Customer Liquidity Provision in Corporate Bond Markets: Electronic Trading versus Dealer Intermediation

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ABSTRACT

We investigate electronic trading among customers under normal market conditions and during the Covid-19 crisis using a unique data sample of U.S. corporate bond transactions from UBS Bond Port. We show that electronic customer-to-customer (C-to-C) trading is beneficial in terms of costs for orders up to $ 1 million. The advantage of electronic C-to-C trading primarily benefits liquidity-consuming customers, as dealers penalize liquidity takers more than the electronic trading channel. Contrary to expectations, at the onset of the Covid-19 crisis the costs for liquidity takers selling bonds electronically inverted, resulting in negative aggressor markups. We argue that this effect is allocated to the trading protocol of a firm and transparent order book. Volumes in electronic C-to-C trading are more driven by orders wherein the liquidity-consuming party is selling; this effect is amplified in stressed markets. Whereas electronic liquidity provision by dealers is primarily concentrated to normal market conditions, electronic C-to-C trading becomes more important in stressed markets. Literature underestimates the effect of inverting markups during the Covid-19 crisis and thus undervalues electronic C-to-C trading as a viable liquidity pool in stressed markets.

Keywords: Corporate bonds, electronic trading, customer-to-customer, dealer-intermediation, Covid-19, customer liquidity provision, riskless principal trading, aggressor, liquidity maker

JEL classification: G10 G12 G14 G24

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Introduction

Customer liquidity provision in corporate bond trading has become an important research subject. In the aftermath of the 2008 financial crisis and the adaption of new banking regulations, dealers have lowered their willingness to provide liquidity as documented for example by Bao, O'Hara, and Zhou (2018). During the Covid-19 crisis, liquidity provision by dealers deteriorated quickly and transaction costs soared to prohibitively high levels with dealers unwilling to committing capital as documented by O'Hara and Zhou (2021) or Kargar et al. (2020). Instead, volumes in customer-to-customer (C-to-C) trading increased substantially, indicating that investors stepped up and provided liquidity to other customers. O'Hara and Zhou (2021) show that, unlike in the past, investors shifted to electronic trading platforms that enable buy-side investors to trade directly with each other. Despite the increasing relevance of electronic C-to-C trading in today's corporate bond markets, there is limited research on this trading channel which can be attributed to a lack of access to relevant data. Our paper is the first that is able to study electronic C-to-C trading using a proprietary trading sample from a large electronic trading platform offering trading between investors. The data set is unique as it identifies the liquidity consuming party of an electronic C-to-C trade allowing us to analyze trading costs between liquidity takers and liquidity makers. Literature studying electronic C-to-C in corporate bond trading, e.g. O'Hara and Zhou (2021), encounter limitations in identifying the aggressor of a C-to-C trade, leading to an overestimation of transaction costs during the Covid-19 crisis and thus undervalues the electronic C-to-C trading channel as a viable source of liquidity during stressed market conditions.

The paper sets the focus on paired trades between two investors, facilitated electronically or intermediated over-the-counter (OTC) by dealers, and addresses the following questions: How efficiently do dealers arrange C-to-C trades, and how does the electronic channel? How did the two trading channels differ during the Covid-19 crisis? Are electronic C-to-C trading platforms able to offer an alternative pool of liquidity in stressed markets? And if so, at which costs? We examine these questions by exploiting a proprietary transaction sample from UBS Bond Port that enables investors to trade directly with each other.[1] We examine the choice of investors for executing limit orders electronically or OTC through a

[1] The platform was launched in 2012 as UBS Price Improvement Network (UBS PIN) for fixed income products and later renamed UBS Bond Port.

dealer's network to determine when services provided by dealers are difficult to be replicated by electronic trading platforms. The electronic trading platform provides customers with the ability to place firm limit orders in corporate bonds electronically and reach a global network of investors. In contrast to limit orders submitted OTC to dealers looking for a trading opponent in their networks of clients, investors are able to provide liquidity directly on UBS Bond Port by expressing firm price quotes to buy or sell securities. Similar to a central limit order book, other investors are able to overview the quotes and transact at the provided prices. The electronic trading venue is provided by UBS, a global investment bank and wealth management firm that oversees $ 2.3 trillion in invested assets making it the largest wealth manager in the world (Forbes (2019)). In the crisis months of March and April 2020, we are able to study 34,000 transactions in U.S. corporate bonds which the platform intermediated between customers, summing up to a trading volume of $ 4.5 billion.

We find that for C-to-C trading, the electronic trading channel is particularly beneficial in term of transaction costs for orders up to $ 1 million in trade size. In times of normal markets, the advantage of the electronic trading channel over dealer-intermediated trades decreases in trade size. Micro and odd-lot trades in investment grade bonds incur 26 and 11 bps lower transaction costs, respectively, when traded electronically. We show that in the electronic trading channel, liquidity-consumers selling investment grade bonds electronically pay 30 bps higher spreads than the liquidity-providing side of a C-to-C trade. This aggressor markup is 40 bps higher in C-to-C trades intermediated by dealers. We find that the cost advantage of electronic trading is primarily collected by the liquidity-requesting party of a trade. This means that customers who act as aggressors and demand liquidity from other investors tend to benefit more from electronic trading than the parties providing the liquidity. On the one hand, liquidity takers are penalized substantially more by dealers than by the electronic trading platform. On the other hand, dealers tend to reward liquidity-providing customers more than the electronic trading channel does.

During the Covid-19 crisis, the cost advantage of electronic trading persisted, albeit decreased for riskier trades, i.e. high yield orders and larger transactions. Surprisingly, the costs for investors who were consuming liquidity on the platform to sell bonds reversed at the beginning of the crisis: While pre-crisis, investors paid average spreads of about 20 bps for actively selling bonds electronically, transaction costs plunged to minus 70 bps at the onset of the crisis resulting in a profit rather than costs. This is intriguing and can be explained by UBS Bond Port's trading protocol of transparent and firm price quotes. When markets fell sharply in a risk-off episode in March 2020, firmly placed limit buy orders were used by other customers to sell their positions. After investors had sold their positions to other customers through passive buy orders, spreads rebounded. Our work also delineates the difference in C-to-C trading volume in the two trading channels separated by liquidity takers and makers. Consistent with the differences in spreads, we find that the electronic channel is more driven by trades wherein the liquidity-consuming party is selling, whereas dealers more often intermediate orders involving active buy trades. This effect has amplified during the crisis with trade volume of active sell trades quadrupling in the electronic trading channel. This implies that electronic C-to-C trading becomes more important in stressed markets. This contrasts with electronic liquidity provision by dealers, which is largely limited to normal market conditions. We argue that the electronic trading protocol of firm and transparent prices offers customers a pool of liquidity not only in normal times, but also, and especially, during stressed market situations. The findings of inverted markups in electronic C-to-C trading during the Covid-19 crisis are novel. Other papers studying electronic C-to-C trading in the crisis, e.g. O'Hara and Zhou (2021), are not able to identify the liquidity-demanding party in a C-to-C trade and therefore overestimate trading costs. As a result, they underdetermine electronic C-to-C trading as an alternative source of liquidity in stressed markets.

Our study contributes to the expanding literature on the microstructure of corporate bond markets. Our results promote an understanding as to when and how electronic trading between investors can be beneficial for market participants. Our results carry important implications for the literature on electronic corporate bond trading. Contrary to the literature, e.g. O'Hara and Zhou (2021), our findings show that the electronic trading protocol of firm quotes where customers can receive an immediate execution is able to improve market liquidity under both normal and stressed market conditions. This is of particular importance since researchers and regulators proclaim the introduction of trading protocols that supports the transparent display of limit orders. Harris, Kyle, and Sirri (2015) argue that the dealer-intermediated OTC mechanism for limit order trades is problematic for certain trades and proclaim a regulation requiring dealers to post their customers' limit orders to an actionable electronically accessible order display facility. Anand, Jotikasthira, and Venkataraman (2017) state that the economic importance of buy-side liquidity supply cannot be overstated and argue for platforms with trading protocols enabling buy-side investors to post limit orders, in order to tap into this channel of liquidity provision. Harris (2015) argue that a lack of pre-trade transparency for limit orders leads to sub-optimal order executions for particular investors and that a rule requiring dealers to post their customers' limit orders on trading platforms would help to prevent trade-throughs. Beside the contribution to the literature, our paper adds value for regulators by increasing the understanding as to how buy-side investors are able to bridge liquidity gaps in times of stressed markets. The trading technology studied here enables buy-side investors to act as liquidity providers and intervene in the market when they see price dislocations. Our results highlight the role of electronic C-to-C trading as a potential solution that can help to improve bond market stability. Finally, our paper also relates to the advent of an alternative electronic trading approach referred to as "all-to-all" trading. This trading protocol allows trading among all market participants and also facilitates C-to-C trades. Although all-to-all trading gained in relevance more recently, only little empirical research has been done on this trading channel in academic studies. Since the trading protocol studied here offers similar functionalities, the results may provide some insights as to how investors are able to improve the quality of electronic auctions in RFQ-trading with dealers.

The paper is organized as follows: Section I briefly describes the context of C-to-C trading and limit order trades and embeds the paper in the literature. Section II provides an analytical framework for electronic C-to-C trading. Section III describes our data sample and presents C-to-C trading in light of the overall bond market. Section IV analyzes the determinant factors for placing limit orders electronically or OTC with a dealer. Section V describes our transaction cost estimation methods and presents preliminary empirical results on trading costs of electronic and dealer-intermediated C-to-C trades. Section VI estimates spread differences across the two trading channels. Section VII studies electronic and dealer-intermediated C-to-C trading during the Covid-19 crisis. Section VIII analyzes the electronic trading channel as a liquidity pool during the crisis. Section IX concludes and discusses the importance of the results in the context of a changing structure of the corporate bond market.

I. Contribution to the Literature

The financial crisis in 2008 and the regulatory initiatives that followed represent a censorship in corporate bond trading that caused dealers to adapt their trading behavior. Prior to the crisis, corporate bond markets have traditionally relied on dealers that provided liquidity to clients on a request-for-quote basis (RFQ). Dealers intermediated trades OTC between clients and took bonds into inventory if they did not immediately find another counterparty to unwind a position. In this traditional market setup, the buy-side (customers) demands liquidity from the sell-side (dealers). Dealers are compensated with the bid-ask spread for providing liquidity and warehousing risky assets. Bao, O'Hara, and Zhou (2018), for example, show that after the financial crisis and the adaption of new banking regulations, i.e. the Volcker Rule, dealers lowered their willingness to provide capital to clients. The change in risk capacity led dealers to adjust their trading strategy. Instead of committing capital to provide liquidity to their network of clients, dealers more often intermediate trades on riskless terms between counterparties. Goldstein and Hotchkiss (2020) argue that the dealer's likelihood to act as a pure broker and execute a pair of riskless trades between two sides increases if the dealer's costs of providing liquidity is sufficiently large. Bessembinder et al. (2018) find that dealers have adapted their behavior and became more reluctant to commit capital and conclude that liquidity provision in the corporate bond markets has evolved away from the commitment of bank-affiliated dealers. Schultz (2017) finds that dealers increasingly avoid taking bonds into inventory after the Volcker Rule was finalized and, instead, more often execute prearranged orders by offsetting client trades directly in the inter-dealer market on riskless terms. Such prearranged or paired trades have become more common, especially in the segment of high yield bonds. Choi and Huh (2017) confirm these behavioral changes and find that dealers increasingly broker trades directly between customers. By reselling a bond quickly to another client, which the dealer located before, the dealer does not carry any price or inventory risk. By placing limit orders, the client bears the risk while the dealer is searching for a trading opponent. Bech et al. (2016) from the BIS argue that the shift of dealers from a principal- to an agency-based model contributes to declining dealer inventories and also emphasize the passing of the execution risk to investors. Ederington, Guan, and Yadav (2015) argue the spreads of paired trades represent the dealers' compensation for their agent-service of searching for another client with the best price. Zitzewitz (2010) concludes that the pairing of limit orders between investors is a symptom of clients being unable to search over the entire market. Dealers are able to produce risk free trading profit with their network of relationships by simply handling order flow. Harris (2015) calls such transactions riskless principal trades since dealers arrange two offsetting trades that produce a riskless profit. He argues that riskless principal trades happen because of lacking market transparency that leads to customers being unaware of better prices in the market. Harris and Mehta (2020) find that over the last 15 years, the share of riskless principal trades wherein dealers earn a risk free markup increased substantially.

