OTC Discount

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Abstract

This paper studies price dispersion and venue choice in the market for German Bunds, the second most liquid sovereign bond market in the world, where exchange platforms with a central limit order book and over-the-counter (OTC) segments coexist for interdealer transactions. We focus on the dealer-to-dealer segment of the market and show that the price differences between the OTC and exchange segments are significant. For the majority of trades the OTC price is favorable with respect to the corresponding quoted price on the exchange, indicating the presence of an *OTC discount*. The size of the OTC discount depends on dealers' search costs and trading relationships. Dealers are more likely to execute a trade on the exchange when the required immediacy is high or when search costs are high. Our findings highlight the complementary roles played by exchange and OTC segments with important implications for the design and regulation of fixed-income trading.

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1 Introduction

The vast majority of fixed-income cash and derivative markets are over-the-counter (OTC) markets in which transactions are based on bilateral negotiations between two counterparties. Prominent examples are the corporate bond and interest rate swap markets. However, for some instruments dealers can also trade among themselves on electronic central limit order books (CLOB) provided by exchange platforms.[1] The interdealer segment of the market for German federal government debt is a case in point, thus providing a unique laboratory to study dealer pricing and trading decisions in a fragmented market structure.[2]

German sovereign bonds, generally known as *Bunds*, enjoy benchmark status for Europe as a safe asset and are considered the second most liquid sovereign bond market in the world after the U.S. Treasury market. The vast majority of transactions in the Bund cash market are dealt over-the-counter. However, dealer banks also have the choice to send a trade to the exchange, with MTS being the leading interdealer exchange for Bunds and other European sovereign debt. Hence, the Bund market effectively constitutes a hybrid market with a dominant OTC segment and a smaller exchange segment.[3]

In this paper, we address two key issues pertaining to hybrid markets for dealer-to-dealer (D2D) trades. We first investigate the price differences between OTC and exchange trades and highlight the main drivers of these differences. Second, we explore the dealers' decision whether to trade in the OTC segment or on the exchange, taking the price differential into account. The crucial advantage of our empirical setup over related studies is that we are able to define for any OTC trade the *contemporaneous* conditions of trading on the exchange. We can thus disentangle the determinants of price differences by relating them to trade, dealer and bond characteristics. Our study therefore also provides insights regarding the modelling of OTC markets (cf. Duffie (2012)). A side contribution is a

[1] In a slight abuse of notation we will refer to an exchange venue that is organized as a central limit order book platform simply as an "exchange" in this paper and use the expressions "exchange" and "CLOB" interchangeably.

[2] Other examples include foreign exchange, CDS and index swap markets.

[3] Securities with a similar market structure are the US Treasury bond market (see, e.g., Barclay, Hendershott, and Kotz (2006)), several other European sovereign bonds, and the CDS index market (see Collin-Dufresne, Junge, and Trolle (2018).

description of the Bund market microstructure, which is so far largely unexplored.[4]

At the core of our analysis is a regulatory dataset which includes *all* transactions on Bunds made by financial institutions regulated in Germany from 2011 to 2017.[5] We match these transactions with the full limit order book and all trades of the interdealer platform MTS, the largest sovereign bond exchange in Europe. The availability of this unique combined dataset allows us to investigate dealer pricing and venue choice in a hybrid market setting. While several previous studies have analyzed venue choice for equity markets,[6] there is little evidence for bond markets. Two notable exceptions are Barclay, Hendershott, and Kotz (2006) who study the choice between electronic and voice brokerage for U.S. Treasuries that go off-the-run and Hendershott and Madhavan (2015) who analyze U.S. corporate bonds trading on a request-for-quote (RFQ) platform and OTC.[7] In contrast to these studies, our unique dataset allows us to directly compare between exchange and OTC trading that is in line with the settings described in theoretical studies (Seppi, 1990; Grossman, 1992; Lee and Wang, 2017).

We measure the price discount or premium of an OTC trade with respect to potential execution of the same trade on the exchange at the same time. To do so, we first calculate the hypothetical trading price of a given trade on the exchange, taking into account the full limit order book, and then calculate the difference between the hypothetical trade price and the actual observed OTC transaction price. When this difference is positive we label it *OTC discount* and when it is negative the *OTC premium*.[8] Our main finding

[4]We are only aware of Upper and Werner (2002), who consider the information content of the Bund futures and cash market in 1998. Schlepper, Hofer, Riordan, and Schrimpf (2018) study the effect of central bank purchases of Bunds on yields, without however providing a detailed description of the Bund cash market.

[5]This dataset is similar in scope to U.S. TRACE for corporate bonds and to the Treasury TRACE data that FINRA has been collecting for the U.S. Treasury market since July 2017.

[6]E.g. on NYSE (Keim and Madhavan, 1996; Madhavan and Cheng, 1997; Madhavan and Sofianos, 1998), Toronto Stock Exchange (Smith, Turnbull, and White, 2001), Helsinki Stock Exchange (Booth, Lin, Martikainen, and Tse, 2002), Paris Bourse (Bessembinder and Venkataraman, 2004) and London Stock Exchange (Friederich and Payne, 2007; Carollo, Vaglica, Lillo, and Mantegna, 2012).

[7]Riggs, Onur, Reiffen, and Zhu (2017) study a hybrid market structure in the dealer-to-costumer (D2C) segment of the market for index CDS. While a central limit order book exists in their empirical setting, it is so illiquid that their comparison is effectively between RFQ and request-for-streaming (RFS) mechanisms. Collin-Dufresne, Junge, and Trolle (2018) study differences in transaction costs between the D2C and the interdealer (D2D) segment in the same market and between market structures in the D2D segment. They find that D2C trades have higher costs (which relate to higher price impacts), while in the D2D segment trading mechanisms with execution risk have lower costs than the interdealer CLOB.

[8]Cenedese, Ranaldo, and Vasios (2017) use a similar terminology in their analysis of interest rate

is that the vast majority of the transactions in the D2D segment trades at a price that is favorable with respect to the price attainable on MTS. Specifically, more than 90% of OTC trades feature a discount relative to the price at which the same security would be traded on the exchange at the same time. On average the OTC transaction cost in trades between MTS dealers is about 55% lower than the corresponding cost on MTS, i.e. the average OTC discount is 55%.

We complement this result with an analysis of the dealer-to-customer segment (D2C) for which we find a significant OTC discount equal to about 35% of MTS trading costs, but lower than the average OTC discount between MTS dealers of about 55%. This indicates that the two market segments are largely complementary and that the MTS limit order book provides an outside option to OTC trading in the sense of Duffie, Gârleanu, and Pedersen (2005, 2007) and thus acts as a bound to price discrimination between MTS dealers.

We assess the drivers of the OTC discount by relating it to proxies of transaction costs on the exchange, demand for immediacy, search cost and dealers' bargaining power. We find that when liquidity conditions in the exchange market worsen, as measured by widening bid-ask spreads or reduced depth of the order book, OTC discounts increase. This implies that lower liquidity on the exchange is only partially passed on to the OTC segment. On days with high intraday volatility OTC discounts between MTS dealers are significantly smaller. Hence, dealers' demand for immediacy lowers the OTC discount.

The OTC discount is larger for bonds that are cheapest-to-deliver for the current Bund futures contract and for those that are more special in the repo market. Hence, OTC discount depends on search costs. Traders with more bargaining power, identified as those with strong trading relationships with their counterparty, receive significantly higher discounts. This may indicate the presence of price discrimination that is potentially facilitated by the opacity of the OTC segment. Finally, OTC trades between MTS dealers carry a larger discount compared to trades involving dealers without MTS access. This

swaps trading in OTC versus centrally cleared markets. They document that the same derivative contract is more expensive when bilaterally instead of centrally cleared, and label the prevalence of these price differentials *OTC premia*.

could reflect their superior bargaining position due to their access to the outside option of the exchange, their centrality to the system, or their larger size (see, e.g. Li and Schürhoff (2018)).

Given the dispersion of prices and their driving forces, we next study dealers' venue choice between the OTC and exchange segments of the market. We focus on the trading activity of dealers with access to both venues. Specifically, we estimate a probit model for the probability that a MTS dealer will perform a given trade on the exchange instead of over-the-counter depending on the trade's characteristics. We find that trading on the exchange is less likely (i) when transaction costs on the exchange are high, i.e., bid-ask spreads are wide, or trade sizes are large, and when expected relative trading conditions in the OTC segment are better; (ii) when demand for immediacy is high, i.e. for traders with high net imbalances in their inventory or for days with high intraday volatility and on days of primary auctions; (iii) for bonds with a higher search cost, i.e. those that are not cheapest-to-deliver for the futures or which are more special in the repo market. To the best of our knowledge the role of immediacy and search cost has not been studied empirically in the context of venue choice yet. Somewhat surprisingly we find that Bund securities associated with higher search cost are more likely traded on the exchange.

Our analysis is relevant in light of current policy debates and regulatory changes. There is a strong effort to improve OTC market transparency both in Europe, where the MiFID II regulation was recently rolled out with the intention to improve market conditions in and beyond European fixed-income markets,[9] and in the U.S. where FINRA has started to collect data akin to those in the TRACE database also for sovereign bonds. In this study, we analyze the incentives of traders faced with venue choices and draw inferences for the effects on the execution price for both dealers and clients. Our results suggest that both OTC and exchange trading play complementary roles in serving the different needs of dealers.

The remainder of this paper proceeds as follows. Section 2 provides an overview of

[9]Since January 3, 2018 directive 2014/65/EU - Markets in Financial Instruments Directive II (MiFID II) is effective for all European markets. It includes provisions for pre- and post-trade transparency, separation of transaction and related services fees, and mandatory best execution among others. Our sample period ends before the introduction of MiFID II.

the related literature and derives our hypotheses based thereon. Section 3 describes the market setting and our dataset. In Section 4 we compare the pricing in the OTC and exchange segment of the Bund market and study the drivers of the price differentials as well as the venue choice between trading on the exchange and over-the-counter. Section 5 concludes.

2 Deriving Testable Hypotheses from Theory

2.1 Theoretical Literature

There is a vast and growing theoretical literature on the design and modeling of financial markets and particularly hybrid markets that we relate to. While the early literature on hybrid markets was inspired by equities exchanges with upstairs segments,[10] the field has recently received increased attention in the context of fixed-income markets.

Grossman (1992) and Seppi (1990) provide concurrently compatible motivations for trading in the upstairs market: in the model of Seppi (1990) an institution has a trading need either because she needs to rebalance her portfolio (termed *liquidity-motivated*) or due to an endowment with private information (*information-motivated*). While a liquidity provider in the downstairs market needs to quote a wider bid-ask spread to insure herself against the risk of being adversely selected by information traders, dealers in the upstairs market can screen their customers and offer better conditions to uninformed clients. That is a liquidity-motivated trader may find it optimal to give up its anonymity by interacting with a dealer in the upstairs market, whereas information-motivated traders resort to the downstairs segment. This implies that dealers are able to infer (at least to some degree) the information state of their clients through a relationship build from repeated interactions. Indeed Seppi (1990) describes implied *no-bagging* agreements incentivizing customers not to trade the same asset again too soon after an upstairs trade and therefore to reveal their full liquidity need to the dealer or else face worse conditions on future trades.

