Agency Issues in Corporate Bond Trading

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Abstract

In an O.T.C. market like the one for corporate bonds, dealer intermediation is essential to execute a trade. Moreover, the incentives of the dealers and those of their customers are likely to be non-aligned. This paper analyzes the relational nature of broker-dealer business and investigates how adverse selection leads to agency issues. Results suggest that dealers set the execution price to shift the risk of informed trading to their clients. Shortages of funding liquidity appear to exacerbate this behavior. During the great financial crisis, dealers "leaned their clients against the wind" without compensating them for liquidity provision. Despite the increasing transparency brought by electronic trading, these agency issues are likely to remain present on the speculative segment of the market, where adverse selection is the most harmful to traders. This paper proposes policy measures in order to overcome these agency issues.

Keywords: Corporate bond, O.T.C. market, Adverse selection, Market microstructure, Dealers' behavior

JEL Classification: G10, G12, G14

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1 Introduction

In an Over-The-Counter market like the one for corporate bonds, security dealers are the essential player for a transaction to be executed. Given their importance, they act as price maker agents. Therefore, the same security is likely to trade at different prices at the same moment (Feldhütter, 2012).

Among the causes of price dispersion, there is the lack of pre-trade transparency, which allows dealers to conduct price discrimination (Bessembinder and Maxwell, 2008). Moreover, dealers may have different inventory rebalancing needs, therefore the price they offer embeds their inventory risk (Randall, 2015). Lastly, the higher the bargaining power of an agent, the better the execution price of the transaction (Duffie et al., 2005).

In such a market, the heterogeneity between participants makes their incentives to be possibly non aligned. In particular, non-dealer participants demand immediacy when they are informed (Gehrig, 1993), while dealers prefer to withdraw from the market and act as a broker while facing an informed investor (Grossman and Miller, 1988). This difference in incentives likely makes the dealer-customer relation to be subject to agency issues.

This paper investigates how agency issues manifest in the corporate bond market: besides unfavourable price conditions, agency issues may also impact other aspects of a trade like immediacy and liquidity provision by the dealers. In detail, I identify the response of dealers to possibly informed and uninformed traders, and the effect of such response on the aforementioned aspects of trading. The scope of the paper involves two main questions: the first addresses how dealers make use of their own or their clients' inventory when facing adverse selection; the second is about the role of liquidity shortages. The time span of the analysis is one of the longest in the literature about corporate bond trading (2004-2012).

The cornerstone of this study is the Trade Reporting And Compliance Engine (T.R.A.C.E.) dataset, I use an enhanced version containing informations about the initiator of each transaction and uncensored trade size for large trades. I relate the price deviation of each trade from the daily mean to the capacity (principal or agent) of both the trade initiator and the executing dealer to see how intermediation affects trade conditions.

Results show that dealers appear to shift the risk of an informed trade on their clients and to trade using their own inventory with uninformed investors. Funding illiquidity is exacerbating these agency issues: in fact, dealers appear to capture firesales and to shift informed trades to their clients even more. Results about a subsample starting with the great financial crisis show that, in a period struck with illiquidity, dealers "leaned their clients against the wind" by exploiting their inventories and providing them low compensation for liquidity provision.

This paper proceeds as follows: section 2 provides a review of related literature, section 3 summarizes the most important features of U.S. corporate bond market, section 4 describes the details of the empirical analysis, section 5 discusses the results, section 6 suggests some policy measures to overcome these agency issues, and finally, section 7 contains concluding remarks.

2 Literature review

Determinants of price discrepancies have been studied for several years. Earlier papers in this field attribute the causes of price dispersion to information and liquidity.

The seminal work of Warga, (1991) compares NYSE Automated Bond System (A.B.S.) transaction prices (transparent trades) with Lehman Brothers bid quotes (opaque dealer trades). He finds that high duration, low credit rating, small issue amount, and low trading volume increase price dispersion. Hong and Warga, (2000) use NYSE A.B.S. data and institutional trades data from the Capital Access International (C.A.I.) database to construct an effective transaction based bid-ask spread. They find that spreads observed in the OTC market are larger than those observed in the exchange.

Price dispersion is also a manifestation of a segmented market: in the interdealer market, we can observe lower "wholesale" prices; instead, the customer-to-dealer market is resembling a retail market where dealers can charge the compensation for market making. Round-trip transaction costs measure the difference between prices of interdealer and customer trades.

Schultz, (2001) uses C.A.I. data to quantify the impact of the trade size and the presence of dealers in the market. He finds that trading costs (as measured as the cost of a round-trip transaction) are decreasing in trade size. In addition, if the trade is executed through a large dealer, costs are halved compared to a small dealer. This difference is imputable to the fact that obtaining information is expensive and only large institution can bear these costs.

In an O.T.C. market, prices are determined by a bargaining process. Duffie et al., (2005) provide an extensive analysis of search and bargaining cost in O.T.C. markets: in their model trading costs are lower when there is less need for immediacy and when the market maker has less bargaining power. Green et al., (2007a,b) use muni bond transaction data to show that price dispersion is linked to market power of dealers and bargaining power of large customers. Large trades are executed with a lower markup even though the risk of losses is larger. Feldhütter, (2012) finds lower trading cost (as measured as round-trip transaction cost) for large trades in presence of sale pressure. He attributes the cause to higher bargaining power of large players.

Several papers spurred from the mandatory transaction reporting through T.R.A.C.E. Many of them analyze the impact of the increased transparency on trading costs. Edwards et al., (2007) and Goldstein et al., (2007) analyze trading costs before and after the introduction of T.R.A.C.E. Not surprisingly, they find lower transaction cost after the availability of more price information. The increased post-trade transparency diffused by T.R.A.C.E. caused lower trading cost not only for securities eligible for reporting but also for non-eligible securities (Bessembinder, Maxwell, and Venkataraman, 2006).

Traders bear the costs of trading in an opaque market to avoid the diffusion of informations. Hendershott and Madhavan, (2015) argue that for active and liquid securities, an electronic auction market is more suitable than bilateral negotiation. In fact, information is already present in the market and risk of leakage is lower. In presence of asymmetrically informed agents, dealers can facilitate trading by layering information asymmetries over sequential transactions (Glode and Opp, 2014).

Dealers' inventory risk is likely to determine the price they offer in different transactions of the same security. Amihud and Mendelson, (1980) analyze how dealers set the price of a transaction: when computing inventory costs, dealers incorporate losses due to adverse selection as a part of them. O'Hara and Oldfield,

(1986) argue that in presence of uncertainty about future market orders, inventory risk is large. Therefore, risk averse dealers are likely to provide better quotes than a risk neutral one in order to reduce their inventory and minimize variability of their profits. Comerton-Forde et al., (2010) report wider bid-ask spread in the equity market after market makers lose money on their inventories and/or find themselves holding large positions. Dick-Nielsen, (2013a) shows that dealers offer worse condition when they face possible inventory shocks like absorption of securities excluded from an index. In the recent years, dealers' inventory management must comply with increasing regulatory requirements in terms of capital adequacy. Due to capital constraints, dealers must ensure that the pricing of transactions reflects the internal costs of allocating capital and providing the desired return on equity (Bank for International Settlements, 2014).

Dealers are likely to form networks to reduce their trading costs and better offset excess inventory (Gale and Kariv, 2007). The position of a dealer in the network determines trading costs. Central dealers offer immediacy by holding securities in their inventory; however, this comes at higher cost compared to peripheral dealers (Li and Schürhoff, 2014). The relational structure of dealers network is explored empirically by Di Maggio et al., (2016): they find that price conditions are advantageous to dealers having stronger trading relationships with their counterparty rather than peripheral dealers or customers.

3 Features of the U.S. corporate bond market

3.1 Stylized facts about the market structure

The market for U.S. corporate bonds is mostly O.T.C.: 25 to 30 billion of dollars of bond par value are traded on average each day[1]. In the O.T.C. corporate bond market, most of the trades are either inter-dealer or customer to dealer. Customer to customer transactions rarely occur (Randall, 2015). Trades are typically large in volume and institutional investors are the main players of this market (Piwowar, 2011). Transactions can be proprietary or agency: in the former case both counterparties hold inventory risk, while in the latter the security does not transit

[1] http://www.finra.org/industry/trace-monthly-volume-report-2014

through the balance sheet of the institution executing the trade. Compensation for dealers bearing inventory risk consists of the spread added to the fundamental value of the security, while compensation for intermediaries is charged in form of a commission. In addition to these two categories of trades, there are trades that are pre-arranged, i.e. there are a buy and a sell trade of the same size occurring within a short time horizon: these trades are registered as principal trades even though the inventory risk is virtually null. The compensation for a dealer executing a pre-arranged trade is the difference between the price of the two legs of the transaction, which is a considerable fraction of the costs for trading corporate bonds (Harris, 2015).

Figure 1 depicts the structure of the market. Every trade is executed by dealers, which represent the core of the market. As mentioned above, dealers' customers do not trade between each other and represent a two levels periphery: a closer one where customers are likely to be informed and an extreme periphery where they are uninformed[2]. According to the report of the Bank for International Settlements, (2014), informed customers are likely to trade directly with dealers while the uninformed are likely to trade through an intermediary. According to this view, in the remainder of the paper I am going to refer to the players trading directly with dealers (proprietary trades) with the term insiders, and to the players trading indirectly (agency trades) with the term outsiders.

This market is less prone to liquidity shocks caused by large orders. In fact, dealers have a balance sheet large enough to absorb them with limited price impact. Information percolation is also reduced because of the bilateral nature of agreements. Therefore, an opaque market is better suited to accommodate the needs of sophisticated and possibly informed investors than an exchange. However, this lack of transparency is disadvantageous for retail traders which are at the margin of this market.