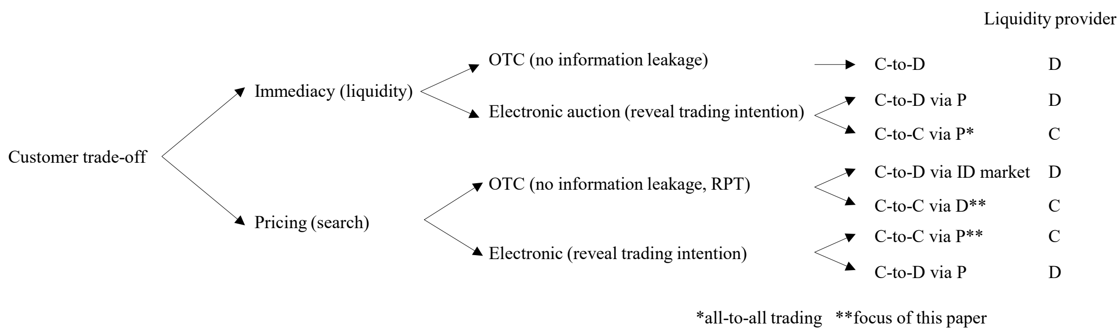
Goldstein and Hotchkiss (2020) argue that dealers implicitly offer customers a trade-off between pricing and immediacy (liquidity). Figure 1 illustrates this binary choice and decomposes the available trading channels of customers. Requiring immediacy in the order execution provides customers with two trading channels that differ in the degree of information leakage: Executing an order via electronic trading auctions increases dealer competition but exposes customers to information leakage. The risk of information leakage refers to possible price changes when market participants are aware of the trading intentions of other participants and therefore adjust their price expectations. Trading OTC with a dealer reduces price competition but also the risk of information leakage. Hendershott and Madhavan (2015) find that electronic auctions among multiple dealers are preferred over OTC trading for easier trades in more liquid bonds where the risk of information leakage is lower. O'Hara and Alex Zhou (2021) show that the electronic dissemination of RFQs to a set of dealers reduces transaction costs mainly because of lower search costs for both customers and dealers.[2] They conclude that electronic RFQ-trading has broad effects on transaction costs in the electronic and the voice trading channel, and also has spillover effects on the inter-dealer market. A developing alternative trading protocol called electronic all-to-all trading enables not only dealers to participate in an auction but also other customers. In this trading framework, dealers compete with quotes from other buy-side institutions allowing the interaction between all market participations. Hendershott, Livdan, and Schürhoff (2021) find that all-to-all trading meaningfully improves transaction prices by increasing competition in electronic RFQ-auctions.

[2] O'Hara and Alex Zhou (2021) examine data from MarketAxess from January 2010 to December 2017, while Hendershott and Madhavan (2015) study data from the same source but from the beginning of 2010 through April 2011.

When customers prefer price certainty over immediacy, they retain the price risk and the risk that the trade is not executed immediately. On the one hand, investors can assign limit orders to dealers who are secretly searching for a counterparty in their networks of clients and dealers. In this case, dealers are able to execute a riskless principal trade by simply matching orders, e.g. between two customers. On the other hand, investors can place orders at their reservation price on an electronic trading platform and publicly search for a counterparty among the platform users. Other platform members, dealers or buy-side customers can match the order and trade at the provided limit price. Similar to electronic auctions among many dealers, the disclosure of trading intentions exposes investors to the risk of information leakage.

Figure 1: Customer trade-off between immediacy and pricing in the order execution process

The figure shows the customers' binary choice in the order execution process and decomposes the available trading channels. C = client, D = dealer, ID=inter-dealer, P = platform, RPT=riskless principal trading



In this paper, we lay our focus on the binary choice of investors in the case of them preferring price certainty, i.e. the lower path in the decision tree in Figure 1. Furthermore, we focus on C-to-C trades where customers provide the liquidity and match a customer's reservation price. The BIS Markets Committee (2016) claim that the success of alternative trading protocols, such as the electronic pooling of customer liquidity, has been limited in the past, but argues that the adaption of new trading protocols are important drivers of the evolution in bond trading. In a Report to the Congress, the SEC (2017) points to the increasing role of institutional investor as liquidity provider on electronic trading platforms. The SEC argues that visibility of quotations reduces counterparty search costs, as trading intentions are visible to a broad set of market participants. The academic literature on electronic C-to-C trading in corporate bond markets is primarily based on transactions from the Trade Reporting and Compliance Engine

(TRACE). Papers often run into limitations when it comes to correctly identifying electronic trades and the trading protocol underlying them. Kozora et al. (2020) studies C-to-C transactions on alternative trading systems (ATS) and argue that market participants benefit from electronic trading protocols quoting firm and transparent prices. Kozora et al. (2020) face limitations in identifying the trading protocols used by an electronic trading platform. They state that most ATS offer either RFQ-protocols, in which platforms solicit quotes that counterparties can meet, or automated matching systems that provide customers immediately executable liquidity. The latter platforms are referred to as electronic communication networks (ECNs) and offer a similar order protocol to the one studied in our work. As Kozora et al. (2020) are not able to distinguish between trading protocols , they are unable to examine orders executed solely pursuant to an ECN protocol. O'Hara and Zhou (2021) study liquidity provision in the Covid-19 crisis and examine the robustness of liquidity provided by customers through electronic trading. They find that liquidity provisions in electronic C-to-C trading increased substantially at the height of the crisis. However, they argue that electronic trading among customers is not robust during stressed markets as trading costs increased to prohibitively high levels. In contrast to our paper, O'Hara and Zhou (2021) are not able to observed the liquidity-providing party of a C-to-C trade. Instead, they simplistically assume that the liquidity-demanding side is always the one that pays a higher spread in an electronic C-to-C transaction. We show that this assumption does not hold during the Covid-19 crisis for electronic C-to-C trading that use a transparent order book with firm price quotations.

II. Analytical Framework: Information Leakage versus Secrecy

An investor’s decision to place a limit order OTC with a dealer or electronically on a trading platform likely reflects a deliberate choice of the most suitable trading channel for an order. We assume that the investor’s decision is an endogenous selection of the best trading channel that depends on a variety of bond, trade and market characteristics. The following analytical framework is based on Hendershott and Madhavan (2015) and shall help to interpret the subsequent empirical results. Hendershott and Madhavan (2015) study the case where investors demand liquidity from dealers and focus on the tradeoff between higher competition in electronic trading auctions and the benefit of limiting the risk of information leakage in bilateral OTC trading. Although our paper studies trades where customers require price certainty, investors face a similar tradeoff: By placing a limit order on an electronic trading platform, investors are able to immediately reach a wide network of possible trading opponents at low search costs. However, investors reveal their trading intention and face the risk of information leakage if other investors adjust their price expectations. Placing a limit order OTC with a dealer has the advantage of limiting the revelation of trading information. Investors rely on the dealers' ability to search secretly in their network of clients. The secret search for a trade opponent by dealers, typically via telephone or chat, is costly and involves high search costs.

We first assume an order where an investor wants to buy a bond. The customer is willing to buy if the price is below his reservation price p_r. He prefers to place the order with a dealer in the OTC market only if the expected purchase price (p_d) is lower than the price (p_e) he can expect when placing the order electronically, this is $p_d < p_e$ (given that $p_e < p_r$). We model the price that the investor can expect to be offered by the dealer as the expected value of a bond θ, plus the expected search costs $\pi_d(x)$ the dealer faces to find a trading opponent, plus a markup $\mu_d(x)$ the dealer wants to earn for his agency service, this is $p_d = \theta + \pi_d(x) + \mu_d(x)$. The vector x includes bond and market characteristics. In practice, search costs and the dealer markup could additionally depend on the dealer's network and might also be client specific.

Placing the limit order electronically, the investor can expect the same pricing function but with varying search costs and markups, this is $p_e = \theta + \pi_e(x) + \mu_e(x)$. However, in the case the investor does not find a trading opponent in the electronic trading channel and decides instead to assign the order to a dealer, the client incurs additional information leakage costs $s(x) \geq 0$. These costs result from the revelation of the trading intentions, which the client had disclosed on the electronic trading platform. Had the investor preferred the OTC market first, the cost $s(x)$ would have not been incurred, instead the client would have had to bear the market risk while the dealer was searching for a trading opponent. We assume the probability that an investor finds a trading opponent electronically is $1 - q(x)$. Thus, the probability-weighted expected price of the electronic trading channel is

$$p_e = q\big(p_d + s(x)\big) + \big(1 - q(x)\big)\big(\theta + \pi_e(x) + \mu_e(x)\big) \tag{1}$$

Substituting θ by $p_d - \pi_d(x) - \mu_d(x)$ leads to the key trade-off function: A customer assigns a limit order to a dealer if and only if

$$q(x)s(x) + \big(1 - q(x)\big)\left(\underbrace{\pi_e(x) - \pi_d(x)}_{\substack{relative \\ search\ cost}} + \underbrace{\mu_e(x) - \mu_d(x)}_{\substack{relative \\ agency\ fee}}\right) > 0, \tag{2}$$

and places the order on the electronic trading channel otherwise. For given bond and trade characteristic, equation (2) leads to the following conclusions:

- The higher the costs of information leakage s, the greater the probability that investors prefer dealers for their limit orders over the electronic trading platform.
- The lower the (relative) search costs $(\pi_e - \pi_d)$, the higher the likelihood that investors place a limit order electronically.
- The higher the difference in the agency fees $(\mu_e - \mu_d)$, the higher the probability that clients prefer the electronic trading channel.

The analytical frameworks suggest that the electronic trading channel is preferred for easier orders where search costs are low and the risk of information leakage is limited. More complex orders, where it is difficult to find an opposing customer, are assigned to dealers who can search precisely within their network of clients. Further, the greater the advantage of the electronic trading in terms of the charged agency fee, the higher the likelihood that investors will substitute dealers with an electronic trading platform. Considering a sell order and assuming a price deduction $d(x) > 0$ to account for the bid-ask spread, equation (2) becomes $q(x)s(x) + \big(1 - q(x)\big)\big(\pi_e(x) - \pi_d(x) + \mu_e(x) - \mu_d(x) - \mathrm{d}(x)\big)$. This implies that sells are more likely to be traded electronically.

III. Data Sample and Sample Construction

Our paper combines transactions in corporate bonds from two data samples. First, we use a proprietary and unique data set from UBS Bond Port that has not been studied before. UBS Bond Port is a large electronic trading platform provided by UBS that enables customers to trade directly with each other.

