Paired Bond Trades

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Using a newly introduced TRACE variable that identifies the side(s) taken by dealers in each trade, I find that 37 percent of dealer-client trades are accompanied by an inter-dealer trade, usually for the exact same quantity and often executed at the exact second as the client trade. All but 0.4 percent of these trade pairs would involve a non-negative profit for a dealer who was involved in both trades. Pairing is much more common for small trades -- 46 percent of trades under $100,000 are paired, but only 4.5 percent of trades of $500,000 and above. Controlling for trade size, pairing is less common for trades by institutional clients. Paired trades involve higher trading costs, which are split roughly 50-50 between the pairing dealer and the dealer ultimately taking the other side. Taken together, the evidence suggests that pairing is a symptom of clients being unable to search over the entire market, producing nearly risk-free trading profits for dealers with client relationships or contractual rights to handle order flow.

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In equity markets, larger trades incur larger trading costs. This is necessarily true for market orders in any continuous double auction, since larger orders will progress further into the limit order book, and a large literature confirms that it is also true for equity trading more generally (see the next section for an review).

The opposite is true of bond trades. During 2003-5, Edwards, Harris, and Piwowar (2007) find mean one-way spreads of 46-75 basis points for small trades (hereafter, less than $100,000 in par value) and only 4-14 basis points for large trades ($500,000 or more in par value). In the time period I examine, November 2008 to April 2010, trading costs are about twice as high. Using a similar method I calculate mean one-way trading costs of 126 basis points for small trades and 29 basis points for large trades.[2]

Why are trading costs so much higher for small bond trades? Two leading explanations emphasize different consequences of the fact that bonds trade almost exclusively in dealer markets, rather than on an exchange.[3] The first explanation emphasizes dealer costs. Trading in a dealer market is more labor intensive than trading on exchanges, and dealer costs likely have a fixed component per trade, whose recovery requires a higher percentage spread for smaller trades (see, e.g., Copeland and Stoll, 1990). The second explanation emphasizes transparency. Dealer markets are less transparent than exchanges, which can differentially disadvantage small-trade clients if they face higher costs of comparison shopping across dealers.

This paper contributes to our understanding of bond trading costs by finding that small corporate bond trades are routinely "paired" -- that is dealer-client trades are commonly accompanied by interdealer trades within 60 seconds, and these pairs of trades are usually for exactly the same quantity and/or are executed during the exact same second. Identifying paired trades using the publicly available version of the Trade Reporting and Compliance Engine (TRACE) corporate bond transaction

[2] Other work on corporate bond trading includes Hong and Warga (2000), Schultz (2001), Chakravarty and Sarkar (2003), and Bessembinder, Maxwell, and Venkataraman (2006), who use the National Association of Insurance Commissioners (NAIC) data on bond transactions by insurance companies and also find higher trading costs for small trades. See Section 2 for a review of this work.

[3] About 300-400 U.S. corporate bonds are listed on the New York Stock Exchange's bond market (Edwards, Harris, and Piwowar, 2007). Trading is very light, however. In 2007, trading activity across all bond types totaled 3,465 trades totaling $90 million in par value, compared with 4.57 million corporate bond trades reported on TRACE totaling at least $1.3 trillion in par value (see http://www.nyxdata.com/Data-Products/Facts-and-Figures, last accessed July 15, 2010).

dataset is now possible due to the addition of a "reporting party side" variable that identifies whether a trade involved a dealer buying from a client, selling to a client, or trading with another dealer.

Using a very conservative definition of pairing, I find that forty-six percent of small client bond trades are paired, but only 4.5 percent of large bond trades are paired. The prices of paired trades imply non-negative profits for the hypothetical pairing dealer in all but 0.4 percent of cases, suggesting that pairing is almost risk-free for the pairing dealer. Furthermore, it is consistent with pairs of trades being arranged in advance, for example if a client approached a dealer requesting to trade a given bond and the dealer delayed trading with the client until it identified another dealer willing to take the other side.

Paired client trades involve larger spreads than unpaired client trades of the same size. The total spread on a paired client trade is split between the pairing and ultimate dealer. For small paired trades the average total one-way spread is 134 basis points, of which 58 basis points is earned by the pairing dealer and 76 basis points is earned by the ultimate dealer (assuming that the ultimate dealer closes her position at the next unpaired inter-dealer trade price). Despite earning just less than half of the total profit, the pairing dealer is arguably the more attractive of the two roles -- whereas the pairing dealer loses money on 0.4 percent of trades, ultimate dealer profit is negative on 27 percent of trades. Furthermore, while the pairing dealer (by definition) holds positions for less than 60 seconds, the ultimate dealer waits an average of 4 calendar days for the next unpaired inter-dealer trade. The relative attractiveness of the pairing dealer role suggests that there is likely a barrier to entering that role for a given trade.

In addition to being much less common for large trades, I also find that pairing is less common for institutional trades of a given size, as identified by matching trades in the National Association of Insurance Companies (NAIC) and TRACE data. Small TRACE trades that are also found in the NAIC data are paired 19 percent of the time, compared with 46 percent of all other small trades. NAIC clients also pay lower trading costs, even when controlling for a trade's size, direction, and pairing status.

Taken together, these results suggest that clients are heterogeneous in their search costs, and that clients that are less able to search are more likely to both place trades with a pairing dealer and pay higher trading costs. The higher trading costs may be partly due to pairing, and partly also a direct result of the higher search costs that also lead to pairing.

Heterogeneity in search costs is likely partly due to contractual arrangements. Clients of retail brokerages are usually locked-in to using a specific dealer or group of dealers as part of their brokerage agreement. These arrangements are typically disclosed on brokerage commission schedules which note that, in addition to any explicit commission or concession, that "the offering broker, which may be our affiliate, may separately mark up or mark down the price of the security and may realize a trading profit or loss on the transaction." [4] These arrangements give an exclusive right to handle a trade to a broker-affiliated dealer or to a group of dealers selected by the broker. Institutional clients can typically interact directly with dealers, and can thus create more competition to handle their trade.[5]

The remainder of the paper is organized as follows. The next section reviews a couple strands of related literature. The third section describes the data and provides some basic facts on the pairing of trades. A fourth section analyzes the incidence and co-variates of pairing. A fifth section analyses trading costs for paired and unpaired trades. A conclusions follows.

II. Related literature

This paper is related to two recent literatures in financial economics, one on market transparency and trading costs and another on the nature and riskiness of proprietary trading.

It is fairly well established that trading costs increase with trade size in equity markets. Lin, Sanger, and Booth (1995) examine this issue directly, decomposing the bid-ask spread for large and small equity trades using methods developed by Huang and Stoll (1997) and Stoll (1989). Consistent with their expectations and with microstructure models such as Kyle (1985) or Easley and O'Hara (1987), they find that the "order processing" component of the spread decreases with trade size, but that the adverse selection component increases with trade size. The latter effect dominates, leading the overall bid-ask spread to increase with size. Many subsequent studies of equity trading costs (e.g., Chan and Lakonishok, 1997) include trade size as a control variable and these studies tend to confirm this result. Stoll (2003, Section 5) reviews the empirical literature on equity trading costs.

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[4] This exact language is from Fidelity's website; essentially identical language can be found on the commission schedules of other major retail brokers. If the pricing of retail brokerage services involves cross-subsidies, affiliated bond dealer trading profits may be used to lower the cost of other services consumed by the same clients, so the implications for consumer welfare of these arrangements need not be negative.

[5] See, for example, Gonze, Josh, "The Institutional Advantage When Buying and Selling Bonds," 2/25/2010 (available at http://www.advisorperspectives.com/commentaries/thornburg_022510.php) or Interactive Brokers' Institutional website, which describes the dealers or groups of dealers available to institutional clients.