[10] Most stock exchanges have or used to have so-called *upstairs* or *off-book* segments where (large) trades could be concluded away from the limit order book of the exchange (the *downstairs market* or *on-book*) in bilateral negotiations effectively resembling over-the-counter market structures.

Grossman (1992) argues that upstairs trades need not necessarily be uninformed. In his model limit orders in the downstairs market represent *expressed order flow*, whereas some traders, for fear of being speculated against, are unwilling to reveal their full trading needs in the observable limit order book. Dealers in the upstairs market acquire knowledge about this *unexpressed order flow* through interaction with their clients. Thus the upstairs market is able to facilitate trades that would otherwise not happen in the downstairs market. As in the model of Grossman (1992) customers choose whether to be active in the upstairs or downstairs segment, this may lead to externalities where, because of a clustering of traders in the upstairs market, bid-ask spreads in the downstairs market are wide and activity is low. Interestingly, this is quite similar to the situation we observe.

Similar themes have resurfaced recently in the wake of increased attention for the market structure of fixed-income markets and regulatory initiatives. The model of Lee and Wang (2017) is similar to Seppi (1990) with informed and uninformed investors that can trade on an exchange or over-the-counter. However the model of Lee and Wang (2017) does not focus on differences in trade size and instead features *price discrimination* based purely on the (assumed) reputation of an investor. Therefore dealers *cream-skim* the order flow from uninformed investors on the over-the-counter market by offering a lower bid-ask spread to investors deemed uninformed whereas informed investors are driven to the exchange. Crucially their model explains why smaller orders are traded OTC despite the availability of liquid exchanges and how OTC trading is predominant for standardized and frequently traded assets.

Another set of articles compare OTC and exchange markets but without considering them jointly. Glode and Opp (2017) present a model with a sequential search process for counterparties, arguing that search frictions in OTC markets can promote higher welfare through rents that encourage expertise acquisition. Also Malamud and Rostek (2017) discusses the efficiencies gained from a more general setup of decentralized markets, while Malinova and Park (2013) compare the price impact in dealer and limit order markets.

Duffie, Dworczak, and Zhu (2017) study the introduction of benchmarks to OTC markets. While the benchmark lowers dealers' profit margins, it also increases market participation and thus welfare. Similarly Vogel (2017) studies the effects of introducing a request-for-quote platform to an OTC market, predicting that it lowers average costs for all traders and providing sufficient conditions for the increased participation due to lower costs to outweigh the gains foregone by the dealers.

Finally note that multimarket trading relates also to a huge literature on dark pool trading. For a recent overview we refer to Menkveld, Yueshen, and Zhu (2017). They create a pecking order of equity trading venues by the transparency and immediacy they offer and show how surprises lead to shifts in trading activity towards lit markets that offer higher immediacy at a higher cost. This payoff between transactions costs and immediacy is also characterized in theoretical models such as Zhu (2014) where dark pools with higher execution risk and lower costs attract uninformed liquidity traders and informed traders prefer the exchange. The crucial difference of dark pools to OTC markets is that dark pools are anonymous and thus do not allow for price discrimination.

2.2 Hypotheses

The first hypothesis investigates how prices in the over-the-counter segment relate to those attainable on the exchange. The hypothesis that we test is

Hypothesis 1. *OTC transaction prices are on average favorable in comparison to the attainable price of executing the same trade on the exchange.*

Hypothesis 1 provides a test for the prediction of Grossman (1992) that the OTC (upstairs) segment is able to make available more liquidity than what is visible on the exchange (downstairs) and consequently offer the same amount of liquidity at a lower cost.

In order to study the price differences between the OTC and exchange segments (and the consequent different costs) we leverage the presence of continuous executable quotes in the central limit order book of the exchange, allowing for a direct comparison of the cost of OTC trades with attainable exchange prices at the level of single trades. To this end we define the *OTC discount* that a trader is facing when initiating a trade as the difference in price between the virtual price a trade would have incurred on the exchange and the observed price of an OTC trade, symmetrized for buy- and sell-trades and normalized by the respective virtual transaction cost on the exchange. More formally we define the OTC discount as:

$$OTC\ discount = \frac{\epsilon\left(price^{\text{virtual,exchange}} - price^{\text{observed, OTC}}\right)}{\left\|price^{\text{virtual,exchange}} - price^{\text{mid,exchange}}\right\|} \quad , \tag{1}$$

where $price^{\text{observed, OTC}}$ is the price of an over-the-counter trade and $price^{\text{virtual,exchange}}$ is a virtual price which the same trade would have incurred on the exchange according to the order book at the same time (including effects of walking up the book in the case of large trades). $price^{\text{mid,exchange}}$ is the exchange midprice at the time of the trade and the trade sign ϵ is $+1$ (-1) for buyer- (seller-) initiated trades.

A positive OTC discount implies that actively executing a trade over-the-counter is cheaper for the initiator than trading on the exchange, whereas for a trade with a negative OTC discount, or rather an *OTC premium*, trading on the exchange would have been favorable. It is worth to stress that we always take the perspective of the active trader that is initiating the trade, not the one of a passive trader.

While Hypothesis 1 is concerned with the distribution of OTC discount, in Hypothesis 2 we study OTC discount at the level of single trades. Specifically we investigate the driving factors behind OTC discounts:

Hypothesis 2. *OTC discount, as defined in Equation (1) is larger when a) market liquidity on the exchange is lower, b) the demand for immediacy is small, c) search costs are smaller, and d) the trader initiating the trade has high bargaining power.*

Liquidity in the exchange/transaction costs. An increase in a bond's transaction costs on the exchange reflects liquidity providers thereon facing or anticipating a higher adverse selection risk and thus e.g. quoting wider spreads or lower depths. In OTC trades, instead, dealers can condition the quotes they offer on their knowledge of the counterparty and offer a tiered pricing depending e.g. on their evaluation of the informedness of their counterparty. The hypothesis thus talks to the predictions of Seppi (1990) and Lee and Wang (2017) that the OTC segment provides favorable quotes to uninformed investors (a feature themed price discrimination in Lee and Wang (2017)). This also implies that an informed trader will find herself less able to trade OTC (or at worse conditions) and therefore prefer the exchange, while uninformed investors flow to the OTC segment.

Immediacy. When traders have a higher demand for immediacy they are more willing to accept a lower OTC discount, as a timely fulfillment of their trading need is preferred over potential price improvements, i.e. they accept to pay a sort of *speed premium*. This is largely related to market conditions, for example during high volatility periods when there is a larger risk of adverse price movements, or immediacy needs specific to a dealer due to, for example, allocation mismatches in primary auctions.

Search costs. By a similar argument the average OTC discount of a trade in a bond for which search costs are high is expected to be lower. Since the bond is harder to obtain, a trader might be forced to accept a less favorable price, i.e. a smaller OTC discount.

Bargaining power. Lastly, as stressed by Duffie, Gârleanu, and Pedersen (2005, 2007) the price paid by a trader is related to their bargaining power. Traders with a better bargaining position can expect a higher OTC discount. Bargaining power can be linked to a number of factors such as the presence of established trading relationships or the position of a trader within the dealer network (Li and Schürhoff, 2018) among others highlighted in the theoretical and empirical literature regarding price discrimination in OTC markets. In our hybrid market framework bargaining power is also related to the outside options provided by the exchange.

In our setup a subset of market participants, referred to as *MTS dealers*, have the choice to trade either over-the-counter (OTC) or on the central limit order book of the interdealer exchange MTS, whereas all other participants (*other dealers* and *non-dealers*) can trade mainly on the OTC market but not on MTS. This implies that for MTS dealers the exchange represents an outside option (with a discount equal to zero by definition) that is not accessible to other participants and valuable especially when immediacy needs or search costs are high.

In the third hypothesis we focus on trades executed by MTS dealers and study the drivers of their venue choice between the OTC and exchange segments. That is, when is an MTS dealer more likely to trade on the exchange or over-the-counter?

There are several structural differences between both venues beyond transactions costs as highlighted in the previous two hypotheses. First, trading on the exchange is immediate. Instead OTC trades are preceded by a search process for a suitable counterparty that incurs search costs, both in monetary terms and time delays. Second, trading on the exchange is post-trade transparent, i.e. a trade is observed by other market participants, whereas trading in the OTC segment is opaque and typically a trade and its details are only known to the involved parties. Lastly, while bargaining power and price discrimination play a role in over-the-counter markets, trading conditions are the same for all participants in the central limit order book. In our hypothesis we test:

Hypothesis 3. *MTS dealers are more likely to execute a trade on exchange instead of OTC when a) market liquidity on the exchange is lower, b) the required immediacy is high, and c) search costs are high.*

Hypothesis 3 reflects the preferences and constraints faced by traders. Foremost market liquidity plays a role. The lower the transaction costs are on a given venue or in a given segment, the more attractive and thus likely is trading therein. Second, we expect a trader who requires immediacy to be more likely to trade on the exchange where trading is immediate. Finally, when search costs for an asset are high, the exchange market represents a convenient outside option.

3 The Bund Market

Our empirical analysis is based on trades in German federal government securities, typically referred to as *Bunds*. In section 3.1 we give an overview of the primary and secondary market for these securities and the related Bund futures market. Section 3.2 introduces our dataset and provides some descriptive statistics.

3.1 Market Structure

German sovereign debt securities enjoy benchmark status in the Eurozone and worldwide as a liquid and safe asset. They are issued as 6- or 12-month zero coupon Treasury discount papers ("Unverzinsliche Schatzanweisungen", *Bubills*), 2-year "Bundesschatzanweisungen" (*Schaetze*), 5-year "Bundesobligationen" (*Bobls*) and 10- and 30-year "Bundesanleihen" (*Bunds*).[11] In this study we will focus on titles with long maturities, i.e. 2-year Schaetze, 5-year Bobls and 10- and 30-year Bunds, and, where not explicitly mentioning maturities, we will intend all of them when referring to Bunds from here on.

German government securities are issued regularly by the German finance agency ("Deutsche Finanzagentur", *DFA*) either as new issues or as reopenings of already issued bonds.[12] Participants in this primary market are the members of the *Bund Issues Auction Group*, a group of currently 36 international banks that commit to subscribing to a certain minimal amount of the total annual issuance. Auction days are announced well in advance and the tender process runs from 08:00 until 11:30 a.m. CET on the day of the auction, after which the allotment decision is made immediately and the results published.[13] Even though Bunds are actively traded and priced in the secondary market and via the Bund futures, information about the quantity and conditions at which the sovereign is able to issue is only revealed during the auction. Issuance days are therefore regarded with great interest by traders in all related securities and markets.