The platform aggregates liquidity from UBS internal and external buy-side customers as well as liquidity from other counterparties such as trading venues. UBS Bond Port enables institutional customers to place firm, i.e. live executable, orders, which are distributed globally to other market participants in the network. During the months of the Covid-19 crisis, UBS Bond Port had a leading position in the distribution of U.S. corporate bonds on Bloomberg.[3] The platform differs from other electronic trading platforms such as MarketAxess in two ways.[4] First, UBS Bond Port is not an electronic RFQ-platform where investors are able to query price quotes to multiple dealers electronically. Instead, UBS Bond Port allows buy-side investors to quote limit orders to a global network of investors and to trade orders against quotes from other investors. Second, the prices quoted on UBS Bond Port are firm and readily available for trading, rather than on an indicative basis, as is common in fixed income markets. The transparent and firm disclosure of the investors' reservation prices provides users with pre-trade price transparency similar to a central limit order book. Customers receive a transparent view of the depth and breadth of orders in a wide range of bond securities. The difference between the clients' limit price and the price displayed on UBS Bond Port determines the commission UBS retains for its agency services, i.e. the markup or markdown. The intermediation commission ranges from 3 to 12.5 bps and considers several bond characteristics such as the rating, maturity, and age. The data set is distinct from other transaction data as it also identifies the liquidity-consuming party, i.e. the aggressor, of a C-to-C trade. UBS acts as the central counterparty intermediating all trades between the participants. The involvement of UBS as the central counterparty enables post-trade anonymity and mitigates counterparty credit risks. It allows clients to transact bonds with a large network of global buy-side traders without maintaining a direct relationship with the participating investors. The platform facilitates trading in a variety of fixed income products such as U.S. investment grade and high yield corporate bonds, Eurobonds, emerging markets debt securities, and government bonds. Our total sample contains data on approximately 600,000 C-to-C transactions which have been executed on UBS Bond Port from October 2018 to June 2020 directly between two customers. For the purpose of this paper, we consider only TRACE-eligible corporate

[3] Bloomberg Dealer Ranking for USD credit (March to June 2021).

[4] We refer here to the electronic multilateral RFQ-trading channel from MarketAxess. MarketAxess also offers the trading model referred to as "all-to-all trading" where all market participants are able to trade with each other.

bonds, i.e. debt securities denominated in U.S. Dollar issued by U.S. or foreign corporates, resulting in about 226,000 transactions with a total volume of $ 23 billion. UBS Bond Port does not report transactions to TRACE as the platform is not registered as an ATS in the U.S. We refer to trades executed on UBS Bond Port as "electronic" or "platform-intermediated" trades.

We enrich the data from UBS Bond Port with transactions from the standard, non-enhanced version of the Financial Industry Regulatory Authority's (FINRA) Trade Reporting and Compliance Engine (TRACE). Dealers who are FINRA member firms are required to report OTC secondary market transactions in eligible corporate bonds to TRACE. The data include information per trade such as date and time, price, volume, and the direction of a trade (buy/sell). In addition, TRACE identifies the involved counterparties for each transaction, allowing to categorize trades as dealer-to-client or inter-dealer transactions. The TRACE sample covers trades in U.S. corporate bonds from October 2018 to June 2020 and contains data on approximately 15.8 million customer-to-dealer trades and 10.5 million inter-dealer transactions. Table VIII in the appendix describes how we clean the TRACE data set.

In both data samples, the focus is set on paired trades between two investors. Dealers in the OTC market intermediate such trades by executing two offsetting orders between two counterparties simultaneously or in quick succession. Riskless orders are either paired with other clients or in the inter-dealer market with another dealer. Riskless principal trades are also referred to as paired, prearranged or agency-trades. These terms are used interchangeably in this paper. Since we study C-to-C trades, only agency-trades intermediated between two clients are considered. The method used to identify riskless C-to-C trades in the TRACE sample is as follows: We identify riskless C-to-C trades to be matched orders in which a dealer executes two dealer-to-client orders of the same quantity in opposite directions within 15 minutes. The holding period of 15 minutes follows Choi and Huh (2017) or Kargar et al. (2020) and is based on the time in which dealers must report trades to TRACE. Other papers studying riskless principal trades, e.g. Zitzewitz (2010), Ederington, Guan, and Yadav (2015), Harris (2015) or Schultz (2017) define a holding period of 60 seconds.[5] The method of matching customer trades on same trade size has the limitation that trades where a dealer splits a customer order into multiple smaller trades are not captured.

[5] We also replicated the main results by applying a 60-second timeframe, and the outcomes remain qualitatively similar.

Our approach is more restrictive and likely reflects the lowest floor for the number of dealer-intermediated C-to-C trades.

In both samples a trade always consists of two orders: One order where the dealer/platform buys/sells from a client, and another leg with the opposite trading direction. One can argue that this double count is unreasonable since there is only one buyer and one seller and the platform which does not take on any risks. Similar to O'Hara and Zhou (2021), we reason that the platform only replaces the dealer. If the trade had been brokered by a dealer, the transaction would be visible as two reports in TRACE. We therefore double count each C-to-C trade in our work. Table I reports summary statistics and shows the fraction of trades within different trade and order characteristics. The table reports the fractions for all dealer-to-client trades in the TRACE sample, paired C-to-C trades intermediated by dealers (from TRACE), and C-to-C trades intermediated electronically on UBS Bond Port. The table shows that dealer-intermediated C-to-C orders tend to be more prevalent for larger orders in bonds with a smaller issue size that are older in age. For instance, 73.7 percent of client-to-dealer transactions reported by TRACE are micro-sized trades, whereas the share of such trades account for only 65.7 percent of all trades paired by dealers. In contrast, odd-lot and round-lot trades are more common to be brokered by dealers. Block trades are not necessarily more often intermediated on riskless terms. This might reflect the difficulty for dealers to find a trading opponent for orders larger than $ 5 million. Instead, dealers might divide such orders into smaller batch sizes.

By comparison, electronic C-to-C trades tend to be more prevalent for easier trades in more liquid bonds. Table I suggests that customers prefer platform-trading for smaller trades in younger bonds with a larger issue size. For example, almost one third of all electronic C-to-C trades are odd-lots, implying a high density of trades in this order segment. Orders larger than $ 1 million appear to be less commonly traded electronically. Moreover, bonds with issue size lower than $ 100 million are rarely traded electronically, instead 88.4 percent of the trades executed electronically take place in bonds with an issue size of more than $ 500 million. This suggest that investors prefer dealers for more complex limit orders in bonds that tend to be more illiquid where the information leakage costs are higher. This is consistent with other research papers, i.e. Goldstein and Hotchkiss (2020), finding that dealers tend to pair trades in more illiquid securities where trading opportunities are scarce. In contrast, clients choose the electronic trading channel for easier limit orders in bonds with a higher expected level of liquidity. Smaller orders incur lower information leakage costs since the market participants are less likely to adjust their price expectations due to smaller trading orders. Further, Hotchkiss and Jostova (2017) find that the issue size and the age of a corporate bond are the two most economically important determinants of liquidity. Table I suggests that limit orders in bonds with higher liquidity characteristics tend to be more prevalently placed in the electronic trading channel.

Table I: Summary statistics

The table reports summary statistics on U.S. corporate bond transactions. The column "*Overall D-to-C trades*" contains all trades between a dealer and a client in the TRACE file. The columns "*C-to-C trades*" consider riskless principal trades where solely dealers or a platform step between two clients. The column "*Dealer-intermediated*" filters the TRACE file by trades where a dealer executes two dealer-to-client orders of the same quantity in opposite directions within 15 minutes. The column "*Platform-intermediated*" refers to C-to-C trades executed on UBS Bond Port. Observation period is from October 2018 to June 2020. Credit Ratings are used from S&P.

	Overall D-to-C trades	**C-to-C trades** (<15 min, riskless principal trades)	
		Dealer-intermediated	**Platform-intermediated**
Number of trades	11,413,022	513,810	226,256
Mean trade size ($)	208,556	270,464	102,264
Median trade size ($)	25,000	31,000	35,000
Trade size (%)			
micro ($1 to $100k)	73.7	65.7	66.6
odd-lot: ($100k to $1m)	20.3	26.3	32.1
round-lot ($1m to $5m)	5.4	7.4	1.3
block ($5m+)	0.6	0.7	0.0
Issue size distribution (%)			
Small (<$100m)	3.6	5.2	0.1
Medium ($100–500m)	14.4	17.5	11.5
Large (>$500m)	82.0	77.3	88.4
Age distribution (%)			
Under 2 years	24.6	23.1	26.0
2–5 years	41.3	39.1	40.4
5+ years	34.1	37.8	33.6
Maturity distribution (%)			
Under 2 years	21.9	21.4	15.6
2–5 years	33.0	34.3	37.2
5–20 years	37.0	37.3	38.0
20+ years	8.1	7.0	9.2
Credit quality distribution (%)			
Superior (AA- and up)	8.3	8.5	8.2
Other Investment grade (BBB-A)	70.2	65.9	57.0
High-Yield (below BBB)	19.3	23.7	34.5
Not Rated	2.2	1.8	0.2

Table II highlights the market share of dealer-intermediated and electronic C-to-C trades as a fraction of dealer-to-client transactions from the TRACE sample, separated by credit quality and trade size. The table provides a qualitative indication of where the share of C-to-C trading is more predominant. Table II shows that C-to-C trading differs across the two trading mechanisms. Customers tend to place limit orders with dealers for larger orders in lower rated bonds.[6] Such trades incur a higher risk of information leakage. For instance, the share of riskless principal trades in high yield bonds intermediated by dealers increases from 4.9 percent for the smallest trades to 8.0 percent for the largest orders. In the segment of investment grade bonds, the share of dealer-intermediated C-to-C trades follows similar patterns, although the portion of riskless principal trades decreases for block trades. This might reflect the fact that the search for a trading opponent for very large trades is difficult, resulting in a lower share of C-to-C trades. In contrast, customers tend to prefer the electronic trading channel for smaller orders. Odd-lot orders account for the highest proportion of electronic limit orders, with investment grade and high yield bonds accounting for a market share of 2.7 and 4.9 percent respectively. Round-lot and block trades account for the lowest share of electronic orders. This is consistent with the approach described in the analytical framework suggesting that clients prefer electronic trading for limit orders where the risk of information leakage is lower.

The qualitative results from Table I and Table II suggest that electronic C-to-C trading seems to follow similar patterns to electronic RFQ-trading. Like electronic multi-dealer trading, investors disclose trading information on UBS Bond Port by placing actionable limit orders. Revealing trading intentions exposes clients to the risk of information leakage. As the risk of information leakage is lower for smaller trades in more liquid bonds, the decision to place a limit order electronically or OTC with a dealer seems to represent a deliberate economic balancing of interests. Considering the statistics from Table I and Table II provides qualitative evidence that investors prefer electronic trading for transacting smaller orders in more liquid bonds that incur a lower risk of information leakage. This is consistent with Hendershott and Madhavan (2015) studying electronic trading when clients ask dealers for liquidity provision.

[6] The results are qualitatively consistent with Choi and Huh (2017) although they find a higher share of client liquidity providing trades for larger trades. This can be explained by their approach to identifying riskless trades, which is less restrictive than the method used here.

Table II: Summary statistics of C-to-C trades

The table presents descriptive statistics on U.S. corporate bond transactions between dealers and clients and reports the fraction of dealer-intermediated and electronic C-to-C trades. The transactions are separated by rating and trade size (micro, odd-lot, round-lot, block). Column 3 shows the total number of dealer-to-client trades in the TRACE sample. Column 4 and 5 depict the number and fraction of dealer-intermediated and electronic C-to-C trades, respectively. Observation period is from October 2018 to June 2020. Credit ratings are from S&P, high yield bonds are rated below BBB.