Studies of bond trading costs have found the opposite result -- larger trading costs for smaller trades. Hong and Warga (2000), Schultz (2001), and Chakravarty and Sarkar (2003) study the NAIC sample of insurance company corporate bond trades find higher trading costs for smaller trades. Harris and Piwowar (2006) and Chakravarty and Sarkar (2003) also find that trading costs decline with size for municipal and Treasury bonds. Schultz (2001) finds that, controlling for order size, trading costs are highest for relatively inactive institutions who trade with small dealers. He hypothesizes that inactive institutions may face higher search costs (p. 697-8), and that large dealers may have cost advantages due to scale economies.

One might expect even the small-trade clients in the NAIC sample to be more sophisticated than the typical retail client, and thus the size-cost relationship to be even stronger in a full sample of bond trades. Edwards, Harris, and Piwowar (2007) examine the sample of corporate bond transactions prices disseminated via TRACE and find higher average trading costs than the studies that used NAIC data. Edwards, Harris, and Piwowar also compare trading costs before and after TRACE began providing historical transaction prices in real time to market participants. Like Goldstein, Hotchkiss, and Sirri (2007) and Bessembinder, Maxwell, and Subramanian (2006), they find that TRACE dissemination was accompanied by lower trading costs, suggesting that a lack of price transparency may contribute to high transaction costs. Bessembinder and Maxwell (2008) provide a discussion of the TRACE expansion studies.

The evidence in this paper about trade pairing and the associated revenue is also relevant for the academic literature and policy discussion of proprietary trading. Proprietary trading accounts for a substantial component of the economic activity of large financial institutions. In the most recent Economic Census, which covers 2007, establishments in the Depository Credit (NAICS 5221), Securities Brokerage (NAIC 5231), and Investments (NAICS 5239) industries reported $70 billion in proprietary trading profits and another $204 billion in revenue from brokering and dealing securities. This $274 billion total represented 20% of total revenue, at least 40% of these industries' Gross Domestic Product (GDP), and 1.9% of U.S. GDP. Of the $274 billion in trading profits and broker-dealer revenue, debt instruments accounted for $88 billion, or approximately one third.

Large financial institutions' proprietary trading has been critiqued by policy makers as either nearly-riskless profiting at client expense or as placing large bets, with shareholders (or taxpayers) bearing the downside risk. These critiques are not necessarily mutually inconsistent, as they may apply to different components of proprietary trading. Existing analyses of proprietary trading (e.g., Hau, 2001;

Garvey and Murphy, 2005; Barber, et. al. 2008) have taken advantage of unique datasets to analyze a small subset of the activity, but little is known about the aggregate and in particular about debt instruments. How important quantitatively is the nearly risk-less profiting at client expense that worries policymakers?

For my 18 month time period, I find that aggregate dealer profits in corporate bond trades on TRACE are $5.6 billion, assuming that dealers liquidated their positions at the next-unpaired interdealer trade following each client trade.[6] Pairing dealer profits in paired trades accounted for $545 milllion, or about 10 percent of overall dealer profit. This suggests that most dealer proprietary trading profits in corporate bonds involves at least some risk for the dealers.

III. Data and Summary Statistics

The main dataset used in this study is the TRACE data on corporate bond transactions.[7] The analysis exploits a new direction of trade variable that was added to the publicly disseminated version of TRACE at the beginning of November 2008. This variable, called "reporting party side," is equal to B if a trade involves a dealer buying from a client, S if a trade involves a dealer selling to a client, and D for interdealer trades.[8]

As individual dealers are, unfortunately, still not identified in TRACE, I identify paired trades by finding client and interdealer trades that are of similar size and are very proximate in time. As a first step, I examine the trades in the same bond occurring at the same second. Just over 35 percent of trades in my sample (4.7 million out of 13.3 million) occur at the same exact second as at least one other trade in the same bond. The odds of this occurring randomly, even for the most actively traded issues,

[6] TRACE truncates trade quantities at $5,000,000 and $1,000,000 in par value for investment grade and high-yield bonds, respectively. Thus dealer profit figures include only the trading profit on the first $5 million or $1 million of these truncated trades.

[7] I eliminate outliers from the TRACE data following rules similar to those used by other authors. Specifically, I drop trades flagged by TRACE as when-issued, cancelled or subsequently corrected, as having special prices or sales conditions, or as including commission. I also drop trades that are reported more than two days after execution, those with par-value quantities that are not even $1,000s, those with prices above $200 or below $10, and those with a price change of more than $20 that is reversed in the next trade. Taken together, these restrictions eliminate less than 1 percent of the sample.

[8] Edwards, Harris, and Piwowar (2007) appear to have also had access to this variable in the version of TRACE they worked with (p. 1426), but do not discuss the pairing phenomenon. The NAIC data has a direction of trade variable, but no interdealer trades, so pairing cannot be observed in this data.

are infinitesimal.[9] Furthermore, almost as many trades (4.1 million or 31%) occur at the same second as another trade of exactly the same quantity.

Table 1 summarizes the most common groupings of trades of the same quantity and time but potentially different directions. Trades are ordered in ascending order of price (or in the order B, D, S if prices are equal). Most CUSIP*second*quantity (CSQ) combinations with two trades are either BD or DS, meaning that these seconds included both a dealer-client and an interdealer trade, and that the trades implied a non-negative profit for a hypothetical dealer who participated in both. Trade pairs that would have involved a loss for the hypothetical pairing dealer (i.e. DB or SD), are over 800 times rarer than pairs implying a positive pairing dealer profit. Trade pairs that could involve the same dealer directly matching a purchasing and selling client (BS or SB) are also much rarer.

For CSQ combinations with three trades, DDS and BDD are the most common groupings. These groupings could be due to there being two pairing dealers between client and ultimate dealer. The groupings BBD and DSS suggest that two client trades are matched with one pairing trade, although the two clients trades may be either one trade that is double-reported. The groupings SSS and BBB (and SSSS and BBBB) also may be due to single trades being broken up or multiply reported. Most of the instances of five or more trades also involve multiple client trades in the same direction.

Given that groupings with multiple trades in the same direction are relatively rare, I proceed by aggregating trades in the same CUSIP*second and direction, adding their quantities and calculating their (quantity-weighted) average price.[10] I then identify, for each client trade, the preceding or subsequent interdealer trade that is closest in time, breaking ties in favor of the trade closest in quantity. Table 2 categorizes dealer-client trades by the time and quantity difference with the matched dealer trade. About 15 percent of client trades have a matching interdealer trade with the same exact execution time and quantity. Another 20 percent occur within one minute of an interdealer trade with the same quantity.

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[9] The most actively traded bond in my sample traded just over 50,000 times, or 133 times per trading day. Bond trades are distributed reasonably uniformly over an 8 hour trading day (96.5 percent of TRACE trades are executed between 9 AM and 5 PM; the most active hour, 3 to 4 PM, contains only 15.6 percent of trades, as compared with 12.1 percent if trade times between 9 AM and 5 PM were uniformly distributed), and there are 28,800 unique seconds in an 8-hour period. There is some tendency in TRACE to report round-minute execution times (18 percent of trades have such times), but there is no other such rounding tendency and there are still a sufficient number of unique round-minute times (480) in an 8-hour day that the degree of clustering we find is still very unlikely to be random.

[10] TRACE truncates trade sizes at $5,000,000 for investment grade bonds and at $1,000,000 for high-yield bonds. When adding quantities, I re-truncate at these levels to maintain comparability with other trades' data.