Pre-trade transparency is almost null in corporate bond trading: dealers are not required to disseminate quotes on a regular basis (BlackRock, 2014). Quotes are still requested by phone and are valid "as long as the breath is warm". Therefore, the ability of a market participant to "shop around" for quotes is very limited (Bessembinder and Maxwell, 2008).

[2]This statement is discussed further in section 3.2.

Despite the rise of electronic trading venues, dealers appear to preserve their central role in the corporate bond market. Corporate bonds are highly heterogeneous and trade at low frequency, therefore a regulated electronic exchange is less likely to prevail in this market (Bank for International Settlements, 2016). Most of the electronic transactions are trades with notional value below 1 million, typically retail trades occurring in platforms such as NYSE A.B.S. Moreover, electronic platforms are more common for the interdealer markets (Mizrach, 2015). In summary, dealers appear to benefit the most from the introduction of electronic trading, however they are still preserving the advantage of their core position in the market in terms of price making (Harris, 2015).

Starting from July 2002, the National Association of Security dealers (N.A.S.D.) introduced a program to partially improve transparency in this market. All members of the N.A.S.D. were required to report price, quantity, and trade conditions for secondary market transaction involving investment grade bonds having more than one billion of dollars outstanding. Reported information are then disseminated through the Trade Reporting And Compliance Engine (T.R.A.C.E.). Transparency progressively increased since the inception of this system: starting from October 2004, practically all secondary market bond transaction are reported and since 2008 the side of the trade (buy or sell initiated) is diffused. The dissemination of such informations brought post-trade transparency to this market.

Despite these efforts to bring transparency to the market, price dispersion is still present: at the same moment the same bond is traded at multiple prices. To gauge the magnitude of this phenomenon, I compute a measure of price deviation: for each bond with at least 5 trades in a given day, I compute the difference between the executed price and the average daily price for that bond[3]. Table 1 reports mean and standard deviation of price deviations distinguishing for trade initiator, trade size class, and for the capacity of the trade initiator. These numbers suggest

[3] I compute the price deviation δ for each trade j in day t of bond i as

$$\delta_{i,j,t} = \frac{1}{\bar{P}_{i,t}} \left(P_{i,j,t} - \bar{P}_{i,t}\right) = \frac{1}{\bar{P}_{i,t}} \left(P_{i,j,t} - \frac{1}{N_{i,t}} \Sigma_j P_{i,j,t}\right)$$

Where P is the price of the security and N is the number of trades.

that trading costs are decreasing in size, but dealers are providing worst quotes when absorbing a large proprietary sale. This unfavourable price may incorporate an adverse selection component (as described in Glosten and Milgrom, 1985) or a compensation for immediacy. Anyway, this does not hold for buyer-initiated trades. This may highlight the tendency of dealers to keep smaller inventories and their willingness to offer better condition to buy side investors.

To have an idea of the type of trades executed in the market, figure 2 and 3 plot monthly time series of the number and volume of trades respectively. The majority of trades for all trade size classes are proprietary trades mostly initiated by customers[4]. Agency trades occur less often and are mostly executed through a dealer. To have a breakdown on the capacity of the executing dealers, table 2 reports the fractions of the number and volume of trades performed using the dealers' inventory or the clients'. On the time horizon considered (2004 to 2012) dealers execute the vast majority of trades using their own inventory, in particular for non-intermediated trades. Anyway, about one third of the total number of trades are pre-arranged, this means that dealers are not bearing inventory risk when executing this kind of transactions.

The aforementioned figures highlight the role of funding liquidity too. There is a clear increment in both the number and volume of trades after the inception of quantitative easing policies. Mega trades appear to be less affected by the interventions of the Federal Reserve.

Recently, regulation such as the Volcker rule and Basel III inhibited banks to conduct proprietary trading and imposed capital requirements on inventories. Therefore, the U.S. corporate bond market is in a phase of transition from being a "principal market" (where dealers assume inventory risk) to an agency market (where dealers act as intermediaries). This transition will lead to an increasing number of agency and pre-arranged transactions.

[4]The drop in customer trades on the later part of the sample is caused by the ceasing of reporting about customer capacity.

3.2 Incentive compatibility among players

Given the unregulated nature of the market described above, and the heterogeneity between core and periphery players, a misalignment between the incentives of dealers and those of their customers is likely present.

Dealers provide the service of immediacy when they engage in proprietary transactions (Demsetz, 1968), they facilitate trades between two heterogeneously informed parties (Merton, 1995), and they are active in information production because of their centrality in the market (Campbel and Krakaw, 1980). In performing such activities, dealers are not subject to regulatory constraints, hence their behavior is solely determined by a maximization of their payoffs compatible with the risks they face. Among such risks we can identify those stemming from the uncertainty about asset returns and transaction arrival (Ho and Stoll, 1981). In addition to these source of risk, dealers have to react to adverse selection as well (Glosten and Milgrom, 1985), one way to do so is to refrain from providing immediacy and act as broker (Grossman and Miller, 1988).

On the other hand customers are quire heterogeneous in their incentives: a retail trader is more concerned about the best price, a sophisticated trader may care more about immediacy, while a large buy-and-hold investor will aim for the lowest price per amount traded (Sensebrenner, 2013). Nevertheless customers behave similarly when taking information into account: buyers or sellers which expect large gains from trading (informed agents) prefer to trade directly with a dealer, while the others prefer to engage in the search for counterparties or to mandate such search to a broker (Gehrig, 1993).

Dealers can identify informed counterparties quite easily in this market: in fact, informed players will demand immediacy to the executing dealer. In order to protect themselves from this adverse selection, dealers can shift this transaction to clients' inventory via an agency trade or by arranging an opposite trade with another client. Being price makers, dealers can arrange trade conditions in order to make their preferred way of transacting appealing to the trade initiator. In this way, a trader who is supplying liquidity to the market is not adequately compensated and might be the recipient of an informed trade.

4 Empirical analysis

4.1 Data sources

The cornerstone of this study is the Trade Reporting And Compliance Engine (T.R.A.C.E.) dataset. WRDS provides an enhanced version containing informations about the initiator of each trade executed since the inception of T.R.A.C.E. (2002), in addition the trade size of large trades is uncensored. The time horizon of this dataset goes from July 1st, 2002 to December 31st, 2012; most recent years are not disseminated to avoid the diffusion of informations about dealers' inventory.

After the removal of errors and duplicates (the procedure is outlined in appendix A), I keep observations from October 1st, 2004, starting from that date security dealers must disclose all trades in corporate bonds.

To find information about the securities traded (e.g. amount issued, price at issue and rating), I rely on Thomson Reuters. The same source provides data about interest rates (Libor and Overnight Indexed Swap) that I use to compute proxies for funding liquidity.

4.2 Empirical modelling

The analysis is based on multiple linear regressions of the price deviation. This variable is defined as the difference between the price at which each transaction of a given security occurs and the average daily price of the same security (See section 3 and table 12 for details on how this variable is computed).

On the subset of customer-to-dealer trades, I estimate a separate model for each initiator of the trade and for its capacity (e.g. buyer-initiated as principal or seller-initiated as agent). The main explanatory variables are: the quantity traded and the capacity of the dealer executing the trade (principal, agent, or riskless principal). To identify the riskless principal trades, I use the simple approach of matching buy and sell initiated trades of the same security, with the same trade volume, and occurring within a 15 minutes time frame. Other controls are: (lagged) market specific liquidity controls, and a proxy for funding liquidity. To control for security-level liquidity in a parsimonious way, I include security fixed effect and a dummy for on-the-run securities (issued in the 90 days before the trade), which are are more actively traded (Mizrach, 2015).

This simple specification for the bid-ask spread distinguishes between possibly uninformed (intermediated) and possibly informed (proprietary) trades. In addition, I run a robustness check by including the measure of order flow toxicity proposed by Easley, López de Prado, et al., (2012) to gauge the impact of a different measure of informed trading[5]. Even though this measure has been developed for high frequency markets, the underlying idea also holds for an illiquid one: once a given volume of trade is observed, the information content depends on how these trades are polarized towards the buy of the sell side. The only possible flaw in the corporate bond market is an overestimation of the information content, which might be contaminated by non-informative order imbalance. As an example, imagine a pension fund facing large inflows at the end of the fiscal period, the purchases of this fund will inflate the VPIN metric in an illiquid market. This overestimation of the information content only allows the interpretation of the related coefficient as a lower bound.

The sample period for these regressions goes from October 1st, 2004 to February 3rd, 2012. After this date reporting standards changed and the capacity of the trade initiator is no-longer available. In addition, I provide results for a subsample starting on Lehman Brothers bankruptcy day to show how dealers' behavior changed in a period characterized by severe illiquidity.

The initiator of interdealer trades cannot be evinced from the data because both parties are reporting the trade. This missing information force these trades to be excluded from the analysis although they represent a relevant fraction of corporate bond trades.

5 Dealers' behavior in the corporate bond market

5.1 Adverse selection and trade execution price

Dealers can execute a trade by using their own inventory or by matching incoming orders with those posted by their clients; that is, using *de facto* the clients'

[5] Details about the construction of this measure are given in appendix B.

inventory. In the first case dealers bear all risks stemming from this execution, while in the second case all the risks are shifted to the client posting the order. The compensation for dealers is the bid-ask spread when they trade as principal, and a commission when they trade on behalf of their clients. When dealers are pre-arranging trades, their compensation is the difference between the purchase and the sale price.