Rating	Size	Dealer-to-client trades	C-to-C trades intermediated by dealers		C-to-C trades intermediated electronically	
IG	micro (<100k)	6'631'525	254'106	3.8%	100'024	1.5%
IG	odd-lot (100k to <1m)	1'714'442	92'740	5.4%	45'464	2.7%
IG	round-lot (1m to <5m)	543'710	32'652	6.0%	2'126	0.4%
IG	block (≥5m)	68'304	3'258	4.8%	34	0.0%
HY	micro (<100k)	1'594'102	78'146	4.9%	50'374	3.2%
HY	odd-lot (100k to <1m)	553'002	39'138	7.1%	27'016	4.9%
HY	round-lot/block (≥1m)	56'151	4'520	8.0%	780	1.4%

IV. Determinants of the Two Trading Mechanism

The previous section shows qualitatively that the intermediation of trades between clients depend on bond and trade characteristics. In the following sections, we examine an investor's likelihood of placing limit orders with a dealer or electronically on a trading platform. Table III estimates a probit model with the dependent variable being one if a limit order is traded electronically, zero if placed with a dealer. We estimate the models separately for investment grade and high yield bonds. Consistent with the qualitative results from the previous section, investor prefer dealers for limit orders where finding a trading opponent is more difficult. Table III suggests that larger orders in smaller and older issues are more likely to be allocated to dealers. For investment grade bonds, orders larger than $ 1 million in size are more likely to be traded through a dealer network. In the segment of high yield bonds, trades larger than $ 100,000 are most likely to be traded with a dealer, resulting in a smaller electronic market share for larger high yield orders. This is consistent with Table I and II, implying that investors prefer the electronical channel for smaller trades in younger bonds with a larger issue size. For investment grade bonds, limit orders in odd-lot trades are most likely to be place electronically. For high yield bonds, the electronic trading channel is most likely to be used for micro trades. This suggests that investors choose the electronic trading channel for bonds they expect to be more liquid and where information leakage is a lesser concern. More complex orders where the search for an opposing investor is difficult are more likely to be traded via a dealer's relationship network.

The variable stressed markets captures the highest-volatility days measured by the VIX index. Interestingly, in times of high market volatility, investors are more likely to prefer the electronic trading channel over a dealer network. This indicates an alternative trading choice by investors in stressed market situations where dealers are more reluctant to provide immediate trading solutions. Goldstein and Hotchkiss (2020) argue that a rise in the dealers' costs of providing liquidity increases the likelihood that a trade cannot be executed at a price acceptable to the customer. Instead, the probability that investors allocate a limit order in the electronic trading channel increases. This suggests that investors switch to the electronic trading channel to benefit from alternative liquidity provided by other buy-side investors. This indicates a change in investors behavioral in stressed markets: Instead of requesting liquidity with a dealer at high costs, investors place orders at their reservation price and search for a trading opponent electronically at lower costs. We further investigate the hypothesis of channel substitution in stressed market in Section VII and VIII when we analyze electronic C-to-C trading during the Covid-19 crisis. The calendar dummies control for potential changes in the choice before weekends or at the end of a month. There is some evidence of weekend and month-end effects suggesting that investors tend to be more reluctant to use the electronic trade channel on Fridays and at the end of the month.

Table III: Probit model for paired limit orders intermediated by dealers or electronically

The table presents probit models for the binary choice of an investor to allocate a limit order either to a dealer or an electronic trading platform. The dependent variable is one if a limit order is placed electronically, zero if traded with a dealer. The table runs separate models for investment grade and high yield bonds. The independent variables include dummy variables for trade size (*Micro*: <100k, *Odd-lot*: 100k to <1m, *Round-lot*: 1m to <5m and *Block*: ≥5m), calendar time (*EoW*: end-of-week, *EoM*: end-of-month), *Stressed markets* (one if the VIX index is at the top 5th percentile over the observation period from January 1990 to June 2020), and lower rated bonds (one if a bond's credit rating is among the five lowest rating categories within investment grade or high yield bonds). The natural logarithm is taken for the variables *Amount issued*, *Age*, and *Maturity*. The categorical variable *quarters* controls for time fixed effects (quarters relative to the fourth quarter 2018). Standard errors are clustered at bond and day levels. ***, **, *, and . denote the statistical significance at the 0.001, 0.01, 0.05, and 0.10 level.

	Investment grade	**High yield**
Odd-lot	0.06*** (0.00)	-0.07*** (0.01)
Round-lot	-1.07*** (0.01)	-0.94*** (0.02)
Block	-1.94*** (0.06)	
Bottom 5 notches within IG/HY	-0.01 (0.00)	-0.33*** (0.02)
Amount issued	0.23*** (0.00)	0.26*** (0.00)
Age	-0.07*** (0.00)	-0.15*** (0.00)
Maturity	0.09*** (0.00)	0.10*** (0.00)
EoW	-0.02*** (0.00)	0.00 (0.01)
EoM	-0.07*** (0.01)	-0.03. (0.01)
Stressed markets	0.16*** (0.01)	0.04*** (0.01)
1Q2019	0.03*** (0.01)	0.13*** (0.01)
2Q2019	-0.17*** (0.01)	0.25*** (0.01)
3Q2019	-0.13*** (0.01)	0.27*** (0.01)
4Q2019	-0.31*** (0.01)	0.22*** (0.01)
1Q2020	-0.43*** (0.01)	0.23*** (0.01)
2Q2020	-0.40*** (0.01)	0.23*** (0.01)
(Intercept)	-5.25*** (0.05)	-5.46*** (0.09)
Observations	530,404	199,974

While the previous sections examine when and for which bonds the two trading channels are used, the following chapters develop an approach for measuring and estimating trading costs.

V. Calculation of Trading Costs and Spreads

Trading in corporate bonds varies fundamentally from stock markets. Bond trading is not centrally assembled in one place – as opposed to equity markets – but largely takes place OTC between market participants. Price quotations are typically provided upon request and are made on an indicative basis. The lack of available and visible quotes makes it difficult to benchmark transactions in corporate bonds. As a result, measuring trading costs for bonds can be sensitive to the calculation method used. The main measure for the bid-ask spread used in this paper follows Choi and Huh (2017) and is defined as follows:

$$Spread\_1_j = 2 \times Trade\ Sign_j \times \frac{Trade\ Price_j - Benchmark\ Price_j}{Benchmark\ Price_j} \times 10{,}000 \qquad (3)$$

$Trade\ Sign_j$ takes the value of +1 for investor-buys and -1 for transactions wherein investors are selling. $Trade\ Price_j$ refers to the price of trade j. Similar to Choi and Huh (2017), the benchmark price $Benchmark\ Price_j$ is calculated as the volume-weighted average price (VWAP) of all inter-dealer trades in a bond on a day.[7] By comparing dealer-to-client trades with prices paid in the inter-dealer market assumes that transactions between two dealers follow the fair value of a bond more closely. Multiplying equation (3) by 10,000 computes the spread in basis points (bps) of value or in a fraction of the price. Since Spread_1 is sensitive to the benchmark price, we additionally benchmark each transaction against the last inter-dealer trade in a bond on a day following Hendershott and Madhavan (2015). Our results remain similar regardless the method applied. Using the VWAP of all inter-dealer trades as a reference

[7] For the purpose of their paper, Choi and Huh (2017) considered only inter-dealer trades larger than $ 100,000 and excluded trades executed within 15 minutes.

price – as opposed to the last inter-dealer trade – has the advantage of a larger number of usable transactions.

Table IV presents average spreads in basis points for dealer-intermediated and electronic C-to-C trades separated by trade size and credit quality (investment grade and high yield). For smaller trades, there are substantial spread differences evident between limit orders executed OTC with dealers and electronically on UBS Bond Port. For investment grade bonds, the average spreads for dealer-intermediated micro trades average 29.5 bps, while the spreads for such platform trades are substantially lower at 6.3 bps. The costs for dealer-intermediated C-to-C trades fall sharply for odd-lot and round-lot trades. The average costs for investment grade orders fall from 29.5 bps to 12.4 and 9.5 bps for odd-lot and round-lot orders, respectively. The costs for pairing client trades electronically fall with trade size as well, albeit less considerably. As a result, the differentials of the two trading channels are greatest for the smallest orders and narrow for odd-lot and round-lot orders. The average spreads are higher for high yield bonds than in bonds with investment grade rating. The results remain qualitatively similar regardless of the method used to determine trading spreads.

Interestingly, the average spreads for dealer-intermediated block trades in investment grade bonds are higher than for odd-lot and round-lot orders. This might reflect the increasing effort of a dealer to find a client for very large trades. The brokerage of block trades between two clients requires dealers to secretly search for counterparties, which can lead to disproportionally high search costs and spreads. The results in Table IV support the approach of information leakage costs. The relative advantage of electronic trading tends to decrease with trade size suggesting that the benefit of secrecy from dealer-intermediation increases with the difficulty to execute an order. While the results provide initial qualitative evidence on the relative costs between the two trading channels, the following section estimates transaction costs using a multivariate regression analysis.

Table IV: Difference in average spreads of electronic and dealer-intermediated C-to-C trades

The table shows average spreads in basis points for C-to-C trades intermediated by dealers or executed electronically on UBS Bond Port. The sample covers trades in U.S. corporate bonds from October 2018 to June 2020. "*Electronic*" refers to C-to-C trades executed on UBS Bond Port. "*Dealer*"-trades are C-to-C trades from TRACE where a dealer executes two dealer-to-client orders of the same quantity in opposite directions within 15 minutes. Row I uses the volume-weighted average price of all inter-dealer trades in a bond on a day as a benchmark price, similar to Choi and Huh (2017). Row II benchmarks each transaction against the last inter-dealer trade in a bond on a day, following Hendershott and Madhavan (2015). Credit ratings are used from S&P, high yield bonds are securities rated below BBB.

	Investment grade			High yield		
	Electronic	Dealer	Δ	Electronic	Dealer	Δ
I: Spread_1 (VWAP of all inter-dealer trades)						
0-100K (Micro)	6.3	29.5	**+23.3**	13.1	46.3	**+33.2**
100K-1M (Odd-lot)	6.4	12.4	**+6.0**	10.4	23.8	**+13.3**
1M-5M (Round-lot)	5.6	9.5	**+3.8**	10.4	18.7	**+8.3**
5M+ (Block)	3.8	14.4	**+10.6**			
II: Spread_1 (last interdealer price)						
0-100K (Micro)	6.2	26.4	**+20.2**	13.1	42.7	**+29.7**
100K-1M (Odd-lot)	6.4	13.6	**+7.2**	10.5	27.1	**+16.6**
1M-5M (Round-lot)	5.7	10.2	**+4.5**	10.5	22.2	**+11.7**
5M+ (Block)	3.8	12.2	**+8.4**			

VI. Regression Spread Estimates

In this section, we estimate spreads of dealer-intermediated and electronic C-to-C trades. As shown in the previous sections, trade size is an important factor in determining trading costs. Furthermore, the difference in the spreads of the two trading channels might be attributable to differences in the sample composition and time-series shifts might also affect the gap in spreads. This suggests that a comparison of spreads between the two trading channels may suffer from a selection bias. To control for the influence of bond and trade characteristics, as well as potential time trends, we follow O'Hara and Zhou (2021) and O'Hara and Alex Zhou (2021) to estimate trading spreads. We estimate the following model to show the difference in spreads for C-to-C trades intermediated by dealers or executed electronically:

$$Spread_{j,i,t,TSize} = \alpha + \beta \times Electronic_{j,t} \times TSize_{j,t} + \mu_{i,t,TSize} + \epsilon_{j,i,t,TSize} \tag{4}$$

The dependent variable $Spread_{j,i,t,TSize}$ refers to average trading costs for trade j in the same bond i, on the same day *t*, and in the same trade size category *TSize*, estimated using equation (3). The variable $Electronic_{j,t}$ is a dummy for C-to-C trades executed electronically and the variable $TSize_{j,t}$ is a categorical variable (levels: micro, odd-lot, round-lot, block) that controls for the trade size of order j. Both variables, $Electronic_{j,t}$ and $TSize_{j,t}$, form an interaction term which we include as an explanatory variable in equation (4). We include the fixed effect variable $\mu_{i,t,TSize}$ that controls for bond-day-trade size fixed effects. This enables us to compare transaction costs for dealer-intermediated and electronic trades in the same bond *i* on the same day *t*, and within the same trade size category *TSize*. Standard errors are clustered at bond and day levels.