Table 2 also provides summary statistics on the dealer profit implied by a pair of trades, which I define as the log percentage difference in price (client price less interdealer price for client purchases, and the opposite sign for client sales). The share of trade pairs with negative dealer profit is low (11 percent for all trades), and especially low for trade pairs involving the same exact time or trades that occur within 60 seconds for the same exact quantity (only 0.4 percent). As Figure 1 illustrates, for pairs of trades with different quantities, there is a clear difference in the negative profit rate between trade at the same exact time and trades that are even one second apart. In contrast, for trade pairs with the exact same quantity, the strongest evidence of a discontinuity is at sixty seconds of time difference.

For the purposes of the rest of the analysis, I define a paired trade to be a trade with either an interdealer trade at the same exact time or an interdealer trade of the same exact quantity within sixty seconds. These pairs are identified in Table 2 with boldface and shading. There are likely pairs of trades that do not meet these criteria that nonetheless involve riskless intermediation between a client and an ultimate dealer, but the low populations of the cells near the shaded range in suggest that even a significant expansion of these criteria would not add significantly to the 2.5 million paired trades under the existing definition.

Table 2, Panels C and D, report that both the mean and standard deviation of implied pairing dealer profit are smaller for the trades I consider to be paired, compared with other pairs of trades that are proximate in time. The ratio of the mean and standard deviation is about 0.87 for paired trades, implying that 19 percent of pairs would have negative implied profit if implied profit were normally distributed -- clearly negative implied profits are much rarer for paired trades than under this distributional assumption.

Figures 2A-2C plot the distribution of implied profit (as percent of par value) for the trades I consider to be paired, for other trade matches where the client and interdealer trade are within 15 minutes of each other, and for all other trade matches. The paired trades are much less likely to have negative implied profit, are more likely to have exactly zero implied profit, and are also more likely to have a round implied profit (as a percentage of par value). Implied profits of 0, 0.1, 1.0, 0.5, and 1.5 percent of par value are the most common -- together these values account for 48 percent of paired trades.

Trade pairs with zero implied profit could come from two sources. They could involve cases where the pairing dealer "worked for free" by matching their client with another dealer without charging a markup, presumably in exchange for compensation elsewhere in a business relationship. They may also involve cases where the dealer has a policy of reporting a pre-markup price to TRACE (interviews with bond dealers suggested that this was not uncommon). In either case, true trading costs may be understated when calculated using the prices reported to TRACE. I return to this issue when discussing trading costs in Section V.

IV. Which trades are paired?

Table 3 reports the pairing rate for trades by size and direction. Pairing rates are much higher for small client trades than for large trades, with the sharpest drop in the pairing rate occurring between trade sizes of $100,000 and $500,000 in par value. This discontinuity motivates the distinction between "small" (under $100,000) and "large" trades ($500,000 and larger) trades that is made when summarizing the results. Forty-three percent of small client trades are paired but only 4.5 percent of large trades are paired; the pairing rate is 23 percent for intermediately-sized trades.

Client purchases are both more common and are more likely to be paired than client sales. This likely at least partly reflects the fact that dealers who are not holding a bond in inventory must locate a source before selling a bond to a client, but it is less necessary to find a dealer who ultimately wants to buy a bond before buying from a client.

Table 3 also reports the pairing rate for interdealer trades. About 60 percent of small interdealer trades are paired with a client trade, whereas this is the case for only 10 percent of large interdealer trades. This is suggests that client trading is the primary motivation for small interdealer trades, and therefore using all interdealer trades as indicative of the "middle of the market" would seem problematic, since many of these trades appear to be buyer or seller-initiated. For instance, the trade-to-trade autocorrelation of interdealer transaction prices is -0.24 when all interdealer trades are included; this drops to -0.20 when paired interdealer trades are excluded. Both of these figures imply a fair amount of so-called bid-ask bounce. Negative autocorrelation drops to -0.034, however, when the sample is restricted to unpaired interdealer trades of $100,000 or more, suggesting that these trades are a better indication of the middle of the market. Understanding pairing thus appears helpful to deriving estimates of assets value from their trading history.

Next I ask whether the incidence of pairing differs with the nature of the client involved in the trade. No information about the type of client is provided in the TRACE data, but I can identify trades that were likely to involve insurance company clients by looking for trades that appear in both the TRACE and NAIC data. There are 286,440 transactions in the NAIC data for the November 2008 to December 2009 time period for which the TRACE direction of trade variable and NAIC data were both available. Of these transactions, 54,005 are of a type unlikely to appear in TRACE (e.g., bonds that mature or are called, tendered, or traded directly with the issuer), 73,649 are for CUSIP numbers that never appear in TRACE during our sample period, and a further, 41,393 are for CUSIP*day combinations with no TRACE trades. This last category may reflect inconsistent dating of transactions in TRACE and the NAIC date, but I do not attempt to correct dates. Of the remaining 69,807 NAIC trades, I am able to find matches for 32,288 in TRACE using fairly strict criteria: the CUSIP, trade date, quantity, and direction must be identical, and the price must be within $0.01 (to allow for the rounding off of prices in the NAIC data).[11]

Table 4 reports pairing rates for NAIC-matched and all other TRACE client trades, disaggregated by size and direction. Unsurprisingly, NAIC-matched are larger on average; 75 percent of NAIC-matched trades are $500,000 or larger, compared with 15 percent of all TRACE client trades. Even controlling for trade size, NAIC-matched trades have significantly lower rates of pairing, especially for small trades and for client sells. Purchases by NAIC clients for less than $500,000 in par value are still paired with fairly high frequency (about 26 percent of the time), however.

The NAIC data, unlike the TRACE data, identify dealers and for this subsample of client trades I can observe heterogeneity in pairing across dealers. In particular, two broker-dealers (UBS/Paine Webber and Merrill Lynch) paired about half of their NAIC client trades, compared with a pairing rate of 4.7 percent for the rest of the sample.[12] Table 5 reports the pairing rates for NAIC-matched trades for major dealers. The higher pairing rates for UBS and Merrill Lynch could simply be due to the structure of entities that handle their trades. Below we find that trading costs are higher for paired NAIC trades

[11] Given that the non-NAIC-matched TRACE trades will also include many trades by non-NAIC institutional clients, I am more concerned with avoiding false matches than I am with missing some potential matches, yielding a set of institutional-client trades that can be compared with the remainder of the sample.

[12] Many observations in the NAIC data report dealers by old, pre-acquisition names. For all mergers that closed before the beginning of our sample, Table 5 aggregates trades by the name of the successor firm. Bank of America and Merrill Lynch are reported separately, in part because of the difference in their pairing rate. The share of NAIC trades reported as being handled by Merrill Lynch does not decline significantly over the course of the sample period, which suggests that many insurance companies continued report based on the pre-2009 employer of the dealer they traded with.

(controlling for trade size, direction, pairing, and other trade and bond characteristics), however, suggesting that there some is economic content to the differences in pairing rates.

Table 6 presents linear probability regressions predicting whether a given client trade is paired with a interdealer trade.[13] The first two specifications are consistent with the pairing rates reported in Tables 3 and 4. As discussed above, pairing rates are higher for client purchases, are higher for transactions below $100,000 in par, and, controlling for direction and size, are lower for trades involving an NAIC client. In addition, the positive coefficient on the investment grade indicator variable reflects the higher pairing rates for investment grade bonds than for high yield bonds. Pairing rates are fairly constant within the investment-grade and high-yield categories, but there is a nearly 9 percentage point increase in the pairing rate between BB+ and BBB- (i.e., exactly at the investment-grade boundary).