Dealers executing the trade offer different conditions depending on both their own capacity and the capacity of the customer initiating the transaction. To have a succint overview of the difference in executed price, I compute the predicted bid and ask spreads as a function of the capacity of parties entering the trade and the quantity traded. Predicted values are computed using coefficients in column (1) of tables 3, 4, 5, and 6. These estimates capture the relation between price deviation and trade size after controlling for market and funding liquidity.

Figure 4 shows the predicted bid-ask spread offered to outsiders. As discussed in section 3.2, an informed trader is likely to demand immediacy for his trade, and therefore trade directly with the dealer. On the other hand, executing the trade through an intermediary is a signal of low information (Bank for International Settlements, 2014; Boyarchenko et al., 2015). An informed agent is unlikely to disguise by trading through an intermediary: first, the speed of transaction is lower and the information may become stale; second, the intermediary controls the terms of the trade, and this may erodes part of the profit of the initiating trader.

When trading as principal, a dealer appears to offer a higher bid price when purchasing from outsiders: they are willing to give up about 20 bps in order to increase their chances to complete the transaction and load the inventory with a lower risk of adverse selection. This relatively safe inventory is likely to be employed on the more lucrative business of immediacy provision. When dealing with buyer-initiated trades, dealers offer favourable price when they offset a client's order. The commission they receive for an executed trade gives them an incentive to sell clients' inventory at a lower price. Finally, when considering pre-arranged trades, we observe high ask prices: when they arrange the terms of trade with an outsider, they squeeze this uninformed trader to obtain a higher markup.

Figure 5 gives the equivalent overview for proprietary trades. These trades are more likely to be informed, but the bargaining power of the initiator is large. When executing this type of trades, dealers not only face a higher degree of adverse selection, but are also impeded to require an adequate compensation. When facing insiders, dealers appear uneager to purchase using their own inventory. When the trade is executed with clients' inventory, dealers appear to offer a higher bid price. This behavior allows them to receive the commission from the execution of a transaction, in addition they are also shifting the risk of adverse selection to their clients. Instead, when dealers cannot shift an order to a client, they make price concessions of about 10 bps to pre-arrange a trade, even though it decreases their profit margin. This behavior does not hold for small trades which have a lower information content. In this case dealers prefer to trade using their own inventory. When dealers are on the sell side of a proprietary trade their capacity matters less: the ask price required to an insider for a transaction is the same whatever the inventory used. Dealers are likely to aim to a smaller inventory in order to reduce the capital charge of their investments. Therefore, they are not refraining from selling securities, even to possibly informed investors. Again, when the trade is pre-arranged, the ask price is higher to maximize the markup profit.

To have a better understanding on how dealers react to adverse selection, I compute the same regressions with the addition of the VPIN order flow toxicity metric. Columns (3) and (4) of tables 3, 4, 5, and 6 report the estimates for this specification of the model.

In presence of buy-side order flow toxicity (positive VPIN metric), dealers appear to adjust the ask price to increase the compensation for the possibility of adverse selection. Coherently with the interpretation provided above, we observe a different effect depending on the information content of the trade: when trading with an outsider, dealers offer worse conditions in presence of high toxicity regardless of the final recipient of the trade; instead, when trading with an informed insider, dealers require a higher spread when trading their own inventory compared to the spread required for a pre-arranged trade.

In presence of sell-side toxicity (negative VPIN metric), dealers react by reducing their bid price. Again, this adjustment depends on the capacity of both the initiator and the dealer. When the trade is initiated by an outsider dealers prefer to use their own inventory and require a lower compensation for the toxicity, this behavior is reversed when the trade is initiated by an insider.

One can argue that the capacity of the trade initiator and size are related and that the latter is driving the results. To address this issue, I compute the estimates including an interaction term between size classes (as defined in table 1), quantity traded and capacity of the dealer. These additional terms do not bring any additional explanatory power and we can conclude that the capacity, hence the risk of informed trading is determining different price conditions.

In summary, when a trader is *de facto* supplying liquidity to the market, he is likely to be exposed to adverse selection instead of getting a compensation for liquidity provision. In addition, when dealers pre-arrange trades, they decrease the speed of trading which might be essential for informed traders. Lastly, large traders of bonds with lower need for immediacy (like pension funds and insurance companies) may get a better price for the volume they trade by trading on the passive side of the market. However, this strategy expose them to a higher risk of adverse selection since the control over the terms of trade would be entrusted to the dealer.

5.2 The impact of funding liquidity

Liquidity constraints obviously play a role on the pricing of securities. Traders facing liquidity issues are pushed to sell their position at lower prices (Coval and Stafford, 2007). Funding liquidity is influencing trading activity of dealers as well. In fact, market making consists of building inventory of securities and selling liabilities (O'Hara and Oldfield, 1986). Hence, Increased cost of funding may cause dealers to withdraw from the market, with the effect of decreasing market liquidity and possibility of market breakdown (Gale and Kariv, 2007). On the other hand, the higher presence of liquidity-based trades increase incentives to stand on the passive side of the market to capture firesales.

To proxy for funding liquidity, I take the spread between the Libor rate and the Overnight Indexed Swap rate. As documented in Brunnermeier, (2009), this spread is a proxy for funding liquidity because it measures the premium demanded for the concession of an unsecured loan.

Results show that liquidity provision decreases when funding liquidity is scarce. Table 3 shows that the ask price offered to execute an agency trade is increasing in the Libor-OIS spread. When funding liquidity is scarce, a dealer is in advantage for two reasons: first, outsiders are likely to have low bargaining power; second, the competition with other dealers is reduces because inventories are likely to be smaller. As a result, dealers charge a higher price to sell securities to outsiders and to squeeze an even higher markup when trades are pre-arranged.

Table 4 reports equivalent results for principal buy-side initiated trades. When dealers face shortages of funding liquidity, they increase the ask price of about 7 bps per percentage point of Libor-OIS spread, well below the 22 bps charged when trading clients' inventory. Dealers are likely to offer a better price for their own inventory for two main reasons: they are keen to sell large quantities of securities and the bargaining power of an insider is higher. The spread is also lower when considering riskless principal trades: in this case dealers give up part of their markup in order to facilitate the trade-through and avoid the inventory risk.

Tables 5 and 6 report results for sell-initiated trades. In presence of funding illiquidity, the behavior of the dealers depends on the capacity of the initiator: when trading with outsiders, dealers offer a better price when loading their own inventory; instead, when facing a possibly informed trader, dealers appear to quote a better bid price for agency and pre-arranged trades, while lowering it when trading on their own account. Comparing trades in which the dealer has different capacity shows that dealers make price concessions to capture a possible firesale when they trade on their own account. A trade initiated by an outsider is more likely to be triggered by liquidity issues: as documented in Duffie et al., 2007, some dealers are "waiting on the sidelines" to purchase securities at a distressed price, hence they are willing to offer better quotes when trading for themselves. When the sale is initiated by an insider, dealers tend to transfer the security to their clients by offering a higher price. In summary, the scarcity of funding liquidity exacerbates the agency issue described above.

The antithetic behavior we observe on the buy and sell side in presence of funding illiquidity may appear hard to reconcile. However, there are different types of dealers, which are likely to behave differently when funding is scarce: dealers can be part of a very large firm (e.g. Barclays, Goldman) or they can be free-standing. The former can rely on both internal and external capital markets: hence, they are more robust to liquidity constraints and they can profit from firesales. The latter can only rely on external capital market: in presence of illiquidity they strive to unload their inventories. In addition, the relational nature of the dealership business may determine the favorable selling price offered by dealers: as argued in Di Maggio et al., (2016), dealers offer better conditions to their most valuable clients in times of turmoil.

5.3 The great financial crisis

The great financial crisis has been a period characterized by extreme illiquidity, both in terms of market frictions and access to funding (Dick-Nielsen et al., 2012). Among the event that occurred in that period, the default of a major corporate bond dealer had negative spillover effects on the liquidity provision by other dealers (Di Maggio et al., 2016).

To investigate the impact of the great financial crisis on the behavior of dealers, I compute the same regressions on the subsample of trades occurring between September 15, 2008 (the day of Lehman Brothers' bankruptcy filing) and the end of the sample. Tables 7, 8, 9, and 10 report the equivalent results for this subsample, while figures 6 and 7 summarize the predicted bid and ask price using results of the aforementioned analysis.

The behavior of the dealers changed during the great financial crisis. Dealers appear to offer the best conditions when the ultimate liquidity provider is a client, hence they are "leaning their clients against the wind", while providing a smaller compensation for liquidity provision. Moreover, we see that dealers ask for a higher compensation while using their own inventory, this occurs irrespectively of the capacity of the initiator. When considering pre-arranged trades, dealers are no longer giving up any of their mark-up profit. Hence, they appear less interested in building safer inventories and more in getting adequate compensation for their liquidity provision and intermediation services.

In presence of order flow toxicity, dealers decrease liquidity supply in line with the behavior inferred from the full sample. However, they appear to make slightly favorable conditions to pre-arrange trades and avoid inventory risk. It is worth noting that when facing a possibly informed seller, dealers require a higher liquidity compensation only when using their own inventory.

Episodes of of funding illiquidity often manifested during the great financial crisis. During those episodes, dealers refrain to provide liquidity to the market by widening their bid-ask quotes when using their own inventory. When pre-arranging trades dealers make some price concessions to avoid inventory risk. Finally, when facing a possibly uninformed seller, dealers offer a better quote in presence of funding illiquidity and this is compatible with their tendency of capturing firesales.

In summary, during the great financial crisis, dealers refrain from providing liquidity and appear less interested in building inventories, even when the risk of adverse selection is low. They rather appear to demand a higher compensation for liquidity provision in averse times, and to set the prices to maximize their profitability.