Trading in the secondary market (*cash* market) is predominantly over-the-counter. A survey by DFA among Bund Issues Auction Group members pegs daily trading volume at more than 17 billion EUR.[14] Several trading platforms exist alongside the over-the-counter

[11] There are also inflation-linked Bobls and Bunds, which we do not consider in this study. We also do not consider any regional-issued debt, such as *Laender* bonds or debt titles from supranationals with a federal guarantee, e.g. by Kreditanstalt für Wiederaufbau (KfW).

[12] In reopenings the amount outstanding of a previously issued bond is increased while its characteristics such as coupon rate and maturity date remain unchanged. The practice of reopening instead of newly issuing bonds alleviates on-the-run and off-the run effects that exist especially in U.S. Treasury bonds.

[13] Auction group members can place competitive and non-competitive bids. The former are alloted in full at the bid price up to the lowest accepted price and the latter at a weighted average price of the accepted competitive bids. For more details regarding the auction process, auction schedule, members of the Bund issues auction group and auction results we refer to the DFA website: `https://www.deutsche-finanzagentur.de/en/institutional-investors/primary-market/`.

[14] See `https://www.deutsche-finanzagentur.de/en/institutional-investors/secondary-market/`. Our sample captures about 15% of this trading activity.

market, most of which are aimed at the retail segment of the market. While the retail segment enjoys a large number of trades, these are typically very small and for this reason not the focus of this study.

Among the non-retail platforms, the most important is the interdealer exchange MTS, which is operated as a fully electronic limit order book market. During the hours from 9 a.m. to 5:30 p.m. CET dealers actively quote executable limit orders on MTS and the depth on both the bid and ask side of the book is typically in excess of 100 million EUR for most bonds, while the minimum trade size amounts to 2 million EUR. This, in conjunction with the availability of MTS data for market participants and researchers, has given MTS a benchmark function for European sovereign bond markets.[15]

Of the other non-retail platforms, only Eurex Bonds and Tradeweb show a significant share of trading activity among dealers. Tradeweb works as a request-for-quote platform while Eurex Bonds operated both a limit order book and as a pre-arranged trade facility.[16]

A major contributor to the liquidity of the secondary market for German Bunds is the even more liquid Eurex futures contract. There exist futures contracts for 2-year Schaetze, 5-year Bobls and 10-year and 30-year Bunds, with most activity in the 10-year Bund futures. Turnover across all futures was almost 32 trillion EUR in 2017, more than seven times the turnover in the cash market, with a minimum size of 100,000 EUR and minimum tick sizes corresponding to $0.5 - 2$ basis points depending on the contract.[17] It is worth

[15] Dufour and Skinner (2004) provides a detailed description of the MTS dataset and Darbha and Dufour (2013) give an overview over market structure and liquidity. The list of MTS participants, available in its current version at `www.mtsdata.com/content/data/public/gem/anagraph/member.php`, largely overlaps with the members of the Bund Issues Auction Group. Note that MTS participants must be banks, thus barring e.g. hedge funds from accessing the trading venue. MTS data have been used and validated in numerous studies at the European level, an incomplete list of which includes Beber, Brandt, and Kavajecz (2009); Pelizzon, Subrahmanyam, Tomio, and Uno (2016); Schneider, Lillo, and Pelizzon (2018). MTS is similar to the BrockerTec platform that dominates interdealer trading in on-the-run U.S. Treasury bonds. The main differences between the two platforms are a) the number of bonds traded (in BrokerTec 6 on-the-run U.S. Treasury bonds are traded compared to about 60 Bunds, including off-the-run titles, on MTS) and b) the set of participants (36 dealer banks on MTS compared to around 100 participants on BrockerTec, including dealers, hedge funds and high-frequency trading firms).

[16] Eurex Bonds was discontinued in December 2017. Conversations with market participants suggest that trading activity was concentrated in the pre-arranged trade facility mechanism of the platform.

[17] Trading activity is generally concentrated in the contract with the nearest delivery day, which is around the 10th of each March, June, September and December. Between three and five bonds are *deliverable* for each contract, one of them being the *cheapest-to-deliver*. Its price is thus closely tied to the one of the futures via an arbitrage relationship. Contractual details for the futures can be found at `http://www.eurexchange.com/exchange-en/products/int/fix/government-bonds/Euro-Bund-Futures/14770`. Trading hours last from 8 a.m. to 10 p.m. CET and thus exceed those of MTS. Due to the low interest and coupon

pointing out that *physical delivery* of the futures on the delivery day is rare and most contracts are closed by entering an opposite position. This implies that, notwithstanding the comparatively more active futures market, anyone wanting to own Bunds, e.g. for regulatory reasons or to enter an arbitrage position, needs to be active on the cash market.

3.2 Data Sources

Our study is based on a unique regulatory dataset of trades by German financial institutions which we link to the full limit order book data from the interdealer exchange MTS. Our observation window spans from June, 1st 2011 through December, 31st 2017, and, as outlined above, we focus on the 2-, 5-, 10- and 30-year maturities.

The regulatory transactions data is based on reporting requirements of German financial institutions to the German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, popularly known as "BaFin") and mandated by the German Securities Trading Act ("Wertpapierhandelsgesetz") and the respective regulation ("Wertpapierhandel-Meldeverordnung"). We refer to this dataset as *transaction data*. It includes any transaction by the reporting institutions in a wide set of securities, including German government bonds, and contains information on the price, size and time of the trade, a flag indicating whether a trade was over-the-counter or the platform in which the trade was executed as well as an indicator whether a trade was a buy or a sell from the point of view of the reporting institution. Further, we obtained anonymized identifiers for the reporting agent and the counterparty of a trade, where the identifier for the counterparty can be missing when the counterparty has no regulatory requirement to the German Federal Financial Supervision.[18] The transactions data does not include information on whether a trade was buyer- or seller-initiated. Hence, we infer the initiator of each trade

rates prevalent during our sample period, the cheapest-to-deliver bond coincided almost always with the eligible bond with the nearest maturity date.

[18]For a detailed description of the dataset, including initial data cleaning procedures, we refer to Gündüz, Ottonello, Pelizzon, Schneider, and Subrahmanyam (2018) and the text of the law and regulation, for which a non-binding English translation is provided at `https://www.bafin.de/SharedDocs/Veroeffentlichungen/EN/Aufsichtsrecht/Gesetz/WpHG_en.html` (Section 9 therein) and `https://www.bafin.de/SharedDocs/Veroeffentlichungen/EN/Aufsichtsrecht/Verordnung/WpHMV_en.html?nn=8379960` respectively.

by comparing the trade price to the contemporaneous midprice on the exchange as in Bessembinder and Venkataraman (2004); Eisler and Bouchaud (2016).[19]

Our dataset from the interdealer exchange MTS contains all trades as well as the full limit order book information on all executable quotes.

We also obtained bond characteristics from Bloomborg and Thomson Reuters Eikon, repo rates from Brokertec as well as auction results from the German finance agency.

3.3 Trading Activity

Table 1 describes the trading activity divided by data subsamples including: number of trades, average trade size, trading volume, market share by type of market participants, and market share by trading venue. Our full sample contains over 500,000 trades across 116 German federal bonds and 402 reporting institutions (labeled "full sample").[20] Most of these trades are for very small amounts. To identify trades where there is an actual choice between trading over-the-counter and on the exchange, we limit our sample to the set of trades where trading in both venues is a viable option. That is, in the following we only consider trades for a nominal amount of at least 2 million EUR, the minimum size requirement of MTS (labeled "trade size $\leq$ 2 million EUR"). Indeed, while the number of observations is thus reduced to almost 200,000, they still represent a 3.27 trillion EUR of trading volume out of 3.40 trillion EUR in our full sample.

[Table 1 about here.]

In order to compute our quantities of interest we require further knowledge on the initiator and counterparty to a trade. This information may be unavailable, either when a party to a trade is not identified in the transaction data, or when the trade sign is undefined, e.g. for trades at exactly the MTS midprice or outside of MTS hours. We can

[19]Whenever the observed trade price is above (below) the midprice of MTS at the full minute preceding the transaction, the trade is identified as buyer- (seller-) initiated. We do not assign a trade sign to trades at the midprice, thus differing from the approach in Lee and Ready (1991).

[20]Reporting institutions are the ones for which the German Securities Trading Act is binding. One bank group might report using more than one reporting institution ID, e.g. in the case of foreign dependencies. Including counterparties identified by an ID there are 1,297 entities in our sample, while for some (e.g. non-German) counterparties this ID is missing.

identify the initiator for 127,404 trades reflecting to 2.02 trillion EUR of traded volume (labeled "initiator ID known"). For 103,619 trades worth 1.52 trillion EUR we can identify both initiator and counterparty (labeled "init. & counterp. ID known"). The latter sample corresponds to roughly half the initial selection of trades with a minimum size of 2 million EUR.

Out of the sample with complete initiator and counterparty information, 11,357 trades (worth 107.66 billion EUR or 7.1% of the market) are between MTS dealers (labeled "D2D (MTS Dealers)"). This is the subsample we use for our venue choice analysis, since both parties of the trade have access to the MTS exchange market beyond the OTC segment. In this subsample 16.56% of volume is traded on MTS, considerably more than for all other samples. The OTC segment accounts for 82.88% of the trading volume between MTS dealers. The remaining 0.56% of the trades take place on other platforms, mostly on Eurex Bonds and Tradeweb. Beyond the set of trades between MTS dealers we also consider the sample of trades among both MTS dealers and "other dealers", which are dealers participating in the primary market and broker-dealers. While these other dealers have similar trading characteristics as MTS dealers, they do not have MTS access. This subsample is labeled "D2D (all dealers)" and accounts for 44.3% of the trading volume where both initiator and counterparty are identified.

Average nominal trade size is 6.75 million EUR across the whole sample and 16.51 million EUR when we consider only trades of at least 2 million EUR. The average size of trades between all dealers is 16.09 million EUR and 9.48 million EUR between MTS dealers.[21] To visualize the distribution of trade size, Figure 1 shows its histogram for trades initiated by MTS dealers with a minimum size of 2 million EUR. The figure reveals a preference for "round" amounts of trade size, such as e.g. 5, 10 or 25 million EUR. This feature is present for both OTC and MTS trades and is in line with trading in the Bund cash market being still predominantly "manual", as expected for an OTC-dominated market.[22] We account for this stylized fact by adding a dummy variable for such round

[21]The higher share of exchange trades between MTS dealers, which typically have smaller sizes, is the main driver of this difference.

[22]Round amounts are associated with manual trading, whereas automated trading algorithms tend to make use of the continuity of possible sizes. See Lallouache and Abergel (2014) for an example in the

amounts in our subsequent estimations.

[Figure 1 about here.]