The higher pairing rates for investment-grade bonds is part of a broader pattern that emerges from Table 6. Pairing rates are higher for more "vanilla" bonds across several measures (investment grade, senior, no credit enhancements, non-callable, short duration, non-convertible) and lower for bonds for which one might expect more uncertainty over their value. This result helps distinguish among different explanations for variation in pairing. Higher pairing rates for vanilla bonds could have the following explanation. If a potential pairing dealer feels constrained in the total spread they can charge a client (i.e., the pairing dealer spread and the difference between the ultimate dealer's price and the middle of the market), then bonds with smaller interdealer spreads will have more room for a pairing dealer to earn profits. A dealer without inventory (or willingness to hold the bonds a client wants to sell) may be willing to serve as a pairing dealer for bonds with low interdealer spreads, but may decline client trades involving bonds with high interdealer spreads, rather than marking these bonds up to the point of facing regulatory scrutiny.

In contrast, the evidence in Table 6 seems inconsistent with alternative explanations of variation in pairing. One might have expected pairing to arise from dealers aversion to adverse selection or inventory risk. Rather than trading with a client and then finding another dealer with whom to offset the position, a dealer with these concerns might delay the client trade until it can be paired. If this were the dominant explanation for variation in pairing rates, we would expect to see more pairing for low-quality or long-dated bonds, for bonds with option-like features such as convertibles, instead of the opposite.

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[13] Standard errors in these regressions are heteroskedasticity robust and allow for clustering in the error term within issuers (as indicated by first six digits of the CUSIP) and trading days.

Specification 4 adds variables that capture whether the client trade was priced using a round-number price. As can be seen from the summary statistics and from Figure 3, round-number prices are far more common than one would expect if prices were distributed uniformly, particularly given the fact that bond prices are reported to the nearest thousandth of a dollar on TRACE. Round-price client trades are significantly less likely to be paired. Round-price trades are also much more common for high-yield bonds (again with a discontinuity right at the boundary with investment grade), and so controlling for the lower pairing rate for round-number priced trades explains part of the lower pairing part for high-yield trades.

The fact that pairing rates are lower for client trades with round-number prices likewise helps distinguish among explanations for both pairing and round-number pricing. Round-number pricing is often viewed as a symptom of low client search effort (Harris, 1991; Li, 2007). Alternatively, and far more controversially, it has been viewed as a device for softening competition among dealers (Christie and Schultz, 1994 and 1995). By definition, pairing involves cases where clients trade with a dealer other than the one offering the best price, and thus involves cases where client search was likely incomplete, due either to low effort or contractual lock-in. If round-number pricing were due primarily to low client search effort, we should expect it to be positively associated with pairing.

The fact that round-number pricing is negatively associated with pairing suggests that round-number pricing is more common in competitive situations. This is more consistent with the competition-softening view of round-number pricing. It also suggests that pairing dealers generally know when trading that they will face limited competition from other dealers, and thus feel less need to soften competition using round number pricing.

V. Pairing and trading costs

This section examines the relationship between pairing and trading costs. Several different approaches have been taken to measuring trading costs in bond markets. The first approach, used by Hong and Warga (2000) and Chakravarty and Sarkar (2003), restricts the sample to bond days with at least one client buy and one client sell and calculates the difference between the average buy and average sell price on those days. An issue with this approach, noted by Edwards, Harris, and Piwowar (2007, p. 1424), is that this biases the sample towards bonds that trade more liquidly. An additional issue is that whether a bond trades in both directions on a given day may be endogenously related to factors that also affect prices (i.e., news, client demand and supply). About 75 percent of the client trades in our sample occur on days with a client trade in the other direction, suggesting that these selection biases could be important empirically.

A second approach, taken by Schultz (2001), is to compare transaction prices with a daily valuation benchmark, such as a dealer quotes or an evaluated price from a pricing service. The difference between the benchmark-adjusted price of client purchases and client sales yields a estimate of the two-way spread. Two potential issues with this approach are that valuation benchmarks may not be available for all bond*days and that benchmarks such as dealer quotes often have unattractive properties as indicators of market value, such as lagging the general bond market and positively auto-correlated changes (Zitzewitz, 2003).

A third approach, taken by Harris and Piwowar (2006), Edwards, Harris, and Piwowar (2007), and Bessembinder, Maxwell, and Venkataraman (2006), is to model transaction prices as deviations from a fundamental value that follows a random walk. Each (log) transaction price P_t is modeled as the sum of expected long-run value $E_t(V_T)$ and a distortion d_t that is a function of the trade's characteristics (e.g., size, direction, pairing). Returns from trade s to trade t are given by:

$$P_t - P_s = (d_t - d_s) + E_t(V_T) - E_s(V_T) \quad (3)$$

If we assume that d_t-d_s is uncorrelated with changes in a bond's expected long-run value, then d_t can be modeled as parametric function of trade characteristics and this equation can be estimated using standard regression techniques. I follow Edwards, Harris, and Piwowar (2007) in adding terms to control for movements in the general bond market between trade *t* and *s* and for excess accrued interest, calculated as the difference between the bond's coupon rate and the risk-free rate multiplied by the number of calendar days between trades *s* and *t* (for cases when they are on different days).

Given the size of the sample, for most analyses it will be convenient to identify a future trades for which d_t can be assumed to be zero. I can then calculate d_s as:

$$d_s = P_s - P_t - r_{st} \quad (2)$$

where r_{st} is the estimated change in the long-run value of the bond from trade s to trade t. In some of the analyses that follow, I will assume that d_t is zero for interdealer trades that are not paired with client trades. I will estimate r_{st} as the sum of the accrued interest less risk-free rate and the intervening total return on an appropriate bond market exchange-traded fund.[14] This direct calculation approach yields similar results to the regression approach, but is less data intensive.

Table 7 reports estimated transaction costs using equation (2) by trade size for paired and unpaired client sales and purchases, and for interdealer trades that are paired with client sales and purchases. Paired trades have larger trading costs than unpaired trades of the same size, especially for client sales. Interdealer trades that are paired with client trades also reflect significant trading costs. The average small paired client trade has trading costs of 134 basis points, of this, 58 is earned as a nearly risk-free profit by the pairing dealer and 76 is earned by the ultimate dealer. The pairing dealer share of trading costs is higher for client purchases than for client sales. Pairing dealer profits are highest for trading sizes between $10,000 and $50,000 and are smaller for both larger trades and for very small trades.

For further tests, it will be useful to parameterize the relationship between trade size and trading costs so as to limit the number of parameters that must be estimated and interacted with variables such as pairing and client type. Figure 4 plots the relationship between trading costs and log trade size using the data reported in Table 6. From this graph, it appears that the relationship is roughly linear with a kink around $50,000. One possible explanation for the kink and the declining pairing dealer spreads for very small trade sizes (as well as the almost complete absence of markups above 2 percent for immediately paired trades in Figure 2A) is that dealers may face regulatory pressure to avoid excessive markups.[15]

[14] I use the iShares Investment Grade Corporate ETF (ticker: LQD) for bonds rated BBB- or above and the SPDR Barclays High Yield Bond ETF (ticker: JNK) for bonds rated BB+ or below. I estimate ETF returns between bond trades using the most recent transactions reported in the NYSE Trades and Quotes (TAQ) data as of the time of the trade, adjusting for distributions as reported in the CRSP Daily Stock file. During time period under study, the correlation of corporate and Treasury bond returns was unstable, and so the bond market ETFs are much better controls for bond market movements.

[15] The National Association of Securities Dealers (NASD) Rule 2440 requires it's members to charge its clients "fair prices and commissions." In 1943, the NASD adopted the "5% policy" as a guideline for what constitutes an excessive markup or commission. The NASD and Security and Exchange Commission (SEC) subsequently warned dealers that even markups below 5% can be deemed excessive (IM-2440-1). For example, one broker was charged in 2010 for markups that averaged 3.68% and markdowns that averaged 1.92% on Fannie Mae and Ginnie Mae securities (SEC Administrative Proceeding File No. 3-13869). In practice, one defense against an excessive markup charge allowed for in IM-2440-2 is to argue that the contemporaneous value of a bond was different than the acquisition cost due to changes in the bond's value. Obviously, there is less scope to make this argument when a client and interdealer trade take place at the same time, which may explain the apparent upper bound on markups for these trades.