6 Policy recommendation

The results discussed in the previous section point out how the opaqueness of the corporate bond market makes it difficult to provide liquidity without facing agency issues. In order to mitigate these agency issues and improve market participation, we need to introduce policy measures allowing non-dealer participants to provide liquidity and to have control over the terms of trade.

One obvious measure would be the introduction of pre-trade transparency. This policy measure is discussed in Bloomfield and O'Hara, (1999), their experiment casts doubt on the welfare effects of market transparency: on the one hand it increases price efficiency, but on the other it increases trading costs. Moreover, both informed and uninformed traders are "losers" in a more transparent market setting. In the corporate bond market, the possibility to know a tradable quote ex-ante is putting both insiders and outsiders on the same level and dealers cannot shift the adverse selection. However, this kind of measure is likely to reduce liquidity since dealers are no longer able to discriminate between informed and uninformed traders, therefore they will rationally adjust their quotes. Pre-trade transparency will not be beneficial to the large players present in the market either, because they are losing their bargaining power. Additionally, this kind of transparency allows a collusive behavior between dealers, which is trivial to monitor.

A more viable approach is the extension to the bond market of two regulations which apply to equity trading. The first one is the order protection rule contained in the Regulation National Market System (Reg NMS): the limitation of trade-throughs would offer protection against the shift of adverse selection via pre-arranged trades, moreover it will eliminate the markup of riskless principal transactions, hence it will reduce trading costs. The second regulation which is likely to improve this market is the FINRA rule 5320 (Prohibition against trading ahead of customer orders): i.e. dealers must always execute clients' orders first, and use their own inventory only when these orders are satisfied. The introduction of this regulation will rule out the possibility for dealer to purchase safer inventory when customer orders are present, hence dealers will only face reputational costs when they trade on behalf of their clients and the price of agency trades will reflect the adverse selection component. These regulations will reduce the possibility of shifting the risk of informed trades to clients without despoiling dealers of the possibility of requiring a compensation for facing an informed trader.

Finally, the promotion of dealer-sponsored electronic trading venues would give more controls over the terms of trading to non-dealer participants. Linking the trading platform to a dealer (or to a group of them) allows the trading venue to inherit the specialization of that dealer, and to overcome the heterogeneity of the bond market. Liquidity provision would be enhanced and not only relegated to dealers. Additionally, buy and hold institutions which have less need for immediacy can benefit from implementing a liquidity provision strategy via these platforms. Dealers would benefit from this innovation because they can decrease their inventory risk by delegating part of the liquidity provision, moreover they can profit from commissions earned for sponsoring these platforms.

7 Conclusions

When executing trades, dealers are able to discriminate between possibly informed and possibly uninformed initiators, and to strategically set the price to avoid the risk of adverse selection. When dealing with a possibly informed trader demanding immediacy, dealers offer better conditions when they are using their clients' inventory via an agency trade or a pre-arranged trade. Instead, when they are facing a possibly uninformed trader, they offer better condition to be the recipient of the trade: in this way they can build their inventory with a lower risk.

Funding liquidity shortages are exacerbating these issues. Dealers with less capital constraints compete to capture possible fire-sold securities when trading on their own account; they also persist in allocating incoming informed trades to their clients.

During the great financial crisis, dealers appear to "lean their clients against the wind" by using their inventories to execute trades, while offering them a lower compensation for liquidity provision. Moreover, they are less focused on building safe inventories and are rather focused on their profitability.

Because of regulatory constraints, the U.S. corporate bond market is now in a phase of transition from being a "principal market", where dealers are the main liquidity providers, to an "agency market", where dealers are acting more and more as brokers. In this new framework, agency issues are going to be more relevant since investors are forced to entrust their orders to dealers rather than executing trades with them.

The progressive introduction of electronic trading is unlikely to mitigate these issues: first, dealers are not sharing the advantages of this innovation with other market participants; second, this new technology is not penetrating the illiquid and the speculative segments of corporate bond market, which are the most prone to adverse selection.

To overcome these issues, a new system of regulation is needed. These new rules should aim towards improving market participation and liquidity provision by non-dealer participants. Regulation focused on increased market transparency are not suitable for a fragmented and bargaining-driven market.

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A Cleaning of TRACE dataset

A large number of trades reported in TRACE are errors and corrections, in addition inter-dealer transactions are reported twice (one by the buyer and one by the seller). To clean the dataset I use as a starting point the procedure suggested in Dick-Nielsen, (2009) and Dick-Nielsen, (2013b). In this appendix, I summarize the additional assumption I use and the outcome of the cleaning procedure.

The starting point is the enhanced version of TRACE dataset distributed by WRDS. Table 11 reports the number of trades of the original dataset (spanning the period going from October 1st, 2004 to December 31st, 2012) and those remaining after each step of the cleaning procedure. The steps recommended in Dick-Nielsen, (2009) are: the deletion of trades missing the security identifier (CUSIP), the deletion of cancelled trades, the deletion of trades rectified on the same day, and the deletion of trades amended later than the execution date (reversals). To make data suitable for my analysis, I also delete trades not occurred in secondary market (e.g. takedown transactions), trades executed at "special" price, and trades missing price or quantity.

After this first cleaning of the dataset, I separate customer transactions from inter-dealer transactions. On the latter group, I match the buy side to the sell side by comparing CUSIP, execution date, price, and quantity. The great majority of inter-dealer transactions are matched, only 1 million trades remains without their counterparty and therefore they are excluded.

The last step of the construction of the dataset is the matching with bond information obtained from Thomson-Reuters. Information are not available for some bonds which are excluded from the sample, leaving around 62,5 millions trades available for the analysis.

To assess the quality of the cleaning procedure, I compare the fraction of trades discarded with the benchmark reported in the papers cited before. Deletion ratio after the first recommended steps is 5,1%, which is not distant from the deletion ratio of 7% reported in Dick-Nielsen, (2009). Deletion ratio after the matching of inter-dealer transactions is 33,5%, which is comparable to the 35% reported in Dick-Nielsen, (2013b).

Finally, I remove outliers by windsorizing the variables relating to the quantity traded and the price deviation at the quantiles 0.05% and 99.95%.

B Construction of the VPIN metric

The VPIN metric (Easley, López de Prado, et al., 2012) is an extension of the PIN model proposed by Easley, Hvidkjaer, et al., (2002) which does not require numerical estimation of unobservable parameters. This metric is computed via a volume-synchronized approach which takes into account the irregular trading frequency and the different information content of trades. In addition, the metric is estimated in closed form which is very convenient for larger data sets.

The first step of the construction of the VPIN metric is the grouping of trades in volume buckets of equal size V. In this analysis, the bucket size V_i is chosen to be one tenth ($1/10$) of the average daily customer-to-dealer trading volume of each security i. A volume bucket is therefore a collection of trades of the security i having total volume equal to V_i. In case the last trade makes the size of the bucket greater than V_i, the excess size is allocated to the next bucket.

The second step is the distinction between buy volume and sell volume. In this application, no additional effort is required to sign the volume since the initiator is known. This approach identify the overall volume V_i as a signal for new information and the signed volume as the positive or negative content of this information.

The last step is the actual calculation of the VPIN metric. For each time period τ, the expected trade imbalance $\mathbb{E}[|V_\tau^B - V_\tau^S|] \approx \alpha\mu$ which is the informed order flow times the probability of information arrival (following the notation used in the model of Easley, Hvidkjaer, et al., 2002). The expected total number of trades is $\mathbb{E}[V_\tau^B + V_\tau^S] = \alpha\mu + 2\epsilon$ which is the sum of both informed and non-informed trades. Thanks to volume timing, we have that $\mathbb{E}[V_\tau^B + V_\tau^S] = V$ because a volume bucket is equivalent to a period for information arrival. The expected imbalance is approximated with the average observed imbalance. Therefore, we can write the volume-synchronized probability of informed trading (VPIN) as

$$VPIN = \frac{\alpha\mu}{\alpha\mu + 2\epsilon} \approx \frac{\sum_{\tau=1}^{n} |V_\tau^B - V_\tau^S|}{nV}.$$

In this analysis, the VPIN metric is computed on a rolling window of $n = 10$

volume buckets. Moreover, to distinguish between buy side and sell side generated toxicity, I sign the VPIN with the same sign of the order imbalance. By means of this modification, I have a VPIN metric close to -1 when there is a high probability of an informed sell trade, and close to $+1$ on the opposite case.

Table 1: Summary statistics for price deviation (values in basis points).

	Type of trade	Regular		Pre-arranged	
	Initiator Capacity	Agent	Proprietary	Agent	Proprietary
Trade direction	Trade Size	Average price deviation (and std. err.)			
Sell Trades	MEGA	-4.88	-12.12	-0.92	-10.98
		(293.85)	(326.03)	(110.45)	(243.81)
	INSTITUTIONAL	-21.85	-25.33	-40.98	-50.82
		(230.42)	(202.85)	(125.05)	(150.6)
	ODD-LOT	-45.43	-41.69	-73.85	-72.33
		(200.02)	(248.13)	(168.24)	(200.62)
	RETAIL	-155.66	-140.17	-83.37	-128.98
		(144.46)	(138.56)	(173.87)	(262.25)
Buy Trades	MEGA	29.57	12.34	27.43	21.65
		(114.88)	(259.62)	(117.19)	(406.98)
	INSTITUTIONAL	56.55	33.93	23.28	77.11
		(167.07)	(153.64)	(99.68)	(134.57)
	ODD-LOT	37.24	37.29	35.36	84.79
		(177.56)	(193.07)	(340.57)	(174.16)
	RETAIL	102.24	68.83	37.19	107.97
		(339.52)	(119.69)	(356.95)	(179.92)

Trade Size

- Mega: Par value traded above 10.000.000$
- Institutional: Par value traded between 1.000.000$ and 10.000.000$
- Odd-Lot: Par value traded between 100.000$ and 1.000.000$
- Retail: Par value traded below 100.000$

Capacity

- Agent: the trade is initiated on behalf of a client.
- Proprietary: the trade is executed on behalf of the initiator and the security is transiting from/to the inventory of the trade initiator.