Table V shows that the advantage of electronic trading decreases in trading size. For instance, electronic micro trades in investment grade corporate bonds incur 26 bps lower spreads when traded electronically. The advantage of lower spreads of the electronic trading channel decreases to 11 bps for odd-lot trades and turns insignificant for trades larger than $ 1 million. The declining advantage of the electronic trading channel over the dealers' network is more pronounced for high-yield orders. With an average spread difference of 42 bps, the cost differentials are most noteworthy for the smallest high yield orders. For high yield trades, the gap in spreads between the two trading channels narrow to 22 bps and becomes negative for round-lot trades. The figures from Table V suggest that trades smaller than $ 1 million tend to be significantly cheaper to execute electronically, while larger orders tend to be more attractive to carry out through a dealer network. This implies that the benefit of electronic C-to-C trading is limited to micro and odd-lot trades. This is consistent with our analytical framework suggesting that the advantage of the OTC dealer channel increases with higher order complexity. In comparison to the differences in Table IV, the differences in the estimates from Table V are more pronounced for micro and odd-lot trades and less so for larger trades. Since Table V controls for bond-day-trade size fixed effects, this suggests that bond and trade characteristics as well as time trends have some effect on the difference in spreads for the two trading channels.

Table V: Estimated spread differences of electronic and dealer-intermediate C-to-C trades

This table presents the results from estimating equation (4) and runs separate models for investment grade and high yield bonds. The variable *Electronic* is a dummy for electronic C-to-C trades executed on UBS Bond Port. The variable *TSize* is a variable for trading size and is based on the four categories micro, odd-lot, round-lot, and block. The two variables form an interaction term. *Bond-day-trade size fixed effects* control for trades in the same bond *i* on the same day *t* within the same trade size category *TSize*. Credit ratings are used from S&P, high yield bonds are rated below BBB. The sample covers C-to-C trades in U.S. corporate bonds from October 2018 to June 2020. Standard errors are clustered at bond and day levels.

	Investment grade	**High yield**
Electronic x micro	-26.10***	-42.00***
	(0.77)	(1.42)
Electronic x odd-lot	-11.10***	-22.10***
	(1.28)	(2.2)
Electronic x round-lot	-1.31	3.42
	(2.74)	(3.35)
Fixed effects:		
Bond-day-trade size fixed effect	Yes	Yes
Observations	530,404	199,974
Within R2	0.05	0.09

The highest cost differences can be observed for orders smaller than $ 100,000 in trade size. Given the large cost differences for micro trades and considering equation (2) from our analytical framework, we are barely able to explain the choice to place a micro-sized limit order with a dealer. An explanation would assume implausibly high costs of information leakage s or a disproportionally high probability of nontrading with a dealer q. This is hardly the case for micro trades. One explanation would be to assume differences in investor composition. Smaller, retail-oriented investors that would benefit from trading such orders electronically might lack access to electronic trading platforms. Instead, retail investors are often required to trade bonds with their broker-dealers. Harris (2015) finds that broker-dealers regularly add a markup to electronically accessible quotes and trade through the order to their retail clients on riskless terms. Hendershott and Madhavan (2015) show that the market share in electronic RFQ-trading is smaller for micro-sized trades and argue that this reflects a lack of access of retail investors to electronic trading platforms.

Our results on electronic trading versus dealer intermediation are consistent with the findings in the literature on electronic RFQ-trading. Hendershott and Madhavan (2015) find that electronic RFQ-trading between investors and dealers is particularly beneficial for micro and odd-lot transactions. O'Hara and Alex Zhou (2021) show that electronic RFQ-trading is almost entirely constrained to small trade sizes, while larger trades are rarely traded electronically. Our paper shows that electronic C-to-C trading follows similar patterns of benefit. These findings are especially relevant given the recent increase in direct trading between customers, as documented by Choi and Huh (2017). In the next session, we examine the robustness of client liquidity provision during the Covid-19 crisis and study how investors use the C-to-C channel under stressed market conditions.

VII. Electronic C-to-C Trading During the Covid-19 Crisis

In the recent Covid-19 crisis, the U.S. corporate bond market nearly collapsed, with yield spreads soaring and liquidity deteriorating. In this section, we examine the robustness of liquidity provision by customers during this period. The subject of stability under stress is relevant as the literature on electronic trading in corporate bond markets, e.g. O'Hara and Alex Zhou (2021) or O'Hara and Zhou (2021), points to the robustness of electronic trading as an important limiting factor. Furthermore, an understanding of the robustness of electronic C-to-C trading can promote an understanding of whether electronic liquidity provision by customers can contribute to improved market stability in the presence of high market imbalances.

We start with Figure 2 plotting daily trade characteristics, i.e. number of trades, trading volume, market share, of C-to-C trades intermediated by dealers and executed electronically. The plots indicate that the number of trades and the traded volume increased substantially at the onset of the crisis for both trade types. For dealer-intermediated agency trades, the number of trades nearly doubled from a base of about 1,100 to more than 2,200 trades per day. The daily volume provided by customers and intermediated by dealers tripled to almost $ 1 billion at the height of the crisis. The volume-based market share of customer liquidity provision intermediated by dealers increased to 10 percent of the overall trading volume. After the Federal Open Market Committee (FOMC) announced on March 23 that the U.S. Federal Reserve (FED) will purchase bonds "in the amounts needed", the volumes intermediated by dealers between two investors decreased notably.

Interestingly, the electronic trading channel followed similar patterns, even slightly more pronounced. The daily traded volume on UBS Bond Port more than tripled during the crisis, peaking at nearly $ 160 million. With the number of trades per day increasing to more than 1,000 transactions, the market share of the electronic trading channel increased to approximately 1.5 percent. After the FED intervention, the number of daily orders and the traded volumes decreased substantially. These qualitative results suggest that electronic C-to-C trading differs during stressed markets from electronic RFQ-trading between investors and dealers: O'Hara and Alex Zhou (2021) find that electronic RFQ-trading is primarily concentrated in normal market conditions and is not robust to periods of stress with declining liquidity. In contrast, electronic customer liquidity provision becomes more important in times of stressed markets. Our results indicate that investors tend to substitute C-to-C trading for principal trading with dealers, although the former still tends to remain small relative to the overall market volume. It appears that the electronic order protocol of firm and readily available prices provide investors with a pool of liquidity that can be consumed when markets fall quickly. While the trade characteristics exhibited in Figure 2 reveal investor preferences, it does not consider the costs or quality of a trading channel. To provide a comprehensive assessment of trading conditions, the next session studies the evolution of trading costs during the crisis.

Figure 2: Trade characteristics of electronic and dealer-intermediated C-to-C trades

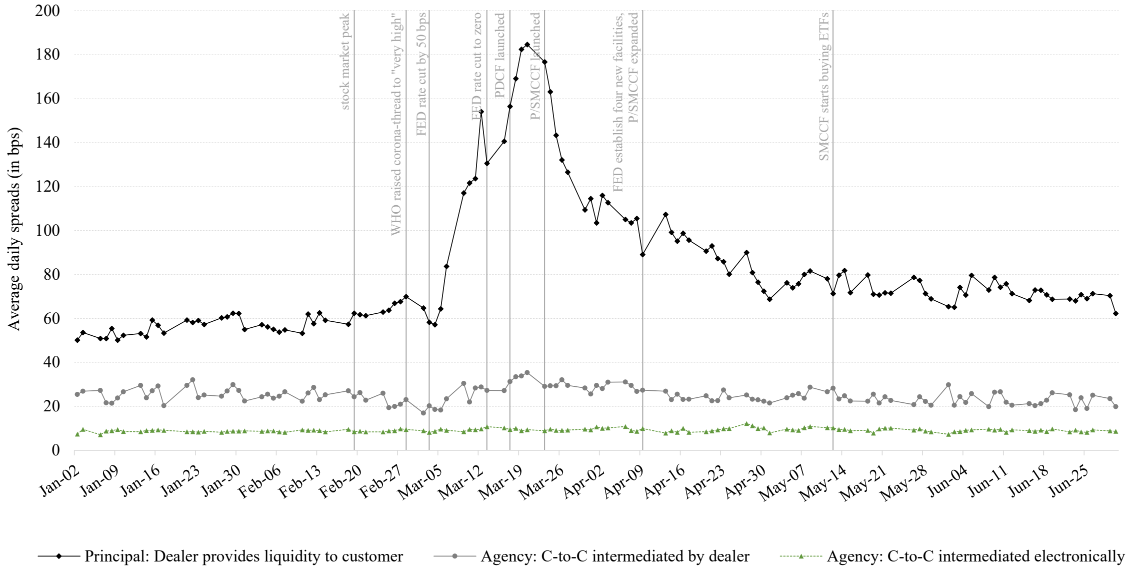
The figure shows plots for the number of trades, trading volume, and the volume-based market share of C-to-C trades intermediated by dealers (left) and executed electronically (right). The gray line shows the daily figures, the green line illustrates the 5-day moving average. Two events from the Covid-19 crisis are shown: 1) February 28 – the World Health Organization (WHO) raises coronavirus threat assessment to the highest level, 2) March 23 – the Federal Open Market Committee (FOMC) announce that the FED is committed to purchasing Treasury securities and agency MBS "in the amounts needed", quantitative easing is restarting and entails $ 700 bln. The sample covers trades in U.S. corporate bonds from January 2020 to June 2020.

Figure 3 plots transaction costs for principal trades, i.e. orders for which dealers provide liquidity to customers, and C-to-C trades that are intermediated by dealers and C-to-C orders intermediated electronically on UBS Bond Port. The chart provides initial insight about spread developments for the three trading channels during the crisis. The time series show that the costs for liquidity provision by dealers spiked substantially during the crisis, while the spreads for C-to-C trades increased much less.

The spreads of risky principal trades tripled from around 60 bps pre-crisis to more than 180 bps during the most turbulent days in March and decreased to below 80 bps post-crisis. C-to-C trades intermediated by dealers, in contrast, increased from around 25 bps to approximately 35 bps. Interestingly, C-to-C trades executed electronically are subject to much smaller variations in spreads. Figure 3 also shows that the Federal Reserve (FED) responded quickly at the height of the crisis (March 23) with the creation of the Primary Dealer Credit Facility (PDCF) and the Secondary Market Corporate Credit Facility (SMCCF). The PDCF offered term funding to primary dealers and aimed at improving market liquidity by enhancing funding conditions for dealers. The SMCCF sought to support secondary market liquidity with the outright purchase of corporate bonds and shares of bond exchange-traded-funds (ETFs).[8]

Figure 3: Transaction costs during the Covid-19 crisis

The figure shows average spreads, estimated using equation (3). The plot shows spreads for three trade types: Principal trades between dealers and customers (black), riskless C-to-C trades intermediated by dealers (gray) and intermediated electronically (green). The sample covers trades in U.S. corporate bonds from January 2020 to June 2020. The events shown are based on O'Hara and Zhou (2021) and Kargar et al. (2020).