In the regressions reported in Table 8, I parameterized the size-trading cost relationship using three variables, allowing for a piece-wise log-linear functional form with a kink at $50,000. For transparency, I use the following piecewise specification:

$$a + b*\mathrm{Ln}(\mathrm{Size}/\$50{,}000)^{+} + c*\mathrm{Ln}(\mathrm{Size}/\$50{,}000)^{-}.$$

The parameter a captures the trading cost for a size of $50,000, which is roughly the geometric mid-point of the range of trade sizes reported by TRACE. The parameter b captures the slope of the relationship above $50,000, and c captures the slope below $50,000.[16]

These three parameters are interacted with three parameters capturing the type of trade: the direction of trade (+1 for client purchases and associated paired interdealer trades, -1 for client sales and associated paired interdealer trades), direction interacted with an indicator for dealer-client trades (as opposed to a paired interdealer trades), and direction interacted with a negative indicator variable for unpaired dealer-client trades. The three type of trade variables are thus structured so that the coefficient on the first will capture the average spread on paired interdealer trades, the second will capture the average pairing dealer spread on paired trades, and the third will capture the "unpaired discount", or the price difference between paired and unpaired client trades.[17] The three variables are abbreviated ID (interdealer), PD (pairing dealer), and UPD (unpaired discount), respectively.

In addition to being interacted with the trade size variables, the trade type variables are also interacted with various bond characteristics (S&P rating, years to maturity, and indicator variables for being investment grade, convertible, junior, callable, and having credit enhancements). The uninteracted trade size and bond categories are also included in the regression, as well as controls for intervening bond market returns and accrued interest.[18]

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[16] There is also evidence of a kink in the opposite direction around a trade size of $1,000,000, but given how rare paired trades (the focus of the analysis) are above this size, I choose to simply drop trades above $1,000,000 from the cross-sectional analysis of trading costs. Likewise, given the small number of NAIC-matched trades and the fact that very few are paired, NAIC-matched trades are dropped from the analysis in Table 8, although they will be explicitly analyzed in Table 10.

[17] Relative to using five indicator variables for the six trade types (omitting one category), this approach imposes that pairing dealer markups and price differences between paired and unpaired client trades must be the same for purchase and sales. This assumption is rejected by the data, as is clear from the means in Table 7, but is made for parsimony, as relaxing it introduces many additional variables to Table 8 that do not yield meaningful additional insight.

[18] The bond market return variables are also interacted with the continuous S&P rating variable and with an indicator variable for being investment grade (i.e., rated BBB- or higher). This allows bonds of different credit qualities to correlate differently with these two indices.

The coefficients on the interaction of the constant and ID, PD, and UPD yield estimates of the average trading costs (in percent) for a trade of $50,000. The coefficients in model one suggest that paired trades of this size yield 56 basis points in spread for the ultimate dealer and 70 basis points for the pairing dealer. Clients in unpaired trades receive pricing that is 15 basis points better than those in paired trades. The negative coefficients on the interactions of the quantity variables with ID imply that interdealer spreads decline about 1.1 basis points for a 10 log percentage point increase in trade size, both above and below the $50,000 kink. The different signs on the interactions with PD, however, imply that pairing dealer spreads peak around $50,000 (as is also observed in Table 7) and are smaller for both larger and smaller trades.

Models 2, 3, and 4 add bond characteristics that capture credit quality, time to maturity, and the features that were most associated with low pairing rates in Table 6. As one might expect, characteristics that reflect uncertainty about a bond's value (not being investment grade, being junior or unsecured, being callable or convertible, having credit enhancements) are generally associated with higher interdealer trading costs, as evidenced by the signs on the interactions with ID. Pairing dealer spreads are lower for these bonds, as evidence by opposite signed interaction coefficients for PD. Again, this suggests that pairing dealers may face constraints on the total spread they can charge, and thus have less room for high spreads for bonds with higher interdealer spreads. This is consistent with these bonds having lower pairing rates, as reported above, due to the pairing dealer role being less attractive.

Models 3 and 4 also include interactions with years to maturity. The coefficients on ID, PD, and UPD are all positive, suggesting that interdealer trading costs, pairing dealer markups, and paired-unpaired trading cost differences are all increasing in time to maturity. This is as expected, since there is more "room" for high trading costs for longer duration bonds, since a given trading costs implies a smaller impact on yield to maturity.

The UPD coefficients captures the differences in client trading costs in paired vs. unpaired trades. If we assume that a paired trade is a symptom of a client being unwilling (or unable) to search across all dealers, then we can view this difference as the percentage difference in trading costs achieved by clients who search and those who do not. This difference increases in trade size and is larger for lower credit quality, convertible, and longer dated bonds. It seems reasonable to expect that the return to comparison shopping might be larger for larger trades and for bonds whose value is less certain.

As mentioned above, implied pairing dealer profit is zero for about 25 percent of paired trades, and one might be concerned that the dealer is not truly working for free in all those instances. One particular concern is that dealers might be unwilling to report prices in TRACE that imply high markups, particularly given the fact that TRACE is used by regulators in enforcing rules against excessive markups.[19] If dealers report zero markups as a substitute for very high markups, then this could distort the signs of the correlation between trade and bond characteristics and pairing dealer profits discussed above. In particular, one might be concerned that reporting high markups as zeros might explain the arguably surprising results that pairing dealer markups are lower for bonds and trade characteristics associated with high interdealer trading costs.

In Table 9, I examine this issue further by disaggregating pairing dealer implied profits into the probability of zero profit and average implied profit conditional on it being positive. Since I am only analyzing pairing dealer implied profit in this table, I can simply measure it directly for each trade pair as in Table 2. Comparing the coefficients in columns 1 and 3 reveals that for most trade and bond characteristics, coefficients remain consistently signed when the zero-implied-profit observations are removed from the sample. The exceptions are the coefficients for convertibility and callability. Both of these features are positively associated with reporting zero implied profit, but are also positively associated with high conditional implied profits. This suggests that the conclusion that these two characteristics are associated with lower profits for pairing dealers should be treated with caution until the extent of this reporting problem is better understood. At the same time, most of the results discussed above appear robust to this attempts to control for the issue.

The final issue I analyze is how transaction costs vary for trades involving NAIC clients and round-number pricing. Table 10 replicates models 1 and 4 from Table 8, adding indicator variables for NAIC clients and for trades with even-quarter-dollar prices. The results suggest that NAIC clients pay lower transaction costs, especially in the few paired trades in which they are involved (recall that the pairing rate is only 6.8 percent for NAIC clients). Institutional clients thus achieve lower transaction costs (controlling for trade size, direction, and characteristics) by avoiding pairing and by achieving lower

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[19] Regulators also bring enforcement actions against dealers for delayed or inaccurate reporting to TRACE. See, for example, FINRA's expulsion of DebtTraders for a combination of excessive markups and failure to correctly report trades (http://www.finra.org/Newsroom/NewsReleases/2005/p015345). Three firms other than DebtTraders were accused of charging similarly excessive markups on a comparable number of trades, but were not accused of inaccurate reporting and were fined rather than expelled. Penalties of this nature should discourage inaccurate reporting, but it is not clear to what extent without knowledge of detection probabilities.

costs conditional on pairing status. This is consistent with these clients having either lower costs or a greater ability to search across dealers.

Trading costs are significantly higher for even-quarter-dollar trades, consistent with the findings of Li (2007) for municipal bonds. This difference is larger for unpaired trades, although most of this difference is eliminated by controlling for bond characteristics (credit quality is the control that changes the coefficient most when added). As discussed above (Figure 3 and Table 6), round-number pricing is more common for unpaired trades, which could indicate that it is used by dealers as a device for softening competition.