Table 2: Breakdown of trades by capacity of the initiator and of the dealer. Upper panel reports the breakdown in terms of number of trades, while lower panel reports it by trade volume. Fraction of pre-arranged trades (riskless principal) is computer with respect to the total.

Trade direction	Initiator	Capacity of the dealer		
		Agent	Principal	of which pre-arranged
Buy	Agent	22.62%	77.38%	19.58%
	Principal	2.14%	97.86%	24.17%
Sell	Agent	19.74%	80.26%	38.95%
	Principal	3.08%	96.92%	53.05%
Buy	Agent	22.36%	77.64%	45.40%
	Principal	2.27%	97.73%	27.55%
Sell	Agent	22.46%	77.54%	33.90%
	Principal	3.24%	96.76%	35.38%

Table 3: Estimates for price deviation for buy side initiated agency trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model.

	Dependent variable: Price deviation (in bps)			
	(1)	(2)	(3)	(4)
Intercept	3.6717	8.12	5.8471	10.9749
	(4.0674)	(8.7336)	(4.0844)	(8.8395)
Dealer is principal	-9.0306***	-9.0311***	-9.1143***	-9.1147***
	(1.3858)	(1.3859)	(1.3879)	(1.388)
Pre-arranged	12.9884***	13.0166***	12.6607***	12.6871***
	(2.5473)	(2.5501)	(2.5786)	(2.5818)
Libor-OIS spread	7.0635***	7.0684***	7.3601***	7.3578***
	(1.3867)	(1.3789)	(1.3662)	(1.3591)
Libor-OIS spread * Dealer is principal	4.3927***	4.3906***	4.2901***	4.2889***
	(0.8459)	(0.8452)	(0.8404)	(0.8397)
Libor-OIS spread * Pre-arranged	8.794***	8.7872***	8.9996***	8.9943***
	(1.1181)	(1.1161)	(1.1126)	(1.1106)
log(Volume)	-0.7559***	-0.7563***	-0.5951**	-0.5955**
	(0.2392)	(0.2392)	(0.2397)	(0.2397)
log(Volume) * Dealer is principal	0.6507***	0.6513***	0.6492***	0.6498***
	(0.131)	(0.131)	(0.1308)	(0.1308)
log(Volume) * Pre-arranged	-1.2238***	-1.2241***	-1.2224***	-1.2227***
	(0.2602)	(0.2603)	(0.2615)	(0.2616)
VPIN			7.6143***	7.6125***
			(1.1373)	(1.1375)
VPIN * Dealer is principal			-0.8803	-0.8772
			(0.5862)	(0.5861)
VPIN * Pre-arranged			1.9009	1.903
			(1.1889)	(1.1891)
Number of observations	2’144’935	2’144’935	2’144’935	2’144’935
R^2	0.0095	0.0095	0.0110	0.0110
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume

Note: *p<0.1; **p<0.05; ***p<0.01

Table 4: Estimates for price deviation for buy side initiated proprietary trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model.

	Dependent variable: Price deviation (in bps)			
	(1)	(2)	(3)	(4)
Intercept	33.8382***	59.9259***	33.0506***	59.9256***
	(12.0618)	(10.7758)	(12.307)	(11.1448)
Dealer is principal	20.2342**	19.9309**	22.0674**	21.7833**
	(9.4615)	(9.47)	(9.8488)	(9.8563)
Pre-arranged	9.2739***	9.4827***	9.6194***	9.8234***
	(0.572)	(0.5676)	(0.5673)	(0.5629)
Libor-OIS spread	20.15***	20.0712***	20.1727***	20.088***
	(3.7478)	(3.7804)	(3.7419)	(3.7728)
Libor-OIS spread * Dealer is principal	-15.1443***	-15.0813***	-14.8081***	-14.7469***
	(3.9472)	(3.9615)	(3.9265)	(3.9399)
Libor-OIS spread * Pre-arranged	2.7485***	2.7261***	2.7758***	2.7545***
	(0.5141)	(0.5135)	(0.5147)	(0.5141)
log(Volume)	-3.9158***	-3.9327***	-3.3334***	-3.3472***
	(0.7375)	(0.7381)	(0.8094)	(0.81)
log(Volume) * Dealer is principal	-0.9005	-0.8809	-1.0114	-0.994
	(0.7393)	(0.74)	(0.8113)	(0.8119)
log(Volume) * Pre-arranged	0.133**	0.1239**	0.1395**	0.1486***
	(0.0579)	(0.0578)	(0.057)	(0.057)
VPIN			8.5949***	8.6359***
			(2.8437)	(2.8444)
VPIN * Dealer is principal			2.7308	2.71
			(2.8469)	(2.8478)
VPIN * Pre-arranged			-2.7902***	-2.7911***
			(0.2074)	(0.2073)
Number of observations	12'937'653	12'937'653	12'937'653	12'937'653
R^2	0.0193	0.0192	0.0213	0.0212
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 5: Estimates for price deviation for sell side initiated agency trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model.

	Dependent variable: Price dispersion (in bps)			
	(1)	(2)	(3)	(4)
Intercept	-71.6276***	-160.4119***	-70.5856***	-158.646***
	(24.1249)	(44.9885)	(24.1036)	(45.0271)
Dealer is principal	13.2611***	13.2145***	13.4011***	13.3527***
	(2.5207)	(2.5185)	(2.6293)	(2.6271)
Pre-arranged	-26.6031***	-26.5319***	-26.6308***	-26.5637***
	(1.9126)	(1.9044)	(1.9029)	(1.8941)
Libor-OIS spread	-66.0701***	-65.4583***	-65.8548***	-65.2498***
	(2.4288)	(2.4255)	(2.4176)	(2.4148)
Libor-OIS spread * Dealer is principal	11.4763***	11.4204***	11.405***	11.35***
	(1.7012)	(1.6972)	(1.6955)	(1.6915)
Libor-OIS spread * Pre-arranged	-5.98***	-5.9674***	-5.9857***	-5.9743***
	(1.6168)	(1.6142)	(1.6184)	(1.6157)
log(Volume)	3.4208***	3.4249***	3.268***	3.2731***
	(0.1561)	(0.1562)	(0.1535)	(0.1535)
log(Volume) * Dealer is principal	1.045***	1.0404***	1.0776***	1.0726***
	(0.2473)	(0.247)	(0.263)	(0.2626)
log(Volume) * Pre-arranged	0.0794	0.0743	0.1319	0.1271
	(0.2098)	(0.2094)	(0.2097)	(0.2093)
VPIN			6.8299***	6.7888***
			(0.5117)	(0.5119)
VPIN * Dealer is principal			-1.2398	-1.2229
			(1.1669)	(1.1649)
VPIN * Pre-arranged			-0.9686	-0.9862
			(0.8402)	(0.841)
Number of observations	1’876’728	1’876’728	1’876’728	1’876’728
R^2	0.0506	0.0509	0.0511	0.0514
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 6: Estimates for price deviation for sell side initiated proprietary trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model.

	Dependent variable: Price dispersion (in bps)			
	(1)	(2)	(3)	(4)
Intercept	-81.6363***	-124.287***	-79.1729***	-120.7727***
	(10.3271)	(18.7685)	(10.4051)	(18.734)
Dealer is principal	-37.849***	-37.9545***	-36.6122***	-36.7128***
	(6.496)	(6.5015)	(6.682)	(6.6873)
Pre-arranged	-39.4392***	-39.4037***	-38.5509***	-38.5218***
	(0.8876)	(0.8865)	(0.8728)	(0.8723)
Libor-OIS spread	-4.6652*	-4.4198*	-4.6507*	-4.4124*
	(2.5431)	(2.5408)	(2.5291)	(2.5266)
Libor-OIS spread * Dealer is principal	-34.0415***	-34.0477***	-33.8378***	-33.8448***
	(3.1133)	(3.1151)	(3.0966)	(3.0984)
Libor-OIS spread * Pre-arranged	5.2032***	5.2058***	5.1501***	5.1526***
	(0.8356)	(0.8369)	(0.8377)	(0.839)
log(Volume)	4.4774***	4.4657***	4.0748***	4.0643***
	(0.4954)	(0.4957)	(0.5214)	(0.5217)
log(Volume) * Dealer is principal	-0.5851	-0.5945	-0.3714	-0.3805
	(0.493)	(0.4933)	(0.5197)	(0.52)
log(Volume) * Pre-arranged	3.0556***	3.0516***	3.0488***	3.0455***
	(0.0787)	(0.0785)	(0.077)	(0.0769)
VPIN			5.8528***	5.8419***
			(2.0043)	(2.0042)
VPIN * Dealer is principal			4.5211**	4.5215**
			(2.018)	(2.0178)
VPIN * Pre-arranged			-1.7034***	-1.7104***
			(0.3473)	(0.3465)
Number of observations	7'803'732	7'803'732	7'803'732	7'803'732
R^2	0.0256	0.0257	0.0270	0.0271
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume
Note:				$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 7: Estimates for price dispersion for buy side initiated agency trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model. Sample period goes from September 15th, 2008 to February 3rd, 2012.

