}$	$\text{LogNumTrades}_{d,b,t}$	$\text{LogNumTrades}_{d,b,t}$
$\text{HasQuote}_{d,b,t}$	0.036***		0.028***	
	(0.008)		(0.006)	
$\text{LogNumQuotes}_{d,b,t}$		0.045***		0.035***
		(0.007)		(0.005)
$\text{LogNumTrades}_{d,b,t-1}$			0.265***	0.264***
			(0.015)	(0.015)
fe	Triple	Triple	Triple	Triple
r2	0.055	0.057	0.121	0.122
N	13,767,800	13,767,800	13,673,500	13,673,500

Table A.2: Importance of quote quality for order flow—Alternate quote quality measure

The table documents the importance of quote quality for order flow. The dependent variable captures the trading activity by dealer d in bond b on the day t by $\text{HasTrade}_{d,b,t}$ or $\text{LogNumTrades}_{d,b,t}$. We measure quote quality using its distance to NBBO. Estimates in Panel A are obtained from panel regressions with dealer fixed effects, bond fixed effects, and day fixed effects. Estimates in Panel B are obtained from panel regressions with dealer fixed effects and all (saturated) interactions of bond and day fixed effects. Standard errors are triple clustered at the dealer, bond, and day levels. Significance levels are *** 1%, ** 5%, * 10%.

Panel A: Dealer's trading activity, extensive margin

	Dependent variable: $\text{HasTrade}_{d,b,t}$		
	(1)	(2)	(3)
	All trades	Trade size ≥\$100K	Trade size <\$100K
$\text{QuoteQuality}_{d,b,t}$ (alternate)	0.022**	0.017**	0.010*
	(0.010)	(0.008)	(0.005)
$\text{HasQuote}_{d,b,t}$	0.043***	0.034***	0.015***
	(0.009)	(0.007)	(0.005)
fe	Saturated	Saturated	Saturated
r2	0.147	0.133	0.132
N	13,700,786	13,700,786	13,700,786

Panel B: Dealer's trading activity, intensive margin

	Dependent variable: $\text{LogNumTrades}_{d,b,t}$		
	(1)	(2)	(3)
	All trades	Trade size ≥\$100K	Trade size <\$100K
$\text{QuoteQuality}_{d,b,t}$ (alternate)	0.034***	0.028***	0.007*
	(0.009)	(0.006)	(0.004)
$\text{LogNumQuotes}_{d,b,t}$	0.049***	0.039***	0.013***
	(0.008)	(0.006)	(0.004)
fe	Saturated	Saturated	Saturated
r2	0.157	0.154	0.135
N	13,700,786	13,700,786	13,700,786

Table A.3: Client execution quality and dealer quotes—Alternate benchmark price

The table documents the relation between the client execution quality of dealer quotes and quote quality. Estimates are obtained from panel regressions with dealer-day fixed effects, bond-day fixed effects, and day fixed effects interacted with a buy-sell indicator. Standard errors are triple clustered at the dealer, bond, and day levels. Significance levels are *** 1%, ** 5%, * 10%.

Panel A: Descriptive statistics on $\text{ClientExecutionQuality}_{d,b,t}$ (alternate)

	N	Mean	SD	5%	25%	50%	75%	95%
$\text{ClientExecutionQuality}_{d,b,t}$ (alternate)	452,235	-0.29	1.18	-2.00	-0.46	-0.08	0.03	0.81
$\text{ClientExecutionQuality}_{d,b,t}$ (alternate), split by:								
Trade size≥\$100K	256,339	-0.19	1.25	-1.81	-0.38	-0.08	0.09	1.13
Trade size<\$100K	195,896	-0.42	1.07	-2.07	-0.63	-0.09	0.00	0.36
IG rated	323,707	-0.26	1.10	-1.81	-0.38	-0.06	0.03	0.68
HY rated	128,528	-0.36	1.36	-2.31	-0.67	-0.17	0.03	1.19

Panel B: Impact of market conditions on client execution quality

	Dependent variable: $\text{ClientExecutionQuality}_{d,b,t}$ (alternate)		
	(1)	(2)	(3)
	All trades	Trade size≥\$100K	Trade size<\$100K
$\text{QuoteQuality}_{d,b,t} \times \text{VIX}_t$	0.943**	0.888**	0.397
	(0.367)	(0.433)	(0.590)
VIX_t	-0.864***	-0.717***	-1.109***
	(0.140)	(0.122)	(0.185)
$\text{QuoteQuality}_{d,b,t}$	0.098	0.207	-0.066
	(0.124)	(0.131)	(0.160)
$\text{QuoteUpdate}_{b,t}$ (alternate)	0.512***	0.565***	0.321***
	(0.048)	(0.046)	(0.040)
$\text{DealerSellTrade}_{d,b,t}$	-0.052	-0.023	-0.084*
	(0.042)	(0.045)	(0.043)
$\text{HasQuote}_{d,b,t}$	0.071***	0.025*	0.069**
	(0.021)	(0.015)	(0.032)
fe	Double	Double	Double
r2	0.116	0.086	0.230
N	451,741	255,769	194,920

Figure A.1: Times series behavior of quoting activity

The figure documents the times series of quoting and trading activity. Each line corresponds to the daily sample average. The daily statistics are smoothed using locally weighted regression. The dotted vertical lines correspond to December 26, 2019, and March 20, 2020, respectively.