VI. Conclusion

Why are trading costs so high for small bond trades? The evidence presented in this paper on the pairing of small trades suggests that an inability of some clients to search over the entire market is part of the explanation. Large trades and trades with institutional (NAIC) clients are much less likely to be paired, suggesting that these clients were able to find a dealer who wanted to take the other side of the trade. Smaller trades, in contrast, were both more likely to be paired and had higher trading costs, suggesting that these clients were less willing, or able, to search.

The negative correlation of pairing and round-number pricing potentially sheds light on the question of willing or able. I argue above that this correlation is most consistent with round-number pricing being used by dealers to soften competition and with pairing dealers expecting to face less competition when making offers to clients. Retail brokerage customers typically argue to trade bonds via an affiliated broker or group of brokers as part of their brokerage agreement, so these clients may partly explain the association of less competition for orders, more pairing, and higher trading costs.

Perhaps the most surprising result in the paper is the lower pairing rates and implied pairing dealer markups for trades with higher interdealer trading costs (high-yield, junior, convertible, credit enhanced, and very small trades). The evidence is consistent with regulatory pressure forcing potential pairing dealers to either refuse quote requests or limit their markups. The latter would likely be considered an intended consequence of markup regulation, but the former might be considered an unintended consequence if it left investors unable to trade. Further regulatory pressure on markups may be unwise unless it is accompanied by changes that facilitate client search across dealers, since it may lead pairing dealers to refuse business without providing clients an alternative means of finding the other side of the market.

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Table 1. Counts of CUSIP*second*quantity (CSQ) combinations with given groupings of trades

This table reports counts of CUSIP*second*quantity combinations with a given grouping of trades involving a dealer purchase from a client (B), an interdealer trade (D), or a dealer sale to a client (S). Trades are ordered in ascending order of price, or alphabetically if prices are equal.

	Unique CSQs (000s)	% of total
One trade in CSQ	9,241	83.0%
S	3,916	35.2%
D	3,460	31.1%
B	1,866	16.8%
Two trades in CSQ	1,606	14.4%
BD	703	6.3%
DS	702	6.3%
DD	96	0.86%
SS	46	0.41%
BS	32	0.29%
BB	24	0.22%
DB	1.1	0.01%
SB	0.7	0.01%
SD	0.5	0.00%
Three trades in CSQ	259	2.3%
DDS	142	1.3%
BDD	83	0.75%
SSS	13	0.11%
BBB	7.0	0.06%
BDS	5.7	0.05%
DDD	5.6	0.05%
DSS	1.7	0.02%
BBD	0.7	0.01%
BSS	0.5	0.00%
BBS	0.4	0.00%
All other combinations	0.4	0.80%
Four trades in CSQ	14	0.13%
SSSS	3.6	0.03%
DDSS	2.6	0.02%
BBDD	1.9	0.02%
BBBB	1.5	0.01%
BDDD	1.4	0.01%
BDDS	0.6	0.01%
DDDS	0.4	0.00%
DSSS	0.3	0.00%
DDDD	0.3	0.00%
BBBD	0.3	0.00%
BBSS	0.2	0.00%
BDBD	0.2	0.00%
All other combinations	0.5	0.00%
Five or more	10.7	0.10%
Total	11,131	100.0%

Table 2. Matching client trades with the most coincident interdealer trade

After aggregating multiple trade with the same CUSIP, time, quantity, and direction of trade, each dealer-client trade is matched with its nearest proceeding or following inter-dealer trade. Ties are broken by matching client trades with the inter-dealer trade that is closest in log size. This table then reports statistics on the number of trades and price differences in these matched pairs of trades. Implied dealer profit is the log difference in trade price, signed to reflect the unit profit earned by a dealer who participated in both trades. In the analysis that follows, a dealer and a client trade will be consider to be a pair if they take place in the same second or if they take place within 60 seconds and are for the exact same quantity. These cells are indicated in the table with boldface text and yellow shading.

Panel A. Number of client trades (in thousands), by nearest prior or next interdealer trade

		Quantity difference		
Time difference	Same exact quantity	Same quantity range	Different range	Total
Same second	**1,001**	**27**	**154**	1,182
1-5 secs	**635**	10	55	700
6-60 secs	**694**	31	171	896
1-5 mins	283	55	354	692
5-15 mins	131	62	422	615
15-59 mins	92	80	580	752
Same day	66	69	503	637
1-7 days	76	97	714	887
8+ days	10	17	118	146
Total	2,988	448	3,071	6,507

Panel B. Percentage of trade matches implying negative dealer profit

		Quantity difference		
Time difference	Same exact quantity	Same quantity range	Different range	Total
Same second	**0.11**	**0.61**	**0.48**	0.17
1-5 secs	**0.23**	4.0	4.6	0.62
6-60 secs	**0.86**	9.2	11.4	3.2
1-5 mins	2.4	12.9	14.4	9.4
5-15 mins	4.9	15.4	16.7	14.1
15-59 mins	9.2	18.7	19.6	18.3
Same day	11.7	21.8	22.8	21.6
1-7 days	15.6	24.6	25.0	24.1
8+ days	29.2	33.3	35.4	34.7
Total	1.8	17.8	19.3	11.2

Panel C. Mean dealer profit implied by trade match (log price difference, in percent)

		Quantity difference		
Time difference	Same exact quantity	Same quantity range	Different range	Total
Same second	**0.52**	**0.57**	**0.59**	0.53
1-5 secs	**0.73**	0.77	0.77	0.73
6-60 secs	**0.58**	0.88	0.92	0.65
1-5 mins	0.68	0.94	0.97	0.85
5-15 mins	0.82	0.97	0.97	0.93
15-59 mins	0.97	0.95	0.96	0.96
Same day	1.08	0.99	0.96	0.97
1-7 days	1.38	1.06	1.03	1.07
8+ days	1.16	0.85	0.76	0.80
Total	0.7	0.9	0.9	0.8

Panel D. Standard deviation of dealer profit implied by trade match (log price difference, in percent)

		Quantity difference		
Time difference	Same exact quantity	Same quantity range	Different range	Total
Same second	**0.64**	**0.78**	**0.82**	0.67
1-5 secs	**0.67**	0.96	1.01	0.70
6-60 secs	**0.71**	1.18	1.29	0.84
1-5 mins	0.92	1.35	1.42	1.21
5-15 mins	1.15	1.50	1.53	1.45
15-59 mins	1.44	1.66	1.69	1.66
Same day	1.70	1.91	1.89	1.88
1-7 days	2.24	2.27	2.27	2.27
8+ days	3.19	3.22	3.30	3.28
Total	0.8	1.7	1.8	1.3

Table 3. Incidence of pairing, by trade size and direction

This table reports the number of trades by size and direction, along with the share of trades that are classified as paired. Both the share of clients trades that are paired with an interdealer trade and the share of interdealer trades that are paired with a client trade are reported. Approximately 0.8 percent of interdealer trades are paired with both a client buy and a client sell, so there are slightly fewer paired interdealer trades than paired client trades.