	Dependent variable: Price dispersion (in bps)			
	(1)	(2)	(3)	(4)
Intercept	6.5565	7.3685	8.3925	10.2925
	(6.5961)	(10.4957)	(6.4757)	(10.5909)
Dealer is principal	-0.8333	-0.8383	-1.0474	-1.0521
	(1.4623)	(1.4622)	(1.4665)	(1.4665)
Pre-arranged	10.7649***	10.7557***	10.4965***	10.4885***
	(3.9726)	(3.9725)	(4.0084)	(4.0093)
Libor-OIS spread	10.5954***	10.6024***	11.0103***	11.0092***
	(1.5453)	(1.5589)	(1.528)	(1.5413)
Libor-OIS spread * Dealer is principal	-0.0371	-0.0325	-0.0426	-0.0379
	(0.706)	(0.7054)	(0.7047)	(0.7041)
Libor-OIS spread * Pre-arranged	7.1107***	7.115***	7.2814***	7.2868***
	(1.1682)	(1.1669)	(1.1615)	(1.1602)
log(Volume)	-0.8187**	-0.8197**	-0.6607*	-0.6614*
	(0.3663)	(0.3662)	(0.3669)	(0.3669)
log(Volume) * Dealer is principal	0.3177**	0.3178**	0.3227**	0.3228**
	(0.1517)	(0.1517)	(0.1516)	(0.1516)
log(Volume) * Pre-arranged	-0.8969**	-0.8964**	-0.8923**	-0.8919**
	(0.4042)	(0.404)	(0.4054)	(0.4054)
VPIN			7.9128***	7.9142***
			(1.1738)	(1.1739)
VPIN * Dealer is principal			-0.4756	-0.4766
			(0.6047)	(0.6047)
VPIN * Pre-arranged			1.9638	1.9673
			(1.217)	(1.217)
Number of observations	1’459’842	1’459’842	1’459’842	1’459’842
R^2	0.0083	0.0082	0.0100	0.0100
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 8: Estimates for price dispersion for buy side initiated proprietary trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model. Sample period goes from September 15th, 2008 to February 3rd, 2012.

	Dependent variable: Price dispersion (in bps)			
	(1)	(2)	(3)	(4)
Intercept	99.3001***	108.8716***	97.9307***	108.4713***
	(13.6573)	(15.2691)	(14.5069)	(16.0628)
Dealer is principal	-14.5976	-14.5943	-13.0496	-13.0518
	(13.4039)	(13.4017)	(14.3011)	(14.2993)
Pre-arranged	2.322***	2.3193***	2.9573***	2.9549***
	(0.6324)	(0.6324)	(0.6289)	(0.6289)
Libor-OIS spread	14.3239***	14.2943***	14.4556***	14.4197***
	(3.5676)	(3.5582)	(3.5585)	(3.5497)
Libor-OIS spread * Dealer is principal	-0.754	-0.7669	-0.4187	-0.4315
	(3.8063)	(3.8035)	(3.7819)	(3.7793)
Libor-OIS spread * Pre-arranged	2.4672***	2.4696***	2.4408***	2.4435***
	(0.4937)	(0.4935)	(0.4923)	(0.4921)
log(Volume)	-6.9131***	-6.9117***	-6.404***	-6.4026***
	(1.084)	(1.084)	(1.2155)	(1.2155)
log(Volume) * Dealer is principal	1.8412*	1.8414*	1.741	1.7418
	(1.0836)	(1.0835)	(1.2156)	(1.2155)
log(Volume) * Pre-arranged	1.1971***	1.1969***	1.0131***	1.0129***
	(0.0587)	(0.0587)	(0.0591)	(0.0591)
VPIN			7.5033**	7.5039**
			(3.5072)	(3.5069)
VPIN * Dealer is principal			2.6844	2.6899
			(3.5134)	(3.5132)
VPIN * Pre-arranged			-2.5566***	-2.5545***
			(0.2245)	(0.2244)
Number of observations	8’352’493	8’352’493	8’352’493	8’352’493
R^2	0.0164	0.0164	0.0180	0.0181
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 9: Estimates for price dispersion for sell side initiated agency trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model. Sample period goes from September 15th, 2008 to February 3rd, 2012.

	Dependent variable: Price dispersion (in bps)			
	(1)	(2)	(3)	(4)
Intercept	-75.7444**	-163.4764***	-75.049**	-161.6102***
	(29.57)	(51.1225)	(29.4139)	(51.0849)
Dealer is principal	-20.8764***	-20.8436***	-20.7276***	-20.6939***
	(1.8126)	(1.815)	(1.8021)	(1.8043)
Pre-arranged	-6.181**	-6.0817**	-6.231**	-6.1392**
	(2.6104)	(2.6023)	(2.5688)	(2.5607)
Libor-OIS spread	-71.4841***	-71.0249***	-71.1774***	-70.7287***
	(2.9873)	(2.971)	(2.9711)	(2.9551)
Libor-OIS spread * Dealer is principal	14.7957***	14.7546***	14.726***	14.6868***
	(1.8301)	(1.829)	(1.8294)	(1.8285)
Libor-OIS spread * Pre-arranged	-6.9703***	-6.9717***	-6.9846***	-6.9875***
	(1.8802)	(1.8751)	(1.879)	(1.874)
log(Volume)	3.5105***	3.5169***	3.3393***	3.3469***
	(0.1915)	(0.1916)	(0.1878)	(0.188)
log(Volume) * Dealer is principal	0.9476***	0.9406***	0.9541***	0.9467***
	(0.2079)	(0.208)	(0.2053)	(0.2054)
log(Volume) * Pre-arranged	-0.1832	-0.1861	-0.1094	-0.1117
	(0.2941)	(0.2946)	(0.2861)	(0.2867)
VPIN			7.9838***	7.9229***
			(0.6481)	(0.6459)
VPIN * Dealer is principal			0.4841	0.5003
			(0.9301)	(0.9255)
VPIN * Pre-arranged			-2.0319*	-2.0604*
			(1.1527)	(1.1538)
Number of observations	1’147’956	1’147’956	1’147’956	1’147’956
R^2	0.0601	0.0605	0.0608	0.0612
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 10: Estimates for price dispersion for sell side initiated proprietary trades. Standard errors (in parenthesis) are clustered by day. R^2 is the fraction of within-group variance explained by the model. Sample period goes from September 15th, 2008 to February 3rd, 2012.

	Dependent variable: Price dispersion (in bps)			
	(1)	(2)	(3)	(4)
Intercept	-77.3609***	-127.4877***	-76.509***	-125.3012***
	(12.4386)	(22.4354)	(12.433)	(22.2848)
Dealer is principal	-36.8805***	-37.1607***	-33.7183***	-33.9952***
	(6.987)	(6.9933)	(7.1348)	(7.1418)
Pre-arranged	-41.151***	-41.0879***	-39.5052***	-39.453***
	(1.3019)	(1.3)	(1.2627)	(1.2616)
Libor-OIS spread	-14.8174***	-14.4782***	-14.7449***	-14.4129***
	(2.5708)	(2.568)	(2.5647)	(2.562)
Libor-OIS spread * Dealer is principal	-28.6952***	-28.6974***	-28.5445***	-28.5474***
	(3.1323)	(3.1325)	(3.1302)	(3.1305)
Libor-OIS spread * Pre-arranged	6.3684***	6.3732***	6.3726***	6.3773***
	(0.9496)	(0.9516)	(0.9512)	(0.9533)
log(Volume)	4.236***	4.2075***	4.0069***	3.9796***
	(0.576)	(0.5762)	(0.598)	(0.5983)
log(Volume) * Dealer is principal	0.7198	0.7435	0.2918	0.3154
	(0.5715)	(0.572)	(0.5946)	(0.5952)
log(Volume) * Pre-arranged	3.0517***	3.0448***	2.9461***	2.9404***
	(0.1193)	(0.119)	(0.1136)	(0.1134)
VPIN			3.6738	3.6638
			(2.3974)	(2.3982)
VPIN * Dealer is principal			7.8577***	7.8495***
			(2.4278)	(2.4283)
VPIN * Pre-arranged			-0.2272	-0.2402
			(0.4998)	(0.4981)
Number of observations	4'753'455	4'753'455	4'753'455	4'753'455
R^2	0.0278	0.0279	0.0294	0.0294
Controls	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume	Bond FE on-the-run daily trades	Bond FE on-the-run daily volume
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 11: Summary of the cleaning procedure

Step of the cleaning procedure	**Number of trades**
Original Enhanced TRACE dataset	96’090’771
Deletion of Trades without CUSIP	96’075’193
Deletion of cancellation and corrections post 6/2/2012	95’152’966
Deletion of cancellation and corrections pre 6/2/2012	93’257’175
Deletion of reversals	91’152’604
Deletion of non-secondary market trades	88’445’696
Deletion of trades under special circumstances	88’406’759
Deletion of trades without price or quantity	88’405’838
Additional steps	**Number of trades**
Reported customer transactions	40’895’538
Reported inter-dealer transactions (matched)	23’008’522
Transactions matched with bond informations	62’543’441

Table 12: Description of variables used in the regressions

Variable	Description
Price deviation	Difference between the traded price and the daily mean price for a given security. For each trade j in day t of bond i the deviation $\delta_{i,j,t} = 1/\bar{P}_{i,t}\left(P_{i,j,t} - \bar{P}_{i,t}\right) = 1/\bar{P}_{i,t}\left(P_{i,j,t} - \frac{1}{N_{i,t}}\Sigma_j P_{i,j,t}\right)$. Where P is the price of the security and N is the number of trades.
Trade Volume	Number of securities traded in a given transaction.
Libor-OIS Spread	Difference between the Eurodollar deposit rate and the U.S. Dollar Overnight Indexed Swap rate.
VPIN	The Volume-synchronized probability of informed trading metric as described in appendix B.
Dealer is Principal	Indicator variable equal to 1 if the dealer executing the trade is using his own inventory and 0 otherwise.
Pre-arranged	Indicator variable equal to 1 if the trade is part of a riskless principal transaction.
daily volume	Sum of the number of all the securities traded in all the transaction occurring in a given day.
daily trades	Number of distinct corporate bond transactions occurring in a given day.
on-the-run	Dummy variable equal to 1 if the security has been issued in the 90 days before the trade and 0 otherwise.
rating	Set of dummy variables equal to 1 if the security has the correspondent rating. The rating classes considered in the analysis are: AAA, AA, A, BBB, and Speculative.