4 Empirical Analysis

4.1 Are OTC Trades Cheaper than Exchange Trades?

In this section, we study price differences between the OTC and exchange segments of the Bund market. Specifically, we test Hypothesis 1, which states that OTC trades are on average favorable with respect to the attainable price of executing the same trade on the exchange. A common approach to estimate transaction costs in OTC markets is via proxies estimated over multiple trades such as e.g. the imputed round-trip cost, price dispersion or effective bid-ask spread measures (Schestag, Schuster, and Uhrig-Homburg, 2016), whereas in hybrid settings it is common to compare prices adjusted for the venue choice (Madhavan and Cheng, 1997; Hendershott and Madhavan, 2015). In our setting the presence of contemporaneous limit order data from MTS allows instead for a direct comparison of the cost of OTC trades with attainable exchange prices at the level of single trades.

We do so considering the *OTC discount*, defined in Equation (1) as the difference in price between the observed price of an OTC trade and the virtual price a trade would have incurred on exchange, symmetrized for buy- and sell trades and normalized by the respective virtual transaction cost on the exchange. A positive OTC discount implies that executing a trade over-the-counter is cheaper for the initiator than trading on the exchange. In our setting, with MTS as the reference exchange, OTC discount is computed as

$$OTC\ discount = \frac{\epsilon\left(price^{\text{virtual,MTS}} - price^{\text{observed, OTC}}\right)}{\left\|price^{\text{virtual,MTS}} - price^{\text{mid,MTS}}\right\|}\quad , \tag{2}$$

where $price^{\text{observed, OTC}}$ is the price of an over-the-counter trade observed in our transaction data and $price^{\text{virtual,MTS}}$ is a virtual price which the same trade would have incurred on

context of a tick size reduction.

MTS at the same time (including effects of walking up the book in the case of large trades). $price^{\text{mid,MTS}}$ is the MTS midprice at the time of the trade.[23] The trade sign ϵ is $+1$ (-1) for buyer- (seller-) initiated trades and inferred by comparing to the contemporaneous MTS midprice. In choosing as the denominator in Equation (2) the effective half-spread of the virtual MTS trade and by our trade sign identification OTC discount is bounded from above by 100%.

Since the discount of MTS trades is by definition equal to zero, we only consider the OTC discount of over-the-counter trades and trades on platforms other than MTS in this section. Figure 2 illustrates the trade sign identification and calculation of OTC discount. Where OTC discount is negative, i.e. where it would have been cheaper to trade on MTS instead of OTC, we also refer to an *OTC premium*.

[**Figure 2 about here.**]

Figure 3 shows the histogram of OTC discount for trades in 2-year Schaetze, 5-year Bundesobligationen and 10-year Bunds with a minimum trade size of two million EUR.[24] Panel (a) refers to all such trades whereas panel (b) is based only on trades between MTS dealers. Our definition of OTC discount already takes into account the effect of walking up the book, i.e. when trades are larger than the quantity available at the best quote and need to be executed at deeper levels of the order book. We observe for both subsets a distribution that is heavy on positive values of OTC discount, i.e. in the majority of cases trading over-the-counter is cheaper than on the exchange.

[**Figure 3 about here.**]

In Table 2 we provide the descriptive statistics of OTC discount. To formally test Hypothesis 1, we perform a t-test, in which H_0 is that the mean of the OTC discount equals zero. For all of our data subsamples defined in Table 1, i.e., regardless of whether a

[23] We match trades from the transaction dataset to the MTS limit order book at one minute precision. This corresponds best to the effective resolution of the transactions data and we have performed extensive robustness checks to determine the optimal frequency and rule out potential lead or lag effects in the data.

[24] We are excluding 30-year Bunds from the figure as their much wider bid-ask spread distorts the distribution. Results are nonetheless similar when including also 30-year Bunds.

trader has MTS access or trade size, we reject the null hypothesis with a 99.99% confidence. Thus, the mean is positive and statistically different from zero. We therefore fail to reject the hypothesis. Our finding supports the prediction from Grossman (1992) that OTC trading can tap into pools of unexpressed liquidity.[25]

[Table 2 about here.]

4.2 Determinants of OTC Discount

In the following, we study the drivers of OTC discount in order to test Hypothesis 2, which states that the OTC discount is larger when a) market liquidity on the exchange is lower, b) the demand for immediacy is high, c) search costs are small, and d) the trader initiating the trade has more bargaining power.

We estimate the following equation:

$$OTC\ discount_n = \Pi v_n + \Delta_i + \varepsilon_n, \tag{3}$$

i.e. the dependent variable is the OTC discount of trade n, defined as percentage share of the effective half-spread as in Equation (2) and given in units of percentage points, v_n is a vector of trade and bond characteristics, and Δ_i are bond-fixed effects. v_n includes proxy variables for liquidity in the exchange market, search cost, demand for immediacy and bargaining power as well as a set of control variables. The components of v_n vary at the trade, day, intraday time, initiator and/or initiator-counterparty level as detailed in Table A.1. The control variables account for when a trade took place on a platform different than MTS, the amount outstanding in the bond, bond age, and end-of-quarter as well as end-of-year dummies. We estimate Equation (3) using ordinary least squares with standard errors clustered on the trade initiator dimension.

Table 3 presents the results of the regression in Equation (3). Panel A reports the estimations for OTC trades between MTS dealers in specifications (1) and (2) and between

[25] This is further confirmed by the fact that we also observe OTC trades that are too large for the MTS exchange.

all dealers in specifications (3) and (4), where in specifications (2) and (4) we also impose an upper limit to nominal trade size of 25 million EUR.[26] Repo market specialness is available only from 2013 and related also to year- and quarter-end-periods. We ensure robustness of our results for this subsample with the specifications in Panel B. Specifications (1) and (5) therein respectively repeat specifications (1) and (3) from Panel A. In specification (2) and (6) we restrain the sample period to 2013-2017 and in specifications (3), (4), (7) and (8) we include specialness as explanatory variable, with and without year- and quarter-end-dummies.

[Table 3 about here.]

We consider several proxy variables for market liquidity in the exchange, immediacy, search cost and bargaining power. Detailed definitions of all proxy as well as control variables are provided in Table A.1 in the Appendix together with their descriptive statistics in Table A.2.

Market liquidity on the exchange. To proxy liquidity on the exchange we use the MTS half-spread, depth at the MTS best and trade size. The quoted bid-ask spread corresponds to the cost of a round-trip trade for a small amount. Here we take the MTS half-spread, i.e. half the bid-ask spread, as the cost of a single trade. The average MTS half-spread is 5.11 basis points of par value. To capture the size-dependency of transaction costs we consider the depth at the best level of the MTS limit order book on the side of the trade (i.e. on the ask (bid) side for a buyer- (seller-) initiated trade) and the natural logarithm of trade size. As large trades on the exchange walk up the deeper levels of the order book, depth at the MTS best is negatively related to exchange transaction costs, while trade size is positively correlated.

Across all estimations MTS half-spread and depth at the MTS best[27] are significant drivers of OTC discount: the larger the bid-ask spread and the less deep the limit order

[26] 25 million EUR corresponds to the 99.4th percentile of trade size on MTS. Trades larger than this are unlikely to be executed on MTS (in a single transaction) and excluding them constitutes another robustness check for our results.

[27] Our results are robust to e.g. considering the depth at the three or five best levels or the available volume at all price levels.

book of MTS, the higher is the average OTC discount. This implies that detoriations of liquidity conditions on the exchange are only partially passed on to the OTC segment. With respect to trade size, we observe an effect only among all dealers, where larger trades receive a higher discount. There also trades at standard sizes, i.e. multiples of 5 million EUR, receive a lower discount.

Immediacy. We proxy demand for immediacy (i.e. how urgently a dealer desires to trade) via three variables. First, through the inventory imbalance of a trader, assuming that dealers with larger net positions prefer to close them faster. Our variable of inventory imbalance is normalized by the average daily trading volume of the dealer in the same bond and has a mean of 1.15, i.e. the average net position is slightly larger than an average daily trading volume of the same dealer. Second, immediacy is proxied via intraday volatility. When volatility is high the risk of adverse price movements is larger and a trader will want to fulfill her trading need faster. Here we define a dummy variable that is equal to one on the days with the highest 10% intraday volatility and zero else. Third, we proxy higher immediacy with a dummy for days of primary issuance. Dealers participating in the primary auction learn only during the auction day of their take-up during the tender process and might be faced by added trading needs from clients that wish to invest in the newly issued bond. 3% of trades in our sample occur on issuance days in bonds affected by the issuance.[28]

Of our variables for immediacy, only volatility implies a reduced discount. On very volatile days OTC discount is on average up to 35 percentage points lower. Dealers with high net positions do not consistently trade at lower discounts as reveiled by the small and insignificant coefficients for inventory imbalance.[29] Interestingly, it appears that discounts are even higher in trades between MTS dealers on issuance days, though this effect is significant only for the 2011-2017 specifications.

Search costs. In the theoretical literature, search cost refers to expenses in terms of

[28]Specifically we define a dummy variable for issuance days that is one on the day of the issuance for the bond being tapped in the case of a re-opening auction and for the bond auctioned and the bond going off-the-run in the case of a new issuance.

[29]However when restricting the imbalance variable to dealers for which we observe their full set of transactions the effect is significant and of the expected sign.

money and time that are necessary to obtain a specific bond through bilateral negotiations. Here we proxy search cost via a dummy variable indicating whether a bond is the cheapest-to-deliver for a current futures contract and via its specialness spread in the repo market. The bonds which are cheapest-to-deliver for the current futures contracts are related to the highly liquid futures market by a close arbitrage link and therefore assumed to be easier to price and obtain and thus to have a lower search cost. 7% of the trades between MTS dealers in our sample are in cheapest-to-deliver bonds. Instead bonds with a high specialness spread in the repo market (i.e. where it is more expensive to obtain the specific bond as collateral in a repo transaction than an unspecified "general collateral" bond) are likely to also incur a higher search cost in the cash market. The average specialness spread (defined as the difference between repo rates for general collateral and the rate for a specific bond) is 17 basis points in our sample.

We observe the expected effects with respect to search costs only for trades between MTS dealers. There a cheapest-to-deliver bond receives on average at least an 8.8 percentage points higher discount, whereas each additional basis point of repo specialness spread decreases OTC discount by 9.1 percentage points on average.

Bargaining power. We capture dealers' bargaining power in several different ways. The relationship share is defined as the initiator's share of dealing with its current counterparty. We assume bargaining power to be higher in well-established trading relationships with a higher relationship share (see Hendershott, Li, Livdan, and Schürhoff (2017)). Furthermore we include eigenvector centrality as a proxy for dealers' interconnectedness, following Di Maggio, Kermani, and Song (2017).[30] The average values of relationship share and eigenvector centrality are 6% and 0.15 respectively. In specifications involving dealers without MTS access, we include dummies for whether the trade initiator has MTS access or whether both parties to the trade have MTS access (interdealer trade). Since the MTS access constitutes an outside option to the OTC search process, dealers with MTS access have a better bargaining position.