[8] O'Hara and Zhou (2021) and Kargar et al. (2020) study the effect of the FED's intervention on liquidity conditions during the Covid-19 crisis.

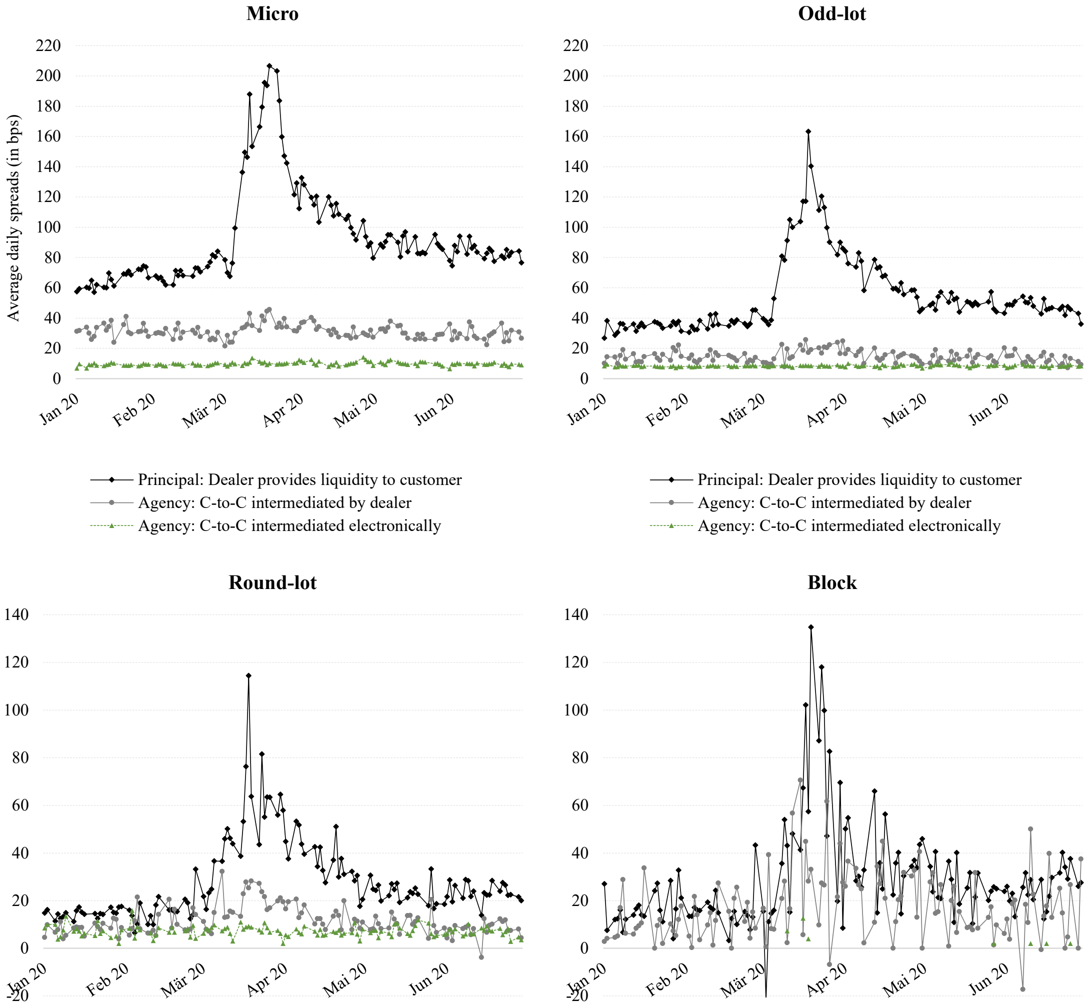
The differences in trading costs shown in Figure 3 might be affected by variations in trade and bond characteristics during the crisis period. Especially the size of an order is an important factor that affects transaction costs as documented by Table V.[9] This means that the trading volume of micro trades in illiquid bonds, which incur higher transaction costs, could be disproportionally high in one trading channel, resulting in larger spreads.

Therefore, the plots in Figure 4 additionally control for trade size and show spreads for the three trade types. We find that dealers have increased spreads substantially for liquidity-demanding principal trades across all trade size categories. The costs for micro and odd-lot trades increased by more than 120 bps, reaching prohibitively high levels of 200 and 160 bps, respectively. It is likely that for these trade size categories in particular, investors switched from costly principal trading to C-to-C trading that offered liquidity at lowered spreads during the crisis. In line with Table V, the plots show that the cost advantage of electronic trading over dealer-intermediation decreases with trade size. There is evidence that transaction cost differences increased during the Covid-19 crisis – in particular for micro trades. While spreads for dealer-intermediated C-to-C trades seem to increase in March, there tends to be less variation for electronic transactions during the crisis. The bottom right-hand chart shows that for block trades the cost advantage of C-to-C trading is rather ambiguous. As shown previously, the electronic trading channel for block trades is almost non-existent. To further study the impact of the Covid-19 crisis on trading costs, we next turn to formal regression analysis that enables us to further control for bond-, trade- and time-level characteristics.

[9] Various papers, e.g. Edwards, Harris, and Piwowar (2007), Feldhütter (2012) document trade size as an essential determining factor of costs in corporate bond transactions.

Figure 4: Transaction costs during the Covid-19 crisis controlling for trade size

The figure shows average spreads for the three trade types similar to Figure 3 but separated by trade size. Trade size categories include micro (<100k), odd-lot (100k to <1m), round-lot (1m to <5m), and block (≥5m). The sample covers trades in U.S. corporate bonds from January 2020 to June 2020.



To facilitate our regression analysis of transaction costs during the Covid-19 crisis, we define the crisis period following O'Hara and Zhou (2021) and split the sample into three periods: normal-period (October 1, 2018 – March 5, 2020), crisis-period (March 6, 2020 – March 19, 2020), and post-crisis-period (March 20, 2020 – June 30, 2020). We define the three sub-periods as categorical variable and include them into the interaction term from equation (4), resulting in the following model:

$$Spread_{j,i,t,TSize} = \alpha + \beta \times Electronic_{j,t} \times TSize_{j,t} \times Period_{j,t} + \mu_{i,t,TSize} + \epsilon_{j,i,t,TSize} \qquad (5)$$

The model controls for bond-day-trade size fixed effects and thus compares electronic and dealer-intermediated trades only in the same bond, on the same date, and within the same trade size category. The results in Table VI show that the transaction cost advantage of the electronic trading channel remained during the crisis for micro trades. In the crisis period, average transaction costs in the electronic trading channel for micro trades are 31 bps and 36 bps lower for investment grade and high yield bonds, respectively. For odd-lot trades, the signs of the coefficients remain negative for investment grade and high yield bonds, albeit they turned statistically insignificant. Table VI suggests that electronic C-to-C trading dominates over dealers even during the crisis for smaller sized transactions. For more risky orders where the risk of information leakage is higher, i.e. high yield orders and odd-lot transactions, the advantage decreased during the Covid-19 crisis and became insignificant.

Table VI: Electronic and dealer-intermediated C-to-C trades before, during and post Covid-19 crisis

This table presents the results from estimating equation (5) across the three sub-periods, similar to O'Hara and Zhou (2021): *Normal* (October 1, 2018 – March 5, 2020), *crisis* (March 6, 2020 – March 19, 2020), and *post-crisis* (March 20, 2020 – June 30, 2020). The table runs separate models for investment grade and high yield bonds. The variable *Electronic* is a dummy for trades executed on UBS Bond Port. The variable *Size* is a categorical variable with levels *micro*, *odd-lot*, *round-lot*, and *block*. The variables *Electronic*, *Size*, *Periods* form an interaction term. *Bond-day-trade size fixed effects* control for trades in the same bond on the same day within the same trade size category. ***, **, *, and . denote the statistical significance at the 0.001, 0.01, 0.05, and 0.10 level.

	Investment grade	**High yield**
Electronic x micro x normal	-27.20***	-41.70***
	(0.92)	(1.53)
Electronic x micro x crisis	-31.30***	-35.80***
	(4.88)	(8.70)
Electronic x micro x post-crisis	-23.20***	-45.00***
	(1.46)	(3.52)
Electronic x odd-lot x normal	-13.80***	-21.40***
	(1.83)	(2.37)
Electronic x odd-lot x crisis	-3.00	-8.05
	(4.91)	(14.30)
Electronic x odd-lot x post-crisis	-8.92***	-26.80***
	(1.87)	(5.04)
Electronic x round-lot x normal	-4.73	1.46
	(4.54)	(3.40)
Electronic x round-lot x crisis		13.20
		(14.02)
Electronic x round-lot x post-crisis	2.07	
	(2.82)	
Fixed effects:		
Bond-day-trade size fixed effect	Yes	Yes
Observations	530,404	199,974
Within R2	0.05	0.09

VIII. Spread Differences of Liquidity Takers and Makers in C-to-C Trading

The previous sections calculate average spreads across the two trading legs that make up a C-to-C trade. However, during the crisis it is of particular interest as to how customers pay for obtaining liquidity from the other side. In this section, we study spreads separately for each trading leg to examine the differences in spreads between the liquidity taker and the liquidity provider of a C-to-C trade. Evaluating these costs is difficult since every C-to-C trade consist of two legs, one in which the client is selling to the dealer/platform and a second where the client is buying from the dealer/platform. The difference in the price given to the first customer and the price paid by the second client is the fee charged by the dealer/platform. Since both prices are likely to be either lower or higher than the reference price, i.e. the volume-weighted average price of all inter-dealer trades in a bond on a day, Spread_1 in equation (3) normally generates a positive transaction cost estimate for one trading leg and a negative for the other. O'Hara and Zhou (2021) argue that the positive spread for the one leg can be seen as a profit, rather than a cost, to the customer who provided the liquidity. Since the TRACE sample does not identify the liquidity-providing party in C-to-C transactions, we follow O'Hara and Zhou (2021) and assume that the trading party which incurs a higher spread is the liquidity-demanding side. The electronic trading sample from UBS Bond Port is unique in that it identifies the liquidity consuming trading party of an electronic C-to-C trade. Our data set classifies the aggressor of each trade, i.e. the client who places the market order on UBS Bond Port. The opposing trading party is the liquidity provider, i.e. the passive side who places the limit order.

Before analyzing the differences in transaction costs between liquidity takers and liquidity makers, we examine the daily volume traded between two customers across the two trade types. Every C-to-C trade involves either a market order that is actively selling or buying and an associated passive limit buy or sell order, respectively. The plots in Figure 5 show the five-day average volume in C-to-C trades across the two trading channels, split into active buys and sells. The left chart shows that dealers intermediate a larger share of C-to-C trades wherein the liquidity-consuming side is buying. In contrast, the right chart displays that electronic C-to-C trading is more driven by orders wherein the liquidity-consuming party is selling. This suggests that customers tend to prefer the electronic trading channel for active sell transactions, while dealer-intermediated C-to-C trading is more used for market buy orders.