Figure 1: Microstructure of the corporate bond market. Dealers in the inner circle represent the core, customers in the outer circle are possibly informed, customers at the periphery are likely to be uninformed. Arrows represent a trade (either buy or sell) from the initiator to the executing dealer. Dashed arrows indicate agency trades: the security is not transiting through the inventory of the player in the middle.

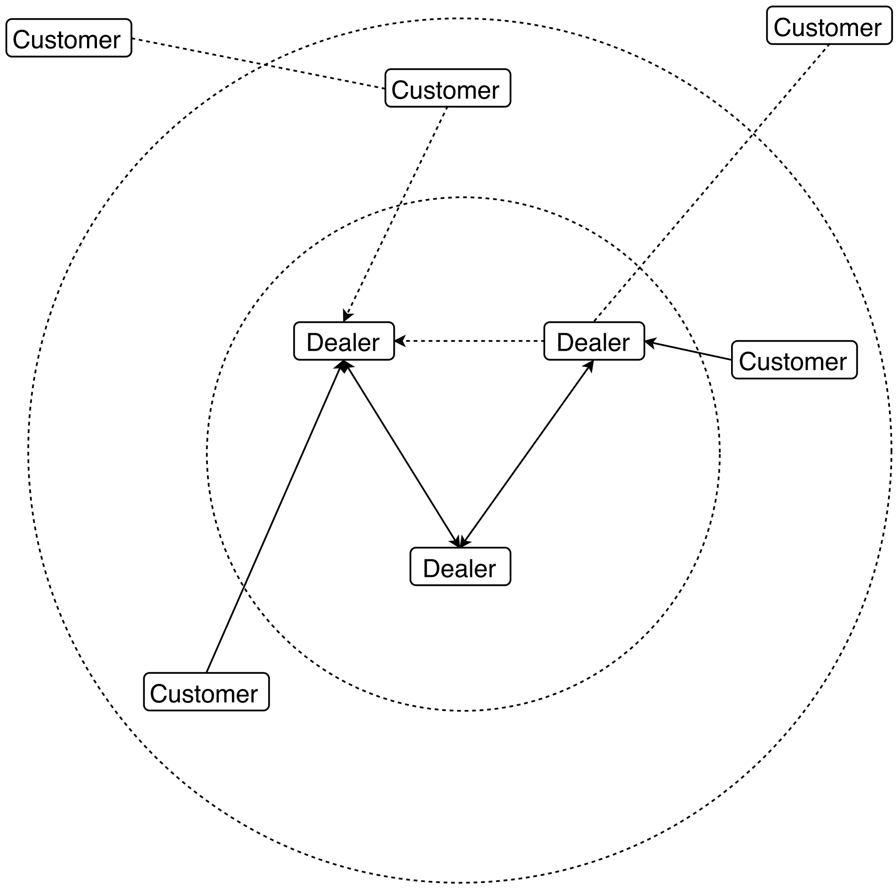

Figure 2: Monthly number of trades

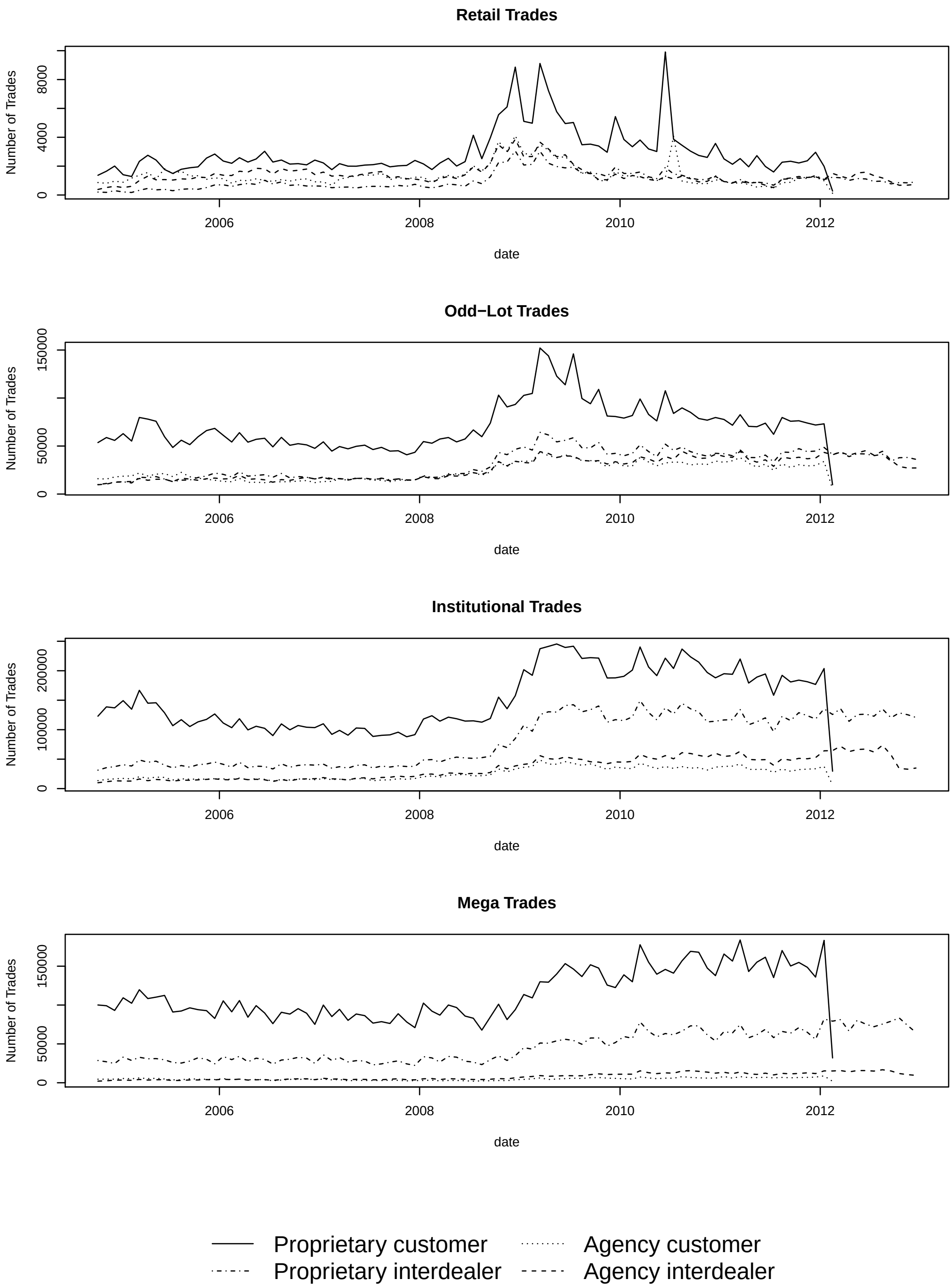

Figure 3: Monthly volume of trades

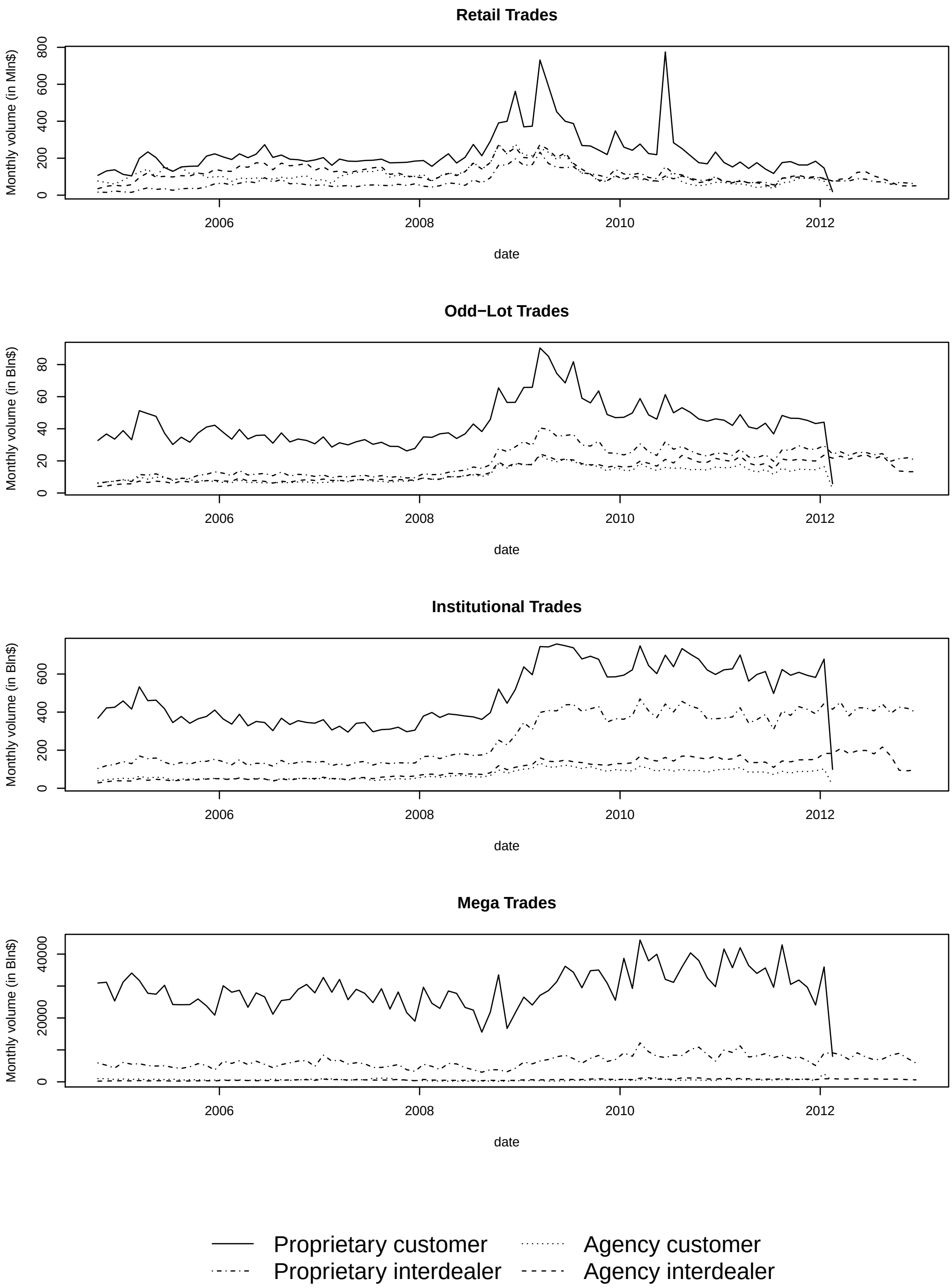

Figure 4: Predicted bid and ask spreads for agency trades.
Predicted ask spreads are computed with the estimates of column (1) of table 3, predicted bid spreads are computed with the estimates of column (1) of table 5.

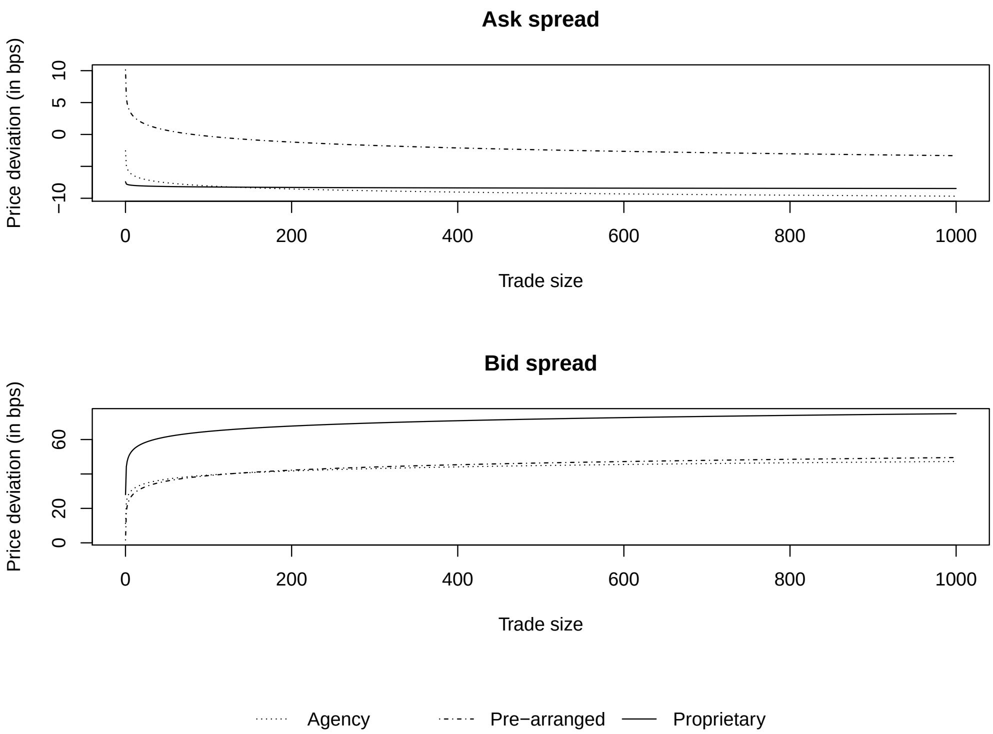