	Client sells		Client buys		All client trades		Interdealer trades	
Trade size (par value)	Number	Share paired	Number	Share paired	Number	Share paired	Number	Paired with client
$1-2k	57,305	0.372	59,036	0.444	116,341	0.409	81,136	0.530
$2-5k	161,144	0.369	157,265	0.536	318,409	0.452	252,517	0.553
$5-10k	232,827	0.308	466,818	0.472	699,645	0.417	467,726	0.585
$10-19k	369,815	0.303	989,356	0.551	1,359,171	0.483	999,953	0.624
$20-49k	405,441	0.284	1,002,546	0.557	1,407,987	0.478	1,124,762	0.604
$50-99k	186,220	0.243	389,700	0.467	575,920	0.395	456,247	0.524
$100-199k	137,756	0.184	260,883	0.329	398,639	0.279	292,883	0.398
$200-499k	116,497	0.115	184,447	0.182	300,944	0.156	195,644	0.257
$500-999k	81,360	0.074	108,160	0.080	189,520	0.077	109,440	0.135
$1-2M*	215,605	0.051	240,951	0.030	456,556	0.040	161,988	0.101
$2-5M	65,470	0.050	74,088	0.029	139,558	0.039	69,727	0.075
$5M+*	73,488	0.034	68,870	0.021	142,358	0.028	43,517	0.084
<$100k	1,412,752	0.301	3,064,721	0.527	4,477,473	0.456	3,382,341	0.591
$100-499k	254,253	0.152	445,330	0.268	699,583	0.226	488,527	0.341
>$500k	435,923	0.052	492,069	0.040	927,992	0.045	384,672	0.104
All trades	2,102,928	0.231	4,002,120	0.438	6,105,048	0.367	4,255,540	0.518

* TRACE truncates trade sizes at $5 million for investment grade bonds and $1 million for high-yield. The $1-2 million and $5 million+ categories include the high-yield and investment grade trades with truncated quantities, respectively.

Table 4. Incidence of pairing, for NAIC and all other trades

This table reports the incidence of pairing for client trades in TRACE for which a matching trade can be found in the NAIC sample of bond trades by insurance companies. Trades are considered matched if they have identical CUSIPs, trade dates, directions, and sizes and have prices within one cent (per $100 in par value).

	Client sells		Client buys		
Trade size (par value)	NAIC trades	All others	NAIC trades	All others	Total NAIC trades
$1-2k	None	0.372	None	0.453	0
$2-5k	0.000	0.371	0.000	0.539	48
$5-10k	0.095	0.310	0.043	0.468	44
$10-19k	0.111	0.303	0.133	0.545	120
$20-49k	0.097	0.285	0.281	0.549	518
$50-99k	0.078	0.245	0.338	0.461	823
$100-199k	0.062	0.188	0.300	0.321	2,474
$200-499k	0.049	0.117	0.216	0.177	3,994
$500-999k	0.051	0.077	0.076	0.079	3,355
$1-2M*	0.046	0.052	0.042	0.031	9,019
$2-5M	0.022	0.050	0.027	0.030	4,808
$5M+*	0.017	0.035	0.014	0.022	7,061
<$100k	0.084	0.302	0.281	0.522	1,553
$100-499k	0.054	0.156	0.251	0.261	6,468
>$500k	0.035	0.053	0.034	0.040	24,243

* TRACE truncates trade sizes at $5 million for investment grade bonds and $1 million for high-yield. The $1-2 million and $5 million+ categories include the high-yield and investment grade trades with truncated quantities, respectively.

Table 5. Pairing rates by dealer, NAIC trades

This table reports the share of client trades that are paired with interdealer trades, for those trades that can be matched with trades from the NAIC sample. The dealer names reported in the NAIC data are adjusted to reflect mergers that closed by the beginning of the sample (November 2008).

Dealer	Trades	Pairing rate
BANK OF AMERICA	2,153	0.009
MORGAN STANLEY	1,941	0.087
CITI	1,919	0.098
J.P. MORGAN	1,650	0.024
JEFFERIES	1,568	0.018
BARCLAYS	1,522	0.007
"VARIOUS"	1,469	0.037
CREDIT SUISSE	1,440	0.010
WACHOVIA	1,362	0.054
GOLDMAN	1,091	0.012
UBS	876	0.522
DEUTSCHE	824	0.005
FIRST TENNESSEE	816	0.018
STIFEL	746	0.021
RBC	733	0.018
MORGAN KEEGAN	664	0.027
MERRILL LYNCH	580	0.505
WELLS FARGO	492	0.116
KEYBANC	445	0.043
CANTOR FITZGERALD	415	0.046
Smaller dealers	9,582	0.071
Total	32,288	0.068
All except UBS and Merrill Lynch	30,832	0.047

Table 6. Linear probability models predicting whether a client trade is paired
Dependent variable: = 1 if trade is paired

This table presents linear probability regressions predicting whether a client trade is paired, as a function of bond and trade characteristics. Means and standard deviations (omitted for indicator variables for brevity) are also reported for all independent variables. The sample includes all client-dealer trades. Standard errors are heteroskedasticity-robust and adjust for clustering within issuers and trading days.

	(1)	(2)	(3)	(4)	(5)	(6)	Summary statistics Mean (SD)
Client buy?	0.170	0.165	0.165	0.154	0.151	0.142	0.644
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	
NAIC client?		-0.023	-0.022	-0.027	-0.041	-0.043	0.004
		(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	
S&P rating (scaled AAA = 23, C or lower = 0)		-0.003	-0.005	-0.007	-0.005	-0.002	16.2
		(0.002)	(0.002)	(0.002)	(0.001)	(0.003)	(4.4)
Investment-grade? (S&P rating BBB- or higher)		0.088	0.097	0.058	0.062	0.054	0.823
		(0.016)	(0.013)	(0.014)	(0.014)	(0.014)	
Security level = Junior, Junior Subordinated, or Unsecured?			-0.154	-0.113	0.104		0.008
			(0.015)	(0.015)	(0.026)		
Credit Enhancements?			-0.015	-0.009	-0.009		0.174
			(0.009)	(0.009)	(0.007)		
Callable?			-0.042	-0.044	-0.018		0.687
			(0.009)	(0.009)	(0.008)		
Indicator variables for round-price trades							
Even dollar				-0.012	-0.009	-0.009	0.108
				(0.002)	(0.002)	(0.002)	
Even $0.50				-0.006	-0.007	-0.011	0.177
				(0.003)	(0.002)	(0.002)	
Even $0.25				-0.093	-0.094	-0.104	0.253
				(0.009)	(0.008)	(0.006)	
Even $0.05				-0.057	-0.047	-0.038	0.355
				(0.012)	(0.010)	(0.008)	
First trading day?					-0.126	-0.217	0.001
					(0.031)	(0.052)	
First trading calendar month?					-0.012	-0.019	0.074
					(0.006)	(0.004)	
Log (Number of trades in prior month)					0.0017		5.27
					(0.0024)		(1.55)
Age in years					0.0070		4.04
					(0.0008)		(3.40)
Years to maturity					-0.0066		7.73
					(0.0005)		(8.04)
Trade outside 7 AM to 5 PM Mon-Fri?					-0.212	-0.187	0.009
					(0.005)	(0.006)	
Indicator variables for bond type (Corporate debenture omitted)							
Medium term notes					0.000		0.143
					(0.014)		
Retail notes					-0.024		0.093
					(0.018)		
Convertibles					-0.052		0.038
					(0.027)		
Other types					-0.067		0.020
					(0.014)		
Indicator variables for trade sizes (in par value, $5 million+ omitted)							
$1-2k	0.385	0.391	0.390	0.402	0.376	0.379	0.019
	(0.014)	(0.014)	(0.014)	(0.013)	(0.014)	(0.012)	
$2-5k	0.427	0.435	0.434	0.445	0.419	0.414	0.052
	(0.007)	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	
$5-10k	0.358	0.367	0.365	0.379	0.358	0.364	0.116
	(0.010)	(0.011)	(0.010)	(0.008)	(0.008)	(0.007)	
$10-19k	0.411	0.420	0.416	0.429	0.400	0.391	0.224
	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.005)	
$20-49k	0.409	0.417	0.413	0.423	0.390	0.375	0.231
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	
$50-99k	0.334	0.343	0.339	0.349	0.313	0.301	0.094
	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	
$100-199k	0.225	0.235	0.233	0.243	0.210	0.205	0.065
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	
$200-499k	0.108	0.120	0.120	0.130	0.103	0.100	0.049
	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	
$500-999k	0.037	0.052	0.054	0.066	0.048	0.043	0.031
	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	
$1-2M*	0.006	0.045	0.046	0.073	0.063	0.043	0.071
	(0.001)	(0.006)	(0.006)	(0.007)	(0.006)	(0.004)	
$2-5M	0.003	0.004	0.005	0.009	0.005	0.002	0.023
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	
CUSIP fixed effects						X	
Observations	7,199,208	7,199,208	7,199,208	7,199,208	7,199,208	7,199,208	
R-squared	0.1313	0.1337	0.1364	0.1533	0.1704	0.2202	

Table 7. One-way spreads for paired and unpaired trades

Spreads (in percent) are measured as the log difference between the trade price and the price from the next unpaired interdealer trade. Future prices are adjusted for intervening returns in the bond exchange-traded fund with ticker LQD (for bonds rated BBB- or higher) or JNK (for those rated BB+ or lower) and for accrued coupon interest when the trading day differs.