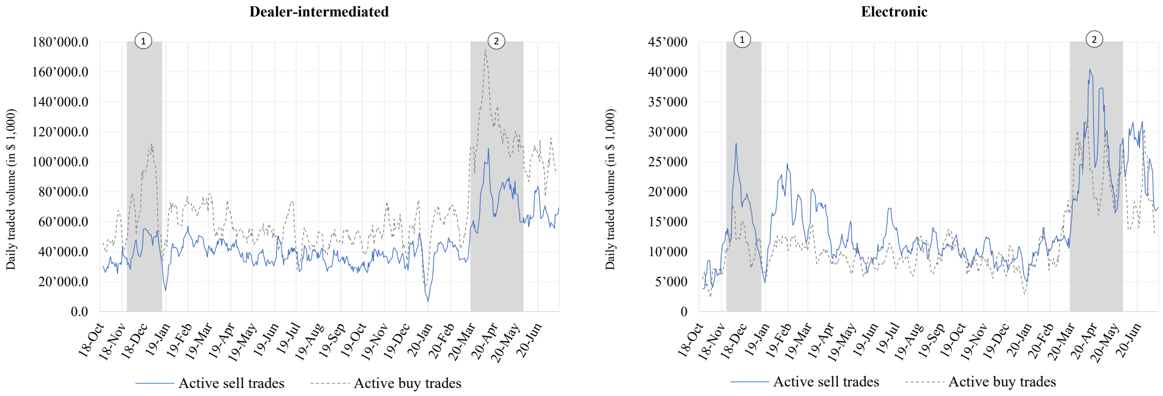
In addition, the charts in Figure 5 highlight two periods of high market volatility. There is evidence that under stressed market conditions, the differences in trading volume in active buy and sell trades is amplified for both channels. For instance, during the end of year turmoil in 2018 with the S&P 500 falling 16 percent within three weeks, the daily volume of active sell orders traded electronically more than doubled to around $ 25 million. The volume in dealer-intermediated active sell trades increased as well, albeit significantly less. The difference in trading volume is even more evident during the Covid-19 crisis. The right-hand plot shows that in the electronic trading channel the volume wherein the aggressing party is actively selling has nearly quadrupled from a base of around $ 10 million to around $ 40 million in trading volume per day (five-day average).[10] The electronic trading volume of active sell orders surpassed the daily traded volume wherein an aggressing party is buying. In contrast, in the dealer-intermediated C-to-C channel, the volume in active sell orders doubled from a base of approximately $ 40 million to around $ 100 million in daily traded volume (five-day average).[11] In the OTC dealer channel, the share of active buy orders increased substantially more with the volume of active buys significantly exceeding that of active sell trades.

[10] For visibility reasons, the plots in Figure 5 show the five-day average volume. At the height of the crisis, the daily studied volume of C-to-C trades with the aggressor actively selling reached $ 56 million in the electronic trading channel.

[11] See [10]. The daily traded volume of C-to-C trades intermediated by dealers with the aggressor actively selling reached $ 131 million.

Figure 5: Five-day average of C-to-C trading volume separated by active sells/buys and across trading channels

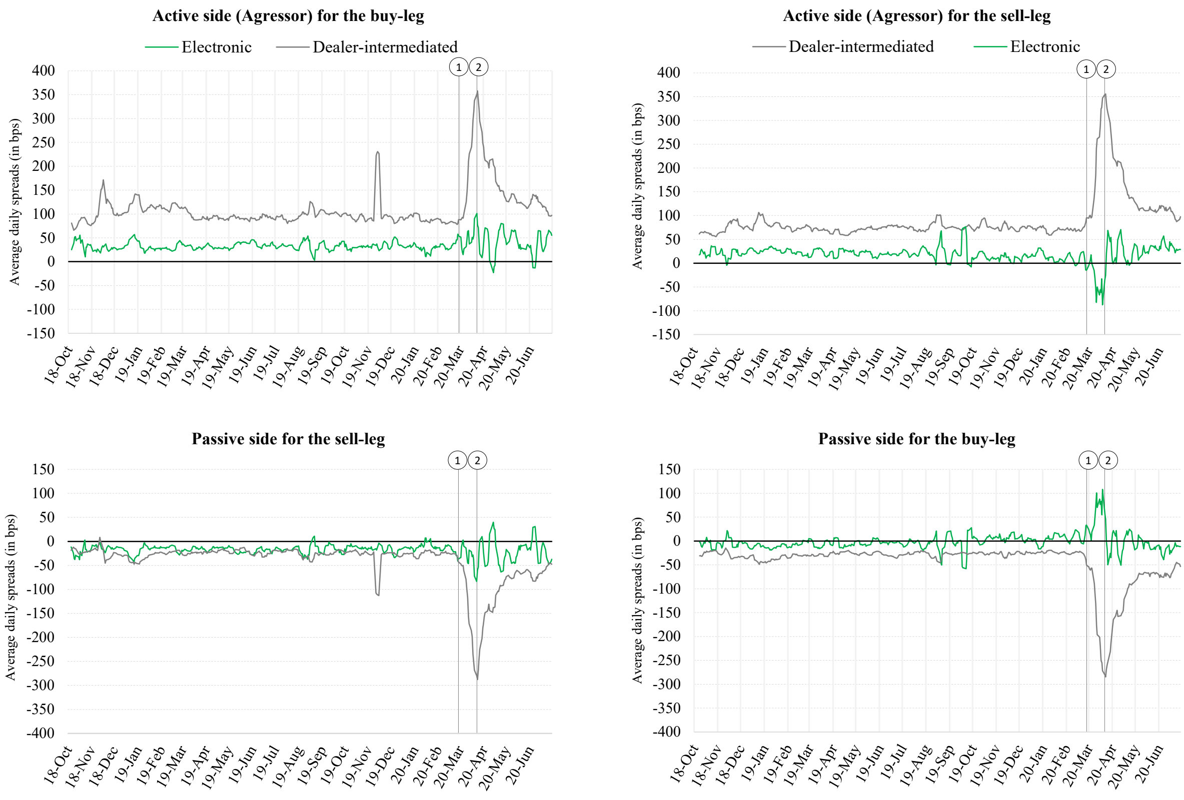
The figure shows the five-day moving average of daily traded volume in C-to-C trades separated by active sell/buy orders and split by trading channel (dealer-intermediated versus electronic). Active sell (buy) trades are orders wherein the liquidity taker is actively selling (buying). The liquidity taker of a C-to-C trade is the aggressor that places the market order, whereas the liquidity maker is the side that places the passive limit order. In the electronic trading sample, the aggressor of each trade is identified. For dealer-intermediated C-to-C trades we follow O'Hara and Zhou (2021) and assume that the trading side, which incurs a higher spread, is the liquidity-demanding investor. C-to-C trades where both legs incur the same spreads are excluded. Buy/sell is from a customer's perspective. Two events are highlighted: 1) end-of-2018 turmoil with the S&P falling 16 percent within three weeks; 2) the Covid-19 crisis with yield spreads soaring and liquidity deteriorating. The sample covers trades in U.S. corporate bonds from October 2018 to June 2020.



In addition to the quantity transacted across trade type and channel, we next study the associated transaction costs. The plots in Figure 6 show average spreads over time, separated into liquidity providers and liquidity takers and split by sell and buy orders. In each plot, the difference in the gray and green line implies the relative advantage of a trading channel in terms of spreads. The plots suggest that the cost advantage of the electronic trading channel is primarily on the liquidity-demanding side (top charts) and less apparent for the passive side providing liquidity (bottom charts). This means that dealers charge the liquidity-demanding side of a C-to-C trade much more and tend instead to reward the liquidity-providing party with a larger discount, both relative to electronic trading. For instance, the top-right chart shows that during normal market conditions, investor pay on average about 20 bps for actively selling bonds electronically, while dealers charge customers for the same trade about 70 bps on average. In contrast, the bottom-right chart displays that the liquidity-providing investor of the same trade is rewarded by the dealer with a negative spread of about 30 bps, while the electronic trading channel compensates the investor for the same trade with only about 5 bps on average.

Figure 6: Transaction costs differences between liquidity takers and makers in C-to-C trades

The figure shows average daily spreads of dealer-intermediated (gray) and electronic (green) C-to-C trades separated by the liquidity consuming party (upper charts) and the liquidity-providing party (bottom charts) and split by trade direction (buy/sell). The liquidity maker of a C-to-C trade is the side that places the passive limit order, whereas the liquidity taker is the aggressor that places the market order. In the electronic trading sample, the aggressor of each trade is identified. For dealer-intermediated C-to-C trades we follow O'Hara and Zhou (2021) and assume that the trading side, which incurs a higher spread, is the liquidity-demanding investor. C-to-C trades where both legs incur the same spreads are excluded. Buy/sell is from a customer's perspective. Two events during the Covid-19 crisis are highlighted: 1) February 28 – the World Health Organization (WHO) raises coronavirus threat assessment to the highest level, 2) March 23 – the Federal Open Market Committee (FOMC) announce that the FED is committed to purchasing Treasury securities and agency MBS "in the amounts needed", quantitative easing is restarting and entails $ 700 bln.



The developments during the Covid-19 crisis are particularly intriguing as transaction costs between the two trading channels inverted. First, the gray lines in the upper plots show that liquidity provision by customers intermediated by dealers during the crisis came at very high costs. These prohibitively high costs for dealer-intermediated trades put the rising volumes of this trading channel during the crisis, as shown by Figure 2 and Figure 5, into perspective. For instance, the spreads for dealer-intermediated C-to-C trades wherein clients are actively offloading risky assets more than tripled to 350 bps. In contrast, customers providing liquidity by buying bonds from the dealer's client network were rewarded with negative transaction costs of around 280 bps. Second, the right-hand charts in Figure 6 display that transaction costs for the electronic trading channel reacted differently, reversing for active sell orders and passive buy trades at the beginning of the crisis. The top right-hand plot shows that clients who were actively selling bonds on UBS Bond Port benefited from negative spreads. While in normal times investors pay average spreads of about 20 bps for actively selling bonds electronically, transaction costs plunged to minus 70 bps at the onset of the crisis resulting in a profit from the spread, rather than a cost. This is intriguing and can be explained by the platform's trading protocol of transparent and firm quotes at which all platform members can trade at any time. The electronic trading channel allows investors to take advantage of this liquidity pool provided by limit buy orders from other customers. As the market fell sharply in the first days of March 2020 in a risk-off episode, these limited orders were used by other customers to sell securities. Figure 2 and Figure 5 shows that trading activities on UBS Bond Port increased substantially, especially the trading volume wherein customers are actively selling. At the height of the crisis and after investors sold their positions through passive buy orders, spreads rebounded to the original level. In contrast, the spreads for active buy orders fluctuated too but remained mostly positive. This can be explained by the fact that investors typically place limit sell orders above the current market prices. These quotes are not triggered during market sell-offs when investors offload risky assets.