Figure 5: Predicted bid and ask spreads for proprietary trades.
Predicted ask spreads are computed with the estimates of column (1) of table 4, predicted bid spreads are computed with the estimates of column (1) of table 6. Trade size expressed in thousands of securities.

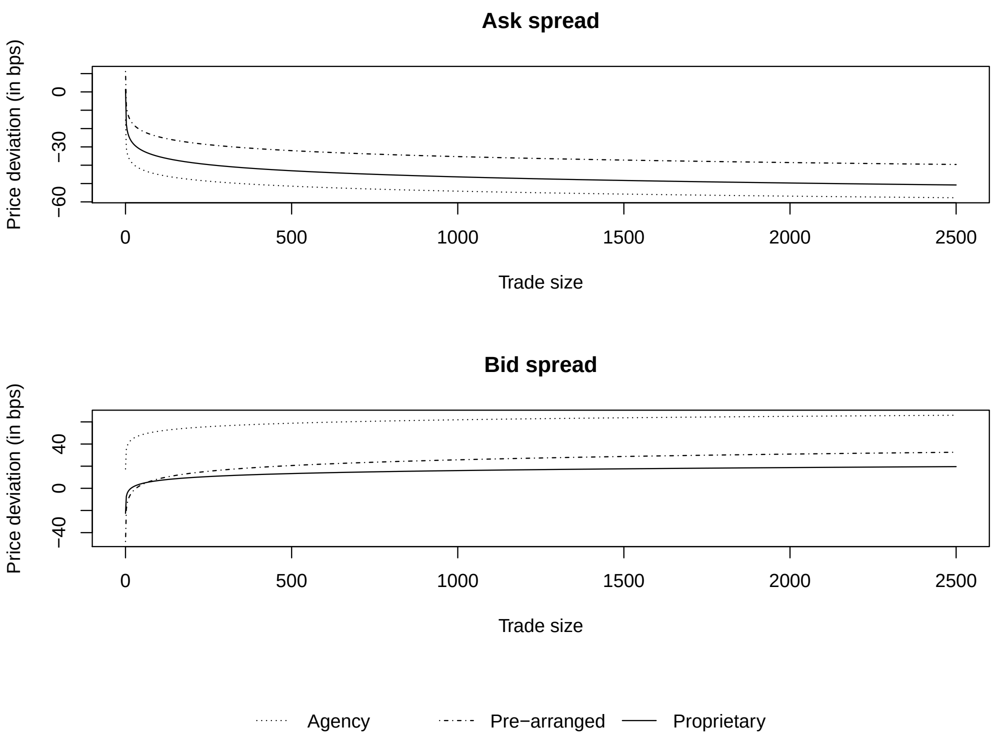

Figure 6: Predicted bid and ask spreads for agency trades after September 15th, 2008. Predicted ask spreads are computed with the estimates of column (1) of table 7, predicted bid spreads are computed with the estimates of column (1) of table 9.

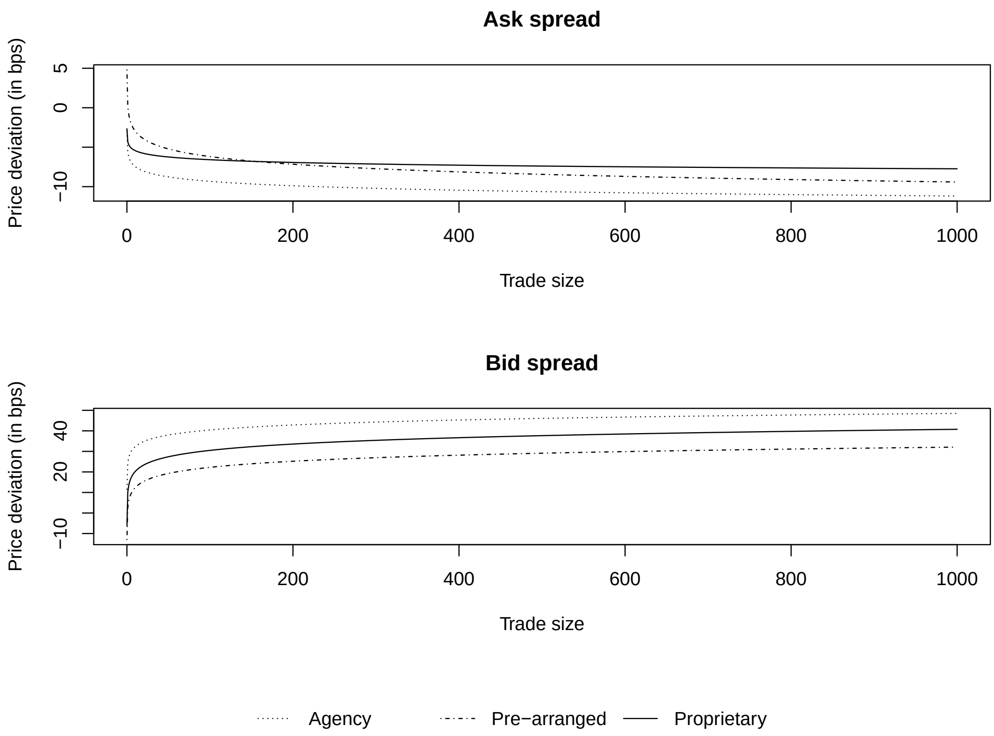

Figure 7: Predicted bid and ask spreads for proprietary trades after September 15th, 2008. Predicted ask spreads are computed with the estimates of column (1) of table 8, predicted bid spreads are computed with the estimates of column (1) of table 10. Trade size expressed in thousands of securities.