[30]We also considered a number of different network measures, such as the number of counterparties per dealer, dealers' market share in a bond, or average daily volumes. All of them are highly correlated with our measure of eigenvector centrality. Note that we are only able to compute eigenvector centrality based on the part of the network involving German financial institutions.

Bargaining power plays a significant role in all specifications: a higher relationship share is reflected in higher OTC discounts. The dummy for MTS access by trade initiators is positive but not significant, whereas trades between two MTS dealers happen at a significantly higher discount of on average at least 22.7 percentage points. Somewhat surprisingly, eigenvector centrality is not a significant driver of OTC discount. This might be due to our incomplete picture of the dealer network, as we are able to compute centrality only based on the subset of trades involving German financial institutions. Alternatively it could imply that dealer network structure is less crucial to pricing among dealers in the presence of an exchange that effectively provides a direct link between them.

Interestingly the dummy for other platforms is negative and statistically significant, i.e. trades thereon receive a smaller discount with respect to MTS transaction costs than ordinary OTC trades. This might be due to additional services offered by these platforms (e.g. clearing, immediacy) that incur costs reflected in the lower discount.

Overall, our results confirm Hypothesis 2. OTC discount is positively related to transaction costs, i.e. illiquidity in the exchange segment is only partially passed on to the OTC segment. Further, we find that OTC discount is negatively related to search costs and related to immediacy and positively related to bargaining power, in line with the theory of outside options presented in Duffie, Gârleanu, and Pedersen (2005, 2007).

4.3 Venue Choice

Given our finding in the previous section that the OTC segment commonly offers favorable prices and especially so for MTS dealers with access to the outside option of the exchange, it is important to study the factors that lead MTS dealers to trade on the exchange instead of OTC.

In order to test Hypothesis 3, which states that MTS dealers are more likely to trade on the exchange when a) market liquidity on the exchange is lower, b) required immediacy is high, and c) search costs are high, we estimate a probit model where the dependent variable *MTS* equals one for MTS trades and zero otherwise. Formally, we estimate

$$Pr(MTS_n) = f(\omega_n) \tag{4}$$

at the level of individual trades indexed by n and where ω_n is a vector of independent variables including security and trade characteristics.[31]

The vector of trade and bond characteristics, ω_n, is similar to the one specified in the previous section, v_n, with minor differences. First, we recognize that the venue choice is dependent on the OTC discount and we include the OTC discount a dealer can expect for a specific trade along with other transaction cost proxies.[32] Furthermore, since MTS trades are pre-trade anonymous, we do not include the relationship share. Finally instead of bond-fixed effects we add to the set of control variables the coupon rate and dummies for 2-years Schaetze, 5-years Bobls, and 30-years Bund.[33]

Table 4 shows the marginal effects of the probit estimation, with standard errors clustered at the trade initiator level. Our sample consists only of trades that are able to take place in either section of the market, i.e. trades between MTS dealers with a minimum size of 2 million EUR that took place during MTS trading hours.[34] We consider several specifications. First, we study the entire sample of trades in specification (1). Second, we restrict trade sizes to at most 25 million EUR in specification (2). Due to data availability, the regressions including the repo specialness spread in specifications (4) and (5) (without and with year- and quarter-end dummies respectively) refer to the period from 2013 and thus in specification (3) we repeat estimation (1) for the shorter sub-period.

[Table 4 about here.]

[31] We group trades on other platforms (effectively Eurex Bonds and Tradeweb) with OTC trades since we deem pre-arranged trades and RFQ structures closer to OTC. We have ensured the robustness of our results by running separate regressions excluding these trades.

[32] In order to avoid endogeneity problems we use a suitably lagged variable as this estimator, see Table A.1 for the precise definition.

[33] That is, our baseline specification refers to 10-year Bunds.

[34] We also exclude trades when the bid-ask spread on MTS was prohibitively high, setting the threshold as 100 basis points, corresponding to the 99%-percentile across all bonds and the 95%-percentile for 30-year Bunds, the least liquid bonds in our sample.

Market liquidity on the exchange. First, we relate the venue choice decision to transaction costs and market liquidity. Transaction costs on the exchange rise with bid-ask spread and trade size, so we expect the coefficients for MTS half-spread and size to be positive, whereas costs decrease with a deeper book, so that we expect a positive coefficient on depth. As the OTC segment is more competitive when the expected discount is larger, our hypothesis implies a negative sign. We find these expectations confirmed and significant in all specifications. On average, a one basis point increase in the half-spread makes it 3.0 - 3.6% less likely that a trade is transacted on MTS and an increase of depth at the best level by 10 million EUR on average increases the likelihood that traders choose MTS by 1.5 - 2.3%. Furthermore, a higher expected OTC discount and larger trade size make OTC trading more likely, even when we restrict the sample to trades of at most 25 million EUR. We also find that round sized trades have a higher likelihood of trading on MTS. This is likely related to the prevalent size grid of 0.5 million EUR increments on this platform.

Immediacy. We next turn to the effect of required immediacy on dealer venue choice. Required immediacy should be higher when dealers face larger inventory imbalance, when intraday volatility is high, and on days of primary issuance. In line with our hypothesis, the dummy variables for volatile and primary auction days are positive and significant across all specifications. On average the likelihood to trade on MTS is 5.7 - 8.4% higher on volatile days and 8.4 - 11.5% higher on days with primary auctions regarding the traded bond. For inventory imbalance we also observe the expected positive signs, which are however only significant for the 2011-2017 sample period.

Search cost. Next we relate venue choice to search costs. We expect the cheapest-to-deliver bonds in the current futures contracts to have a lower search cost and thus less likely to trade on exchange, whereas bonds with a higher repo specialness spread are likely scarcer also in the cash market and thus more likely traded on the exchange. Both predictions are confirmed by the regression results. The cheapest-to-deliver bonds are on average 10.9 - 12.2% more likely to trade in the over-the-counter segment. An increase in specialness spread by one basis point on average increases the likelihood of trading on the exchange by 5.1 - 6.2%. Note that also the dummies for year-end and 30-year Bunds are positive and significant, underlining the role of search cost in venue choice.

Our results thus confirm Hypothesis 3, identifying transaction costs (and thus market liquidity), immediacy and search costs as important determinants of venue choice. Let us stress that we are unable to observe dealers' decision whether to trade or not. Especially in the OTC market a trader might be unable to find a counterparty to a transaction only at a cost that outweighs the expected benefits of the trade. For example, Hendershott and Madhavan (2015) report that on average only $51.0 - 73.4\%$ of electronic auctions (corresponding to multi-dealer requests-for-quote) lead to trades and $8.2 - 14.7\%$ of such auctions do not receive a quote from a dealer.

5 Conclusion

In an environment where academics and regulators increasingly call for a shift from traditional over-the-counter market structures towards electronic platforms and greater transparency, an in-depth understanding of the drivers and motivations behind price dispersion in the OTC markets and venue choice is ever more important. A priori, it is far from obvious what the optimal market design for safe fixed income markets is.

In this paper we contribute on several levels. We study the price difference between market segments and its drivers in dealer-to-dealer transactions in the German Bund market. Our main finding is that the large majority of OTC trades execute well inside the spread quoted on the interdealer limit order book. Hence, OTC trades typically have a better price for the dealer initiating the trade, implying an OTC discount. The limit order book instead is mainly used as an outside option. We further show that the OTC discount is larger in the presence of significant trading relationships, when the limit order book is less liquid, as well as when search costs and the need of immediacy are low.

Exploring the venue choice, we find that dealers are more likely to execute a trade on the exchange when the required immediacy is high, and search costs are high. Surprisingly, there is a preference to trade the most illiquid bonds on the exchange. On the other hand, when traders require opacity because of a large trade size, they prefer to trade OTC.

Our findings highlight the complementary roles played by exchange and OTC markets and their ability to satisfy the different needs of dealers. While the OTC market segment plays an important role with respect to opacity and cost efficiency, the central limit order book satisfies immediacy needs. These aspects ought be considered in the design and regulation of fixed-income trading.

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Figures

Figure 1: **Histogram of Trade Size:** This table shows the distribution of trade size (in terms of nominal amount) for interdealer trades where MTS is a possible option, i.e. between MTS dealers during MTS hours with a minimum size of 2 million EUR of nominal amount. The sample includes OTC trades and trades on MTS as well as on other platforms. The binwidth is 0.5 million EUR. A preferences for “round” amounts (defined as multiples of 5 million EUR) is clearly discernible.

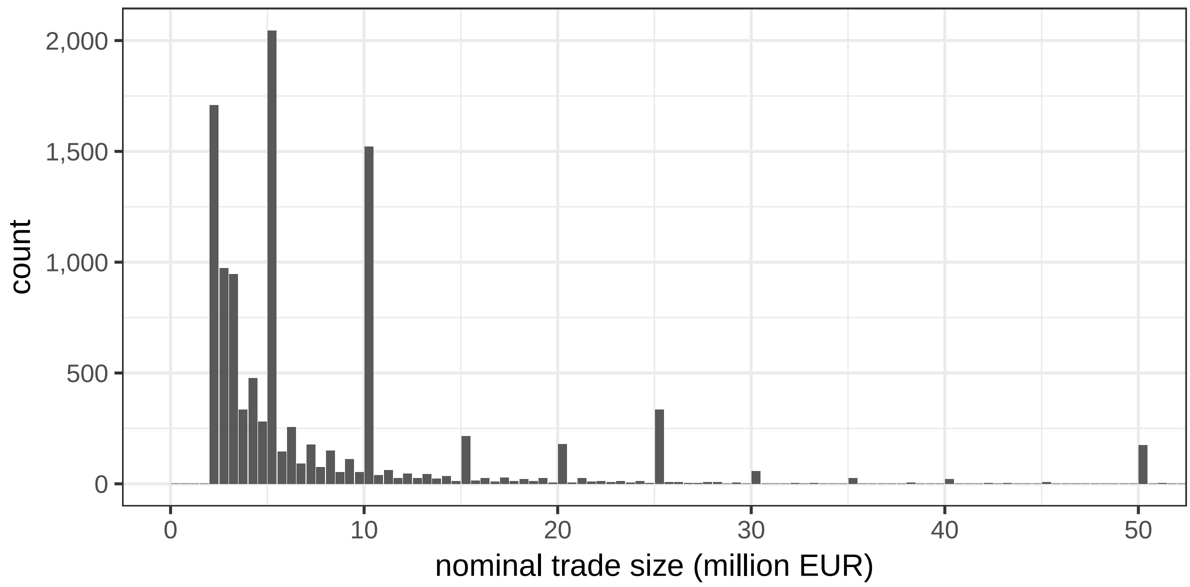


Figure 2: **Trade Sign and OTC Discount:** We classify OTC trades above (below) the quoted midprice on MTS as buyer- (seller-) initiated. *OTC discount* is the price difference between the virtual price a trade would have incurred on MTS and the actually observed price of the trade, symmetrized for buyer- and seller-initiated trades. By this definition, a positive OTC discount implies that executing a trade over-the-counter is cheaper for the initiator than trading on the exchange. We identify an *OTC premium* where OTC discount is negative, i.e. when trading on MTS would have been cheaper. Note that the definition of OTC discount in Equation (1) takes into account the effects of large trades walking up the limit order book, which is not shown in this draft for ease of presentation.