Table VII complements the qualitative findings on changing transaction costs between the two trading channels during the crisis with a multivariate regression analysis. For our model, we form an interaction term with dummies for the liquidity-providing side of a C-to-C trade and for the trade direction (buy/sell) and add the categorical variable containing the three periods introduced in Table VI. We estimate the following model:

$$Spread_{j,i,t,TSize} = \alpha + \beta \times Aggressor_{j,t} \times Direction_{j,t} \times Period_{j,t} + \mu_{i,t,TSize} + \epsilon_{j,i,t,TSize} \qquad (6)$$

Results in Table VII show that after controlling for bond-day-trade size fixed effects, the reversal in spreads for active sell orders during the crisis period remain. Table VII displays that in the electronic trading channel, liquidity takers pay 35 bps higher spreads for buy orders in investment grade bonds during normal market periods. The aggressor markup increases to 96 bps when a dealer intermediates the same trade between two clients. In both trading channels, the differences in spreads between liquidity takers and liquidity makers increase for high yield bonds. Most intriguing is the difference in spread movements during the Covid-19 crisis for trades, wherein investors are actively selling securities. The aggressor markup for sell orders in the electronic trading channel reversed for both investment grade and high yield bonds. While liquidity takers paid 30 bps more for selling investment grade bonds pre-crisis, this markup plunged to -150 bps during the crisis. In contrast, dealers substantially increased the aggressor markup for the same trades from 80 bps in normal market conditions to 460 bps during the crisis. We observe analogous developments for orders in high-yield bonds. This shows that the trading protocol of the electronic trading channel leads to an asymmetric development in spreads for buys and sells in fast falling markets. Liquidity-demanding customers selling bonds electronically at the onset of the crisis benefited from the transparent order book with actionable price quotes. Customers placing limit buy orders electronically seem to be penalized by faster liquidity takers.

One can argue that in fast changing markets, the availability of firm quotes in the electronic trading channel primarily benefits the party that is able to respond more quickly to changes in the market prices. Hendershott and Madhavan (2015) argue that the quotation of live executable prices offers a free option to the market and exposes the liquidity-providing party to adverse selection. In the electronic trading channel, the disclosure of trading intentions enables liquidity consumers to trade at the expense of the liquidity providers. The reversal of spreads, i.e. from negative and rewarding to positive and costly spreads, can be seen as a form of materialization of the risk of adverse selection. Compare to electronic trading with live executable quotes, investors are less exposed to the risk of adverse selection in the OTC trading channel. In the OTC trading channel, dealers and investor are able to adjust their pricing for each trade.

Table VII: Spread markups for liquidity takers in C-to-C trades intermediated electronically and OTC by dealers

This table presents results from estimating equation (6). It shows transaction cost estimates for liquidity takers (versus makers) across the three sub-periods: *Normal* (October 1, 2018 – March 5, 2020), *crisis* (March 6, 2020 – March 19, 2020), and *post-crisis* (March 20, 2020 – June 30, 2020). The variable *sell/buy* is a dummy for an investor's trade direction. The *Aggressor* is the side that places the market order. In the electronic trading sample, the aggressor of each trade is identified. For dealer-intermediated C-to-C trades we follow O'Hara and Zhou (2021) and assume that the trading side, which incurs a higher spread, is the liquidity-demanding investor. C-to-C trades where both legs incur the same spreads are excluded. The table runs separate models for the electronic and dealer-intermediated trades and differentiates between investment grade and high yield bonds. *Bond-day-trade size fixed effects* control for trades in the same bond on the same day within the same trade size category. Credit ratings are used from S&P, high yield bonds are securities rated below BBB. Standard errors are clustered at bond and day levels. ***, **, *, and . denote the statistical significance at the 0.001, 0.01, 0.05, and 0.10 level.

	Electronic		Dealer-intermediated	
	Investment grade	High yield	Investment grade	High yield
Aggressor x sell x normal	30.30***	49.31***	79.60***	175.30***
	(1.34)	(5.50)	(0.55)	(1.86)
Aggressor x sell x crisis	-149.50***	-158.80***	459.30***	703.60***
	(28.40)	(42.30)	(9.97)	(27.60)
Aggressor x sell x post-crisis	16.60**	56.60***	221.90***	438.70***
	(6.23)	(15.50)	(2.45)	(8.76)
Aggressor x buy x normal	34.90***	65.10***	95.70***	192.20***
	(0.988)	(2.69)	(0.68)	(2.10)
Aggressor x buy x crisis	76.30*	97.50*	424.50***	646.50***
	(29.7)	(41.20)	(12.10)	(26.90)
Aggressor x buy x post-crisis	38.40***	76.60***	205.40***	483.50***
	(5.87)	(13.30)	(2.55)	(10.90)
Fixed-Effects:				
Bond-day-trade size fixed effect	Yes	Yes	Yes	Yes
Observations	147,648	78,170	377,828	120,830
Within R2	0.15	0.13	0.27	0.33

The results of reversing spreads in electronic C-to-C trading in the Covid-19 crisis are novel and differ from the findings in O'Hara and Zhou (2021). We think that three reasons lead to the differing results. First and foremost, our sample on electronic trades identifies the liquidity-demanding side of a C-to-C trade, while O'Hara and Zhou (2021) are not able to separate the two parties of an electronic C-to-C trade. Deriving the liquidity providers of electronic C-to-C trades from the TRACE sample requires assumptions that change over time and do not hold during stressed markets, i.e. the Covid-19 crisis. We show that the liquidity taker premium reversed during the crisis. Therefore, O'Hara and Zhou (2021) overestimate transaction costs of the electronic C-to-C trading channel and undervalues its liquidity provision potential. Second, electronic trading platforms use different protocols for execution. Our proprietary data sample allows us to examine C-to-C trades executed in a limit order book with transparent and firm quotes. O'Hara and Zhou (2021), in contrast, examine electronic C-to-C trading across multiple trading platforms. SIFMA (2016) finds that electronic trading platforms use varies protocols, including hidden order books, order books with live and firm quotes, session based trading, or platform determined midpoint pricing. Many platforms even offer more than one order execution protocol. The absence of information identifying the execution protocol of the electronic trading platform may lead to averaged results across all platforms. Kozora et al. (2020), who study alternative trading systems using TRACE data, also point out the limitation of being unable to uniquely identify trading protocols. Third, electronic trading platforms may also have different market participants. The trading platform studied in this paper aggregates liquidity predominantly from buy-side investors while other electronic trading platforms might rely more on quotes provided by dealers. The varying composition of market participants may lead to different trading characteristics across platforms. Overall, the literature on electronic C-to-C trading underestimates the liquidity potential of electronic trading protocols in stressed market situations offering firm and pre-trade transparent price quotations.

IX. Conclusion

Continued changes in dealer behavior in corporate bond trading are important drivers of changes in the microstructure of liquidity provision. With tighter banking regulations, dealers have become more reluctant to provide liquidity in the aftermath of the financial crisis. Instead, customers are increasingly acting as liquidity providers. We examine an established electronic trading platform called UBS Bond Port that aggregates customer liquidity by using a limit order protocol of transparent and firm price quotes. In contrast to placing limit orders with a dealer, customers can show their reservation price electronically to all platform members and are able to transact at the provided quotes. Using a unique data sample of 226,000 electronic customer-to-customer (C-to-C) trades with a total volume of $ 23 billion, we show that under normal market conditions the electronic trading channel is particularly beneficial in term of transaction costs for orders up to $ 1 million in trade size. For round-lot orders, the difference in average trading costs becomes statistically insignificant. We find that investor prefer the electronic trading channel over dealer-intermediation for orders incurring a lower risk of information leakage. Block trades are rarely intermediated electronically between two customers. Our data sample is unique in that it also identifies the aggressor of an electronic C-to-C trade allowing us to demonstrate the differences in trading costs between liquidity takers and liquidity makers. We show that under normal market conditions, the cost advantage of the electronic trading channel is mainly collected by the liquidity-requesting party. Compare to electronic trading, dealers charge the liquidity-demanding side of a C-to-C trade much more and tend instead to reward the liquidity-providing party with a larger discount. For instance, investor pay on average about 20 bps for actively selling bonds electronically, while dealers charge customers for the same trade about 70 bps on average. In contrast, the liquidity-providing investor of the same trade is rewarded by the dealer with a negative spread of about 30 bps, while the electronic trading channel compensates the investor for the same trade with only about 5 bps on average. We find that the electronic trading channel handles a higher proportion of trades where aggressors are selling, while the OTC dealer channel has a predominance of trades with active buyers.

As the Covid-19 crisis unfolded, we reveal how trade volume in C-to-C trading increased, both traded electronically and intermediated by dealers. The cost advantage of the electronic trading channel persisted during the crisis, although decreased for riskier trades, i.e. high yield orders and larger transactions. We show that dealers increased the cost for liquidity takers in C-to-C trades to prohibitively high levels. Surprisingly, spreads for liquidity takers selling bonds electronically inverted at the onset of the crisis resulting in negative aggressor markups for active sell orders. For instance, while liquidity takers paid 30 bps more for selling investment grade bonds pre-crisis electronically, this aggressor markup plunged to -150 bps during the crisis. This means that customers were able to sell securities electronically at negative spreads. This is intriguing and can be explained by the electronic trading protocol of a transparent order book with live tradable price quotes. When markets fell sharply in a risk-off period, firmly placed limit buy orders were used by other customers to sell their positions. We demonstrate that the volume in electronic trades wherein customers are actively selling quadrupled at the height of the crisis. In the two most turbulent weeks from March 6 to March 19, 2020, the studied trading platform intermediated trades worth \$ 530 million between investors. These results contrast with electronic liquidity provision by dealers, which is largely limited to normal market conditions. Our analysis delineates how customers used an electronically accessible limit order book with firm quotes as a trading channel to access liquidity from other customers in both normal times and under stressed market conditions.

To the best of our knowledge, our work is the first that dedicatedly analyzes a comprehensive data set of C-to-C trades in corporate bonds executed electronically in a globally accessible limit order book with transparent and firm price quotations. Other studies on electronic C-to-C trading, e.g. O'Hara and Zhou (2021), underestimate the potential of electronic order protocols as their data sample does not identify the liquidity-taking party of a C-to-C trade. As a result, they do not consider the reversal of spreads in the electronic trading channel during the Covid-19 crisis, leading to an overestimation of transaction costs. They undervalue electronic C-to-C trading as a viable source of liquidity during stressed market conditions. Other papers on electronic corporate bond trading study electronic auction trading between customers and dealers, i.e. Hendershott and Madhavan (2015) and O'Hara and Alex Zhou (2021).

Our results speak to the debate regarding the importance of buy-side investors as liquidity providers. We demonstrate that the electronic intermediation of liquidity between customers is a trading channel capable of absorbing liquidity in stressed markets. Although electronic customer liquidity provision is still small relative to the overall market, we provide valuable insights to researchers and regulators as to how buy-side investors are able to bridge liquidity gaps in times of stressed markets. Harris, Kyle, and Sirri (2015) proclaim the introduction of electronically accessible order display facilities that require dealers to post their customers' limit orders. Our analysis provides insight as to how such innovations add value to market participants. Our work highlights the role of electronic C-to-C trading as a potential solution that can help improve the stability of the corporate bond market, both from a systemic perspective and from the perspective of selected market participants.

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Appendix

Table VIII: TRACE sample construction

This table describes how the data set from TRACE is cleaned. The initial data set includes all dealer-to-client transactions in U.S. corporate bonds from the non-enhanced TRACE file from October 2018 until June 2020. We follow Bessembinder, Maxwell, and Venkataraman (2006), Edwards, Harris, and Piwowar (2007), Ederington, Guan, and Yadav (2015) and Elkamhi, Groba, and Nolte (2017) to clean the data set.

Step	Exclude observation if	Remaining sample size (in %)
1	…the transaction has no CUSIP or time/date stamp	100.00
2	…the trade price is smaller than $ 25 or larger than $ 500	99.7
3	…it is a “when issued” or “special price” trade	99.5
4	…it is an “as of” trade	98.1
5	…a special sale condition is attached	96.5
6	…the settlement date is over a week in the future	96.1
7	…the trade is later corrected or canceled	93.0
8	…the trade cannot be benchmarked due to a missing inter-dealer trade	80.4
9	…the price deviates more than 10 percent from the daily mean of all inter-dealer prices	80.4