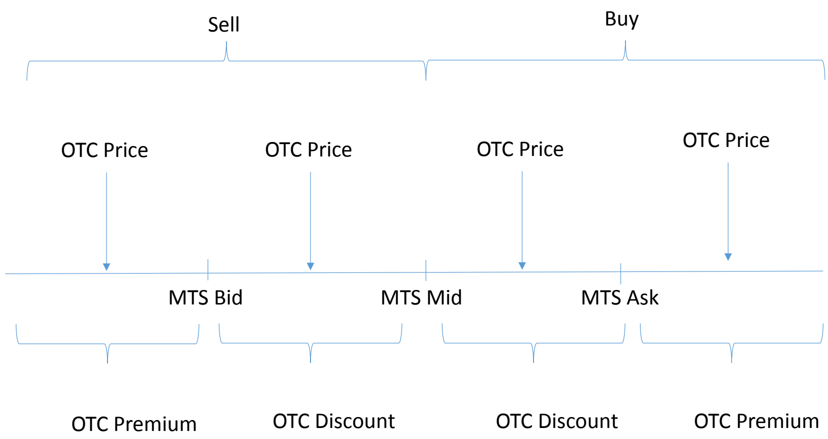
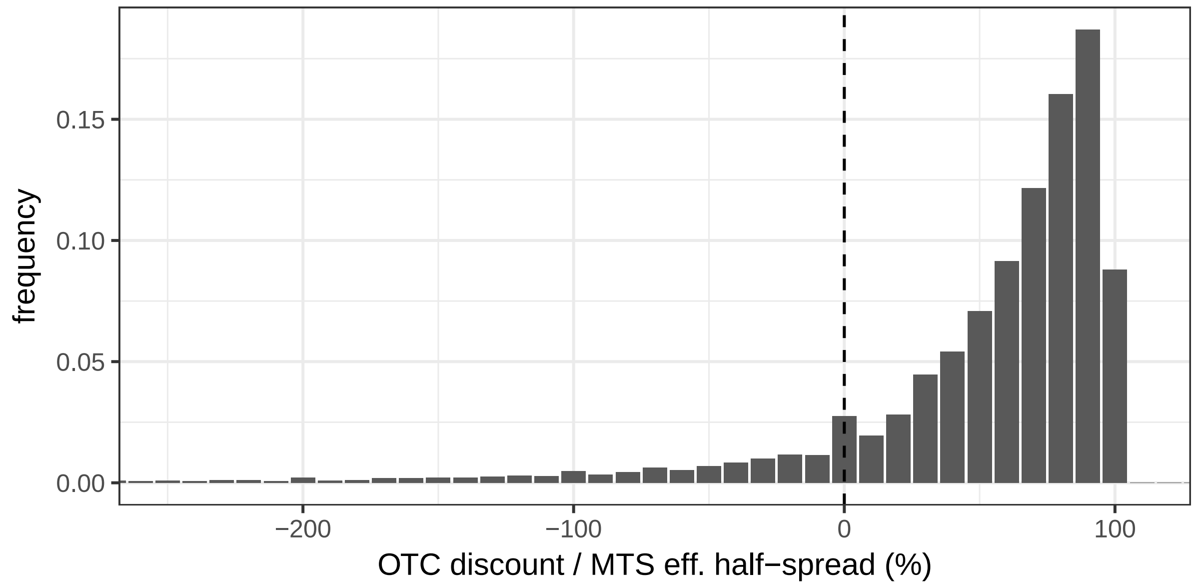
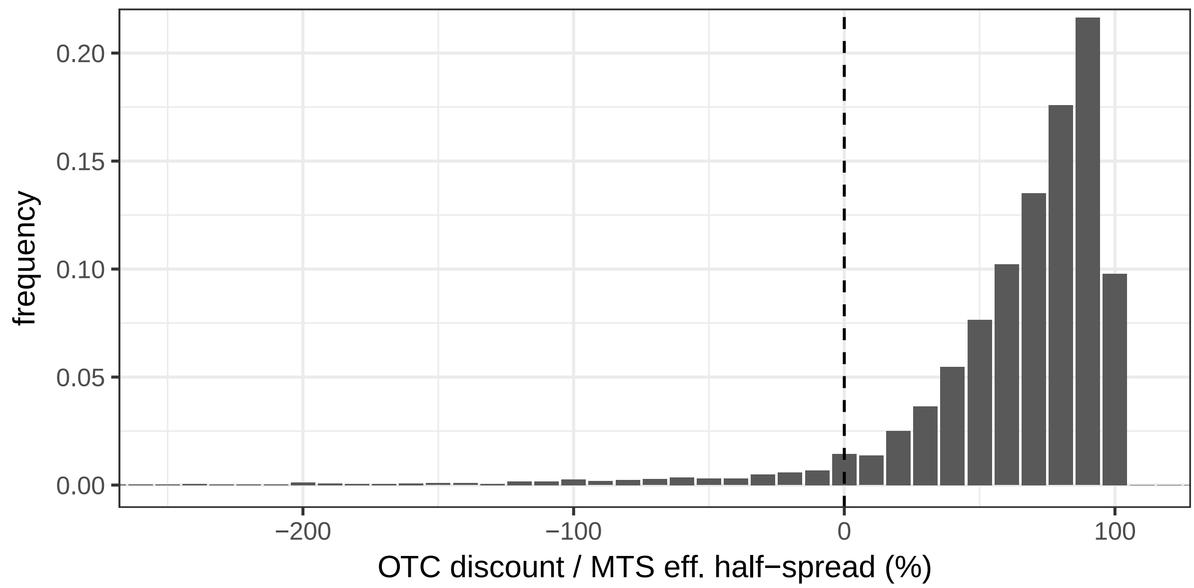


Figure 3: **Histogram of OTC Discount:** *OTC discount*, defined in Equation (1) in Section 4, is the difference in price between the observed price of an OTC trade and the virtual price a trade would have incurred on MTS, symmetrized for buy- and sell trades and normalized by the respective virtual transaction cost on MTS. A positive OTC discount implies that executing a trade over-the-counter is cheaper for the initiator than trading on the exchange. OTC discount is bounded from above to be at most 100%. The Figure shows the distribution of OTC discount based on trades in 2-, 5- and 10-year Bunds with a minimum trade size of two million EUR. Panel (a) refers to all such trades and Panel (b) to the subset of trades between MTS dealers.



(a) OTC trades in 2-,5- and 10-year Bunds with a minimum size of 2 million EUR.



(b) Interdealer OTC trades in 2-,5- and 10-year Bunds with a minimum size of 2 million EUR.

Tables

Table 1: **Trading Activity by Data Subsamples:** This table provides provides an overview of trading activity for the full sample and subsamples used in our analysis. *Full sample* refers to the cleaned sample including trades of all sizes. The subset *trade size* $\geq$ *2 million EUR* includes all such trades for a nominal amount of at least 2 million EUR, the minimum trade size on the interdealer exchange MTS. The last subset is further reduced to trades where either at least the initiator or *both initiator and counterparty are known*. The row *D2D (MTS dealers)* refers to the set of such trades where both initiator and counterparty are MTS dealers, whereas *D2D (All dealers)* includes trades between MTS dealers as well as primary dealers and brokers without MTS access, referred to as *other dealers*. Reported are the number of trades for each subsample, average trade size and total trade volume, as well as the volume-weighted market share as a function of counterparty type and trade segment (over-the-counter, OTC, on the interdealer exchange MTS or on other trading platforms).

	# trades	trade size	trade volume	market share with (in %)				market share (in %)		
		mean (M EUR)	sum (billion EUR)	MTS dealers	Other dealers	Non-dealers	w/o ID	OTC	MTS	other platforms
full sample	503,264	6.75	3395.39					84.78	0.62	14.60
trade size $\geq$ 2 million EUR	198,326	16.51	3274.43					84.40	0.64	14.95
initiator ID known	127,404	15.87	2021.97					86.95	0.93	12.12
initiated by:										
MTS dealers	57,577	16.84	969.48	11.10	22.55	33.72	32.62	94.09	1.92	3.99
Other dealers	22,443	17.00	381.57	88.77	2.59	7.29	1.35	99.37	0.00	0.63
Non-dealers	47,384	14.16	670.92	55.78	4.29	13.67	26.26	69.57	0.00	30.43
init. & counterp. ID known	103,619	14.71	1524.40					93.12	1.18	5.70
D2D (MTS dealers)	11,357	9.48	107.66	100.00	-	-	-	82.88	16.56	0.56
D2D (All dealers)	41,959	16.09	674.92	66.14	33.86	-	-	97.14	2.64	0.21

Table 2: **Descriptive Statistics of OTC Discount:** *OTC discount*, defined in Equation (1) in Section 4 and given here in percent, is the difference in price between the observed price of an OTC trade and the virtual price a trade would have incurred on MTS, symmetrized for buy- and sell trades and normalized by the respective virtual transaction cost on MTS. A positive OTC discount implies that executing a trade over-the-counter is cheaper for the initiator than trading on the exchange. OTC discount is bounded from above to be at most 100%. Reported are summary statistics of OTC discount for the subsets defined in Table 1. The column p-value gives the p-value for a t-test of the mean being different from zero and *share* < 0 gives the share of trades with an OTC premium (negative OTC discount) in percent, i.e. a trade would have been available at a cheaper price on the exchange MTS.

	Mean	Std Dev	5 Pcl	25 Pcl	Median	75 Pcl	95 Pcl	# obs	p-value (%)	share < 0 (%)
full sample	34.65	245.62	-96.43	35.00	66.67	85.51	96.67	445,867	0.0000	12.32
trade size $\geq$ 2 million EUR	38.61	318.93	-80.00	40.00	70.00	86.54	96.97	176,277	0.0000	11.36
initiator ID known	39.10	313.19	-77.39	40.00	70.00	86.67	96.95	124,805	0.0000	11.00
initiated by:										
MTS dealers	43.13	190.98	-75.30	40.55	70.25	86.74	97.10	55,000	0.0000	10.93
other dealers	35.83	264.58	-94.74	37.00	68.89	86.15	96.89	22,439	0.0000	12.34
others	35.98	427.68	-70.00	41.60	70.27	86.23	96.77	47,366	0.0000	10.45
init. & counterp. ID known	39.48	304.38	-71.11	40.00	70.00	86.67	96.92	101,148	0.0000	10.75
D2D (MTS dealers)	54.90	126.81	-14.29	52.00	74.15	88.00	96.92	8,916	0.0000	5.88
D2D (All dealers)	42.19	198.80	-76.01	42.22	71.11	87.01	97.14	39,513	0.0000	10.54

Table 3: **Drivers of OTC Discount:** Estimation of $OTC\ discount_n = \Pi v_n + \Delta_i + \varepsilon_n$, where the left hand variable captures how much the transaction cost of OTC trade n was lower than on MTS, v_n is a vector of trade and bond characteristics, and Δ_i are bond-fixed effects. The sample consists of OTC trades between MTS dealers in specifications (1) and (2) and between MTS dealers, primary dealers as well as brokers without MTS access in specifications (3) and (4), for a minimum trade size of at least 2 million EUR. The specifications in Panel B include also repo specialness spreads as explanatory variable, which is only available from 2013. Regressions include bond-fixed effects and standard errors are clustered at daily time and dealer level. t-values are given in brackets and *, ** and *** denote significance at the 10%, 5% and 1% level respectively.

Panel A

Market Segment: trades between ...	MTS dealers		all dealers	
trade size (million EUR):	≥ 2	$2-25$	≥ 2	$2-25$
	(1)	(2)	(3)	(4)
MTS half-spread (bp)	1.998***	2.053***	1.785***	2.081***
	(5.297)	(4.992)	(3.436)	(3.939)
Depth at MTS best (million EUR)	-0.420**	-0.383**	-0.461**	-0.476**
	(-2.379)	(-2.094)	(-2.587)	(-2.272)
Trade size (log)	-0.435	-3.058	8.012***	9.148**
	(-0.127)	(-0.684)	(3.428)	(2.076)
Round trade size (dummy)	6.915	9.585	-19.599**	-21.451*
	(1.344)	(1.308)	(-2.321)	(-1.747)
Inventory imbalance	0.417	0.784	0.372	1.452
	(0.561)	(0.585)	(0.394)	(0.867)
Volatility (dummy)	-35.465**	-31.765**	-25.821	-27.090
	(-2.404)	(-2.046)	(-1.669)	(-1.582)
Issuance day (dummy)	20.510***	23.678**	0.628	0.867
	(2.859)	(2.392)	(0.072)	(0.085)
Cheapest-to-deliver (dummy)	9.797**	8.791*	-2.104	-6.055
	(2.130)	(1.969)	(-0.438)	(-0.923)
Relationship share (%)	41.944***	44.679***	37.360***	46.142***
	(3.177)	(2.973)	(2.739)	(2.755)
Eigenvector centrality	13.580	29.380	33.377	58.485
	(0.352)	(0.670)	(0.769)	(1.261)
Initiator is MTS dealer (dummy)			13.093	12.667
			(0.961)	(0.880)
Between MTS dealers (dummy)			22.708***	26.692***
			(3.228)	(3.504)
Other platform (dummy)	-24.887***	-24.792***	-19.405**	-22.021**
	(-4.747)	(-4.493)	(-2.135)	(-2.373)
Amount outstanding (log)	-10.046	-10.680	-10.852*	-9.927
	(-1.626)	(-1.465)	(-1.974)	(-1.362)
Bond age (years)	9.964***	10.150***	10.992***	10.429***
	(3.457)	(3.152)	(4.504)	(3.948)
End-of-quarter (dummy)	7.295	7.942	-6.176	-8.437
	(1.142)	(1.125)	(-0.599)	(-0.685)
End-of-year (dummy)	-4.583	-4.795	10.224	12.895
	(-0.523)	(-0.530)	(0.995)	(1.086)
R^2	0.0434	0.0449	0.0323	0.0345
R^2_{adjusted}	0.0294	0.0300	0.0290	0.0307
R^2_{within}	0.0210	0.0193	0.0186	0.0200
N	8,871	8,317	39,213	32,647
Fixed Effects	bond	bond	bond	bond

Table 3 continued on next page.

Table 3 continued from previous page.
Panel B: Specialness specifications

Market Segment: trades between ...	MTS dealers				all dealers			
Period	2011-2017	2013-2017			2011-2017	2013-2017		
trade size (M EUR):	≥ 2							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MTS half-spread (bp)	1.998***	2.284***	2.266***	2.268***	1.785***	1.570***	1.717***	1.714***
	(5.297)	(4.693)	(4.523)	(4.459)	(3.436)	(3.023)	(3.255)	(3.245)
Depth at MTS best (M EUR)	-0.420**	-0.433*	-0.381**	-0.382**	-0.461**	-0.356***	-0.334***	-0.332***
	(-2.379)	(-1.980)	(-2.243)	(-2.232)	(-2.587)	(-3.109)	(-2.903)	(-2.883)
Trade size (log)	-0.435	1.150	0.001	-0.013	8.012***	10.785***	10.135***	10.152***
	(-0.127)	(0.510)	(0.000)	(-0.005)	(3.428)	(4.101)	(4.229)	(4.230)
Round trade size (dummy)	6.915	-0.428	-0.256	-0.240	-19.599**	-19.874**	-18.810**	-18.792**
	(1.344)	(-0.102)	(-0.050)	(-0.047)	(-2.321)	(-2.361)	(-2.435)	(-2.433)
Inventory imbalance	0.417	0.708	0.934	0.933	0.372	-0.701	-0.648	-0.653
	(0.561)	(0.901)	(1.028)	(1.033)	(0.394)	(-0.950)	(-0.875)	(-0.879)
Volatility (dummy)	-35.465**	-17.317***	-17.827**	-17.778**	-25.821	-27.772***	-28.542***	-28.607***
	(-2.404)	(-2.695)	(-2.520)	(-2.510)	(-1.669)	(-3.394)	(-3.137)	(-3.149)
Issuance day (dummy)	20.510***	15.137	16.326	16.259	0.628	1.636	1.047	1.338
	(2.859)	(1.590)	(1.583)	(1.561)	(0.072)	(0.239)	(0.162)	(0.206)
Cheapest-to-deliver (dummy)	9.797**	10.650*	10.234*	10.252*	-2.104	0.166	-0.697	-0.778
	(2.130)	(1.941)	(1.894)	(1.907)	(-0.438)	(0.029)	(-0.115)	(-0.128)
Specialness (percentage points)			-9.122*	-8.749			-3.658	-4.592
			(-1.889)	(-1.606)			(-0.548)	(-0.668)
Relationship share (%)	41.944***	29.211*	44.078**	44.064**	37.360***	36.844***	36.740***	36.706***
	(3.177)	(1.827)	(2.045)	(2.044)	(2.739)	(2.674)	(2.849)	(2.847)
Eigenvector centrality	13.580	29.149	43.493	43.542	33.377	68.742	67.411	67.315
	(0.352)	(0.959)	(1.286)	(1.294)	(0.769)	(1.598)	(1.641)	(1.638)
Initiator is MTS dealer (dummy)					13.093	3.941	4.128	4.155
					(0.961)	(0.289)	(0.322)	(0.324)
Between MTS dealers (dummy)					22.708***	29.981***	29.209***	29.137***
					(3.228)	(3.868)	(3.929)	(3.929)
Other platform (dummy)	-24.887***	-20.293***	-23.250***	-23.243***	-19.405**	-20.099**	-18.917**	-18.814**
	(-4.747)	(-3.831)	(-4.214)	(-4.055)	(-2.135)	(-2.240)	(-2.153)	(-2.141)
Amount outstanding (log)	-10.046	-5.912	-5.422	-5.449	-10.852*	-8.504	-11.247**	-11.211**
	(-1.626)	(-0.934)	(-0.773)	(-0.784)	(-1.974)	(-1.599)	(-2.103)	(-2.094)
Bond age (years)	9.964***	6.318**	7.127**	7.125**	10.992***	12.364***	12.888***	12.909***
	(3.457)	(2.215)	(2.275)	(2.261)	(4.504)	(3.617)	(3.727)	(3.727)
End-of-quarter (dummy)	7.295	-3.224		-2.371	-6.176	4.500*		6.700**
	(1.142)	(-0.420)		(-0.275)	(-0.599)	(1.969)		(2.321)
End-of-year (dummy)	-4.583	-1.173		0.837	10.224	-4.143		-0.621
	(-0.523)	(-0.104)		(0.074)	(0.995)	(-0.614)		(-0.081)
R^2	0.0434	0.0332	0.0364	0.0364	0.0323	0.0662	0.0637	0.0638
R^2_{adjusted}	0.0294	0.0171	0.0187	0.0185	0.0290	0.0626	0.0597	0.0597
R^2_{within}	0.0210	0.0084	0.0087	0.0087	0.0186	0.0395	0.0399	0.0400
N	8,871	7,048	6,232	6,232	39,213	31,292	27,610	27,610
Fixed Effects	bond	bond	bond	bond	bond	bond	bond	bond

Table 4: **Probit model for Venue Choice:** Marginal effects at means of a probit model for the choice of trading on MTS or over-the-counter. Based on the estimation of $Pr(MTS_n) = f(\omega_n)$, where the left hand variable takes the value one if trade n took place on the exchange MTS and zero for OTC trades (and trades on other platforms), and ω_n is a vector of trade and bond characteristics. The sample consists of trades between MTS dealers during MTS hours with a minimum size of 2 million EUR. Z-scores are given in brackets where standard errors are clustered at the dealer level and *, ** and *** denote significance at the 10%, 5% and 1% level respectively.

Period	2011-2017		2013-2017		
Sample: trade size (M EUR):	≥ 2	$2-25$	≥ 2		
	(1)	(2)	(3)	(4)	(5)
MTS half-spread (bp)	-0.0298***	-0.0304***	-0.0375***	-0.0359***	-0.0363***
	(-9.1305)	(-8.8882)	(-9.4155)	(-8.2222)	(-8.5310)
Depth at MTS best (M EUR)	0.0023***	0.0017***	0.0020***	0.0015***	0.0015***
	(4.6665)	(3.5346)	(4.3791)	(3.9394)	(3.9725)
expected OTC discount	-0.0531**	-0.0526**	-0.0522**	-0.0523**	-0.0520**
	(-2.3106)	(-2.1322)	(-2.2695)	(-2.5549)	(-2.5591)
Trade size (log)	-0.1313***	-0.1200***	-0.1232***	-0.1123***	-0.1100***
	(-5.2186)	(-3.9245)	(-4.1679)	(-3.7495)	(-3.7217)
Round trade size (dummy)	0.3065***	0.3076***	0.2983***	0.2892***	0.2875***
	(7.6209)	(7.4778)	(6.5677)	(5.9909)	(6.0511)
Inventory imbalance	0.0095*	0.0161**	0.0095	0.0061	0.0060
	(1.8677)	(2.2590)	(1.5066)	(0.9237)	(0.9009)
Volatility (dummy)	0.0790***	0.0840***	0.0708***	0.0583**	0.0567**
	(2.9574)	(3.0363)	(2.7332)	(2.2167)	(2.1708)
Issuance day (dummy)	0.1047***	0.1010***	0.1149***	0.0844***	0.0853***
	(3.1844)	(2.9260)	(3.5957)	(2.7941)	(2.7737)
Cheapest-to-deliver (dummy)	-0.1094***	-0.1114***	-0.1223***	-0.1178***	-0.1168***
	(-5.5755)	(-5.3009)	(-5.6819)	(-5.0702)	(-5.1141)
Specialness (percentage points)				0.0616**	0.0510*
				(2.3033)	(1.6810)
Eigenvector centrality	0.1589	0.1733	0.1824	0.1161	0.1105
	(0.3672)	(0.3849)	(0.3710)	(0.2422)	(0.2321)
Amount outstanding (log)	0.0464***	0.0490***	0.0603***	0.0485**	0.0474**
	(2.6305)	(2.5792)	(3.5423)	(2.3181)	(2.2641)
Bond age (years)	-0.0004	-0.0010	-0.0014	0.0018	0.0016
	(-0.1174)	(-0.2781)	(-0.3103)	(0.3888)	(0.3560)
Coupon rate (%)	0.0376***	0.0380***	0.0408***	0.0351***	0.0341***
	(3.8027)	(3.7956)	(3.5312)	(3.0838)	(2.9971)
End-of-quarter (dummy)	-0.0394*	-0.0409*	-0.0205		-0.0238
	(-1.7822)	(-1.6595)	(-1.0842)		(-1.3643)
End-of-year (dummy)	0.1775***	0.1815***	0.1885***		0.1780**
	(2.7507)	(2.6900)	(2.6594)		(2.1599)
2-years Schaetze (dummy)	0.2365***	0.2447***	0.2437***	0.2294***	0.2252***
	(8.0363)	(8.4441)	(9.4123)	(8.9006)	(9.2669)
5-years Bobls (dummy)	0.0792***	0.0803***	0.0804***	0.0860***	0.0819***
	(4.0251)	(4.0675)	(3.8079)	(4.2760)	(4.1232)
30-years Bund (dummy)	0.5165***	0.5231***	0.4950***	0.4773***	0.4849***
	(5.9211)	(5.7988)	(6.5593)	(6.0545)	(6.1643)
R^2_{pseudo}	0.2550	0.2490	0.2626	0.2591	0.2602
N	11,308	10,720	8,955	7,742	7,742

Appendix

Table A.1: **Variable Definitions:** Definitions and details for the explanatory and control variables used in the paper. The column variation indicates the dimensions along which the variable varies, where d, t, b, i and j indicate day, intraday time (minute), bond, trade initiator and trade counterparty respectively. n indicates that a variable varies from trade to trade even with all other dimensions equal.

Variable	Description	Source	Variation
OTC discount	See Section 4 and Equation (1).	transactions, MTS & own calculations	n
MTS (dummy)	Equals one for trades on the interdealer exchange MTS and zero else.	transactions	n
MTS half-spread	Half bid-ask spread on MTS in minute preceding the trade, in basis points	MTS	d, t, b
Depth at MTS best	Volume available at the best level of the MTS order book on the side of the trade (i.e. ask/bid side for buy/sell) in million EUR	MTS	d, t, b
Expected OTC discount	Predicted OTC discount in percentage points of hypothetical MTS trade cost. Calculated as the OTC discount of the previous trade from same dealer in the same bond or, where missing, (in order) as avg. OTC discount of the same dealer in the last 3 trades in this bond, avg. OTC discount by all traders in the last 30 days in the same bond, avg. OTC discount by the same dealer in all bonds in the last 30 days, avg. OTC discount by all dealers in all bonds in the last 30 days	own calculations	d, t, b, i
Trade size (log)	Log of market value of trade, where market value is in EUR	transactions	n
Round trade size (dummy)	Equals one if nominal trade size is a multiple of 5 million EUR and zero else.	transactions	n
Inventory imbalance	Absolute net imbalance of the initiating trader during the same day in the same bond up to the moment of the trade, normalized by the average daily volume of trading of the same dealer in the same bond.	transactions & own calculations	d, t, b, i
Volatility (dummy)	Equals one if intraday volatility for the bond and day is among the top 10 percentile. Intraday volatility is calculated for each bond and day as square root of the variance of 5-minute returns in MTS midprices.	MTS & own calculations	d, b
Issuance day (dummy)	Equals one on the day of a primary auction for the bond auctioned and the bond going off-the-run in the case of a new issuance, and equals zero else	DFA	d, b

Table A.1 continued on next page.

Table A.1 continued from previous page.

Variable	Description	Source	Variation
Cheapest-to-deliver (dummy)	Equals one if the bond is the cheapest to deliver for its respective futures contract an zero else	Bloomberg	d, b
Specialness	Difference between the special collateral (tommorrow-next) and general collateral rate, in percentage points. Positive specialness implies a bond is ”on special” and more expensive to obtain in the repo market.	Brokertec	d, b
Relationship share	Share of the trade initiators overall trading done with the counterparty of the same trade.	transactions & own calculations	i, j
Eigenvector centrality	Trade initiator’s network centrality, estimated on network of all OTC trades.	transactions & own calculations	i
Initiator has MTS (dummy)	Equals one if the initiator of the trade is a MTS dealer and zero else.	transactions & own calculations	i
Interdealer trade (dummy)	Equals one if both sides of a trade are MTS dealers and zero else.	transactions & own calculations	i, j
Other platform (dummy)	Equals one if the trade took place neither OTC nor on MTS, i.e. on another trading venue or platform other than MTS.	transactions	n
Amount outstanding (log)	Logarithm of the outstanding amount of a given bond in EUR.	DFA, Bloomberg & own calculations	d, b
Bond age	Time since the bond’s first issuance in years.	DFA & own calculations	d, b
Coupon rate	Bond’s coupon rate in percentage points	DFA	b
End-of-quarter (dummy)	Equals one in the last 3 trading days of each quarter and zero else.	own calculations	d
End-of-year (dummy)	Equals one in the last 3 trading days of the year and zero else.	own calculations	d
2-years Schaetze (dummy)	Equals one if the bond has an original maturity of 2 years (Schaetze) and zero else.	DFA	b
5-years Bobl (dummy)	Equals one if the bond has an original maturity of 5 years (Bobl) and zero else.	DFA	b
30-years Bund (dummy)	Equals one if the bond has an original maturity of 30 years and zero else.	DFA	b

Table A.2: **Statistics of Explanatory Variables:** Descriptive statistics of explanatory and control variables as defined in Section 3.3 and Table A.1 in the Appendix. Summary statistics in Panel A are calculated over the sample of all trades in German Bunds between MTS dealers for a minimum size of 2 million EUR and during MTS trading hours, and in Panel B over the sample of all trades in German Bunds between all dealers for a minimum size of 2 million EUR and during MTS trading hours.

Panel A: D2D (MTS dealers)

Variable	Mean	Std dev	5 Pcl	25 Pcl	Median	75 Pcl	95 Pcl	# obs
Dependent variables								
MTS (dummy)	0.21							11,357
Transaction cost variables								
MTS half-spread (bp)	5.11	55.68	0.70	2.00	3.00	4.00	15.00	11,357
Depth at MTS best (M EUR)	10.02	10.90	2.00	5.00	10.00	10.00	20.00	11,357
Expected OTC discount	0.61	0.35	-0.05	0.47	0.69	0.86	0.97	11,357
Trade size (log)	15.65	0.85	14.55	14.97	15.48	16.14	17.20	11,357
Round trade size (dummy)	0.40							11,357
Immediacy variables								
Inventory imbalance	1.15	1.95	0.04	0.23	0.61	1.30	3.98	11,357
Volatility (dummy)	0.10							11,357
Issuance day (dummy)	0.03							11,357
Search cost variables								
Cheapest-to-deliver (dummy)	0.07							11,357
Specialness (bp)	0.17	0.21	0.00	0.05	0.11	0.22	0.53	7,783
Bargaining power variables								
Relationship share	0.06	0.12	0.00	0.00	0.01	0.05	0.30	11,106
Eigenvector centrality	0.15	0.08	0.05	0.09	0.12	0.22	0.26	11,357
Control variables								
Other platform (dummy)	0.01							11,357
Amount outstanding (log)	23.56	0.33	22.92	23.50	23.61	23.77	23.90	11,357
Bond age (years)	3.59	3.90	0.12	0.69	2.51	4.87	9.83	11,357
Coupon rate (%)	2.09	1.56	0.00	0.50	2.00	3.25	4.50	11,357
End-of-quarter (dummy)	0.05							11,357
End-of-year (dummy)	0.01							11,357
2-years Schaetze (dummy)	0.11							11,357
5-years Bobl (dummy)	0.23							11,357
30-years Bund (dummy)	0.07							11,357

Table A.2 continued on next page.

Table A.2 continued from previous page.
Panel B: D2D (all dealers)

Variable	Mean	Std dev	5 Pcl	25 Pcl	Median	75 Pcl	95 Pcl	# obs
Transaction cost variables								
MTS half-spread (bp)	6.54	53.59	1.00	2.00	3.00	4.50	25.00	41,959
Depth at MTS best (M EUR)	9.43	8.08	2.50	5.00	10.00	10.00	20.00	41,959
Trade size (log)	15.98	1.09	14.59	15.06	15.69	16.81	17.90	41,959
Round trade size (dummy)	0.40							41,959
Immediacy variables								
Inventory imbalance	1.23	2.04	0.06	0.27	0.63	1.35	4.41	41,959
Volatility (dummy)	0.14							41,959
Issuance day (dummy)	0.04							41,959
Search cost variables								
Cheapest-to-deliver (dummy)	0.10							41,959
Specialness (bp)	0.18	0.21	0.00	0.05	0.12	0.24	0.57	29,377
Bargaining power variables								
Relationship share	0.29	0.37	0.00	0.02	0.07	0.52	0.98	41,709
Eigenvector centrality	0.12	0.09	0.02	0.04	0.10	0.22	0.26	41,959
Initiator has MTS (dummy)	0.54							41,959
Interdealer trade (dummy)	0.27							41,959
Control variables								
Other platform (dummy)	0.00							41,959
Amount outstanding (log)	23.54	0.35	22.92	23.50	23.61	23.72	23.90	41,959
Bond age (years)	3.40	3.96	0.10	0.54	2.05	4.72	10.94	41,959
Coupon rate (%)	2.06	1.56	0.00	0.50	1.75	3.25	4.75	41,959
End-of-quarter (dummy)	0.04							41,959
End-of-year (dummy)	0.00							41,959
2-years Schaetze (dummy)	0.09							41,959
5-years Bobl (dummy)	0.21							41,959
30-years Bund (dummy)	0.12							41,959