	Client sells		Interdealer trades		Client buys	
Trade size (par value)	Paired	Unpaired	Paired with sell	Paired with buy	Unpaired	Paired
$1-2k	-1.72	-1.11	-1.50	0.61	1.29	1.22
$2-5k	-1.32	-0.91	-1.16	0.57	1.20	0.96
$5-10k	-1.31	-0.87	-1.07	0.55	1.40	1.09
$10-19k	-1.31	-0.92	-0.96	0.60	1.47	1.29
$20-49k	-1.22	-0.84	-0.86	0.60	1.37	1.30
$50-99k	-1.04	-0.69	-0.71	0.53	1.12	1.17
$100-199k	-0.86	-0.49	-0.54	0.46	0.86	1.04
$200-499k	-0.65	-0.30	-0.39	0.38	0.65	0.82
$500-999k	-0.51	-0.19	-0.26	0.28	0.49	0.60
$1-2M*	-0.29	-0.03	-0.04	0.14	0.48	0.38
$2-5M	-0.26	-0.11	-0.14	0.09	0.32	0.23
$5M+*	-0.18	-0.16	-0.06	0.03	0.23	0.14
<$100k	-1.41	-0.97	-1.09	0.67	1.34	1.32
$100-499k	-0.81	-0.42	-0.52	0.45	0.77	0.98
>$500k	-0.35	-0.11	-0.13	0.19	0.44	0.44

* TRACE truncates trade sizes at $5 million for investment grade bonds and $1 million for high-yield. The $1-2 million and $5 million+ categories include the high-yield and investment grade trades with truncated quantities, respectively.

Table 8. Trading costs, sizes, and bond characteristics
Dependent variable: log price change to next unpaired interdealer trade (in percent)

Each set of three columns reports coefficients from a single regression, in which three trade type variables (ID, PD, and UPD) are interacted with variables capturing trade size and bond characteristics. The coefficient on ID captures the trading cost for paired interdealer trades, the coefficient on PD captures the implied pairing dealer profit on paired dealer-client and interdealer trades, and UPD captures the "unpaired discount", or the difference in trading costs between paired and unpaired client trades. Regressions include main effects, as well as controls for intervening accrued interest, intervening returns on investment-grade and high-yield bonds (as proxied by the log total returns on the LQD and JNK exchange-traded funds), and the interaction of these returns with bond's credit rating and investment grade indicator. The sample excludes unpaired interdealer trades, trades over $1,000,000 in par value, and trades placed by NAIC clients. Standard errors are heteroskedasticity robust and allow for clustering within issuer and trading date.

	Model 1			Model 2			Model 3			Model 4		
	Interactions with			Interactions with			Interactions with			Interactions with		
	ID	PD	UPD	ID	PD	UPD	ID	PD	UPD	ID	PD	UPD
Constant	0.555	0.702	0.149	1.830	0.844	1.068	1.754	0.692	0.990	1.970	0.743	1.028
	(0.024)	(0.011)	(0.027)	(0.109)	(0.032)	(0.180)	(0.109)	(0.024)	(0.178)	(0.117)	(0.023)	(0.185)
Ln(Quantity/$50,000), positive component	-0.101	-0.183	0.044	-0.141	-0.192	0.018	-0.138	-0.194	0.031	-0.123	-0.188	0.034
(Range = 0 to 3.0)	(0.011)	(0.005)	(0.015)	(0.012)	(0.005)	(0.022)	(0.012)	(0.005)	(0.022)	(0.012)	(0.005)	(0.021)
Ln(Quantity/$50,000), negative component	-0.124	0.076	0.072	-0.124	0.077	0.087	-0.127	0.084	0.051	-0.134	0.082	0.049
(Range = -3.9 to 0)	(0.007)	(0.004)	(0.011)	(0.007)	(0.004)	(0.012)	(0.007)	(0.004)	(0.012)	(0.007)	(0.004)	(0.012)
S&P rating (scaled AAA = 23, C or below = 0)				-0.054	-0.014	-0.037	-0.055	-0.015	-0.039	-0.063	-0.016	-0.043
				(0.005)	(0.003)	(0.009)	(0.005)	(0.002)	(0.009)	(0.006)	(0.002)	(0.009)
Investment grade?				-0.450	0.105	-0.322	-0.462	0.067	-0.297	-0.429	0.067	-0.261
				(0.069)	(0.031)	(0.072)	(0.067)	(0.023)	(0.069)	(0.068)	(0.022)	(0.070)
Convertible?				0.374	-0.177	0.502	0.276	-0.418	0.285	0.251	-0.420	0.328
				(0.141)	(0.028)	(0.127)	(0.106)	(0.059)	(0.109)	(0.112)	(0.056)	(0.111)
Years to maturity							0.022	0.038	0.027	0.024	0.038	0.027
							(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)
Junior/Unsecured?										0.090	-0.085	-0.094
										(0.158)	(0.108)	(0.199)
Callable?										0.172	-0.024	-0.006
										(0.025)	(0.010)	(0.023)
Credit enhancements?										0.165	-0.089	-0.095
										(0.028)	(0.011)	(0.035)
Main effects for variables listed above		X			X			X			X	
Controls (accrued interest, ETF returns)		X			X			X			X	
Observations		7,685,866			7,685,866			7,685,866			7,685,866	
R-squared		0.165			0.169			0.176			0.177	

Table 9. Determinants of pairing dealer implied profit

The regressions in this table predict the implied profit in a trade pair (in percent) using bond and trade characteristics. The first two columns include all trade pairs in the sample, with the first column using implied profit as the depedent variable and the second column using an indicator variable for implied profit equalling zero. The third column restricts the sample to trade pairs with positive implied profit. Standard errors are heteroskedasticity-robust and allow for clustering within issuers and trading days.

	Dependent variable		
	Implied profit	Implied profit = zero?	Implied profit, conditional on being positive
Side (Client purchase = +1, client sale = -1)	-0.177	0.102	-0.150
	(0.004)	(0.003)	(0.004)
Ln(Quantity/$50,000), positive component	-0.133	0.060	-0.155
(Range = 0 to 3.0)	(0.003)	(0.002)	(0.003)
Ln(Quantity/$50,000), negative component	0.066	-0.048	0.049
(Range = -3.9 to 0)	(0.002)	(0.002)	(0.002)
S&P rating (scaled AAA = 23, C or below = 0)	-0.019	0.014	-0.015
	(0.002)	(0.001)	(0.002)
Investment grade?	0.017	0.022	0.050
	(0.019)	(0.011)	(0.021)
Convertible?	-0.274	0.254	0.045
	(0.042)	(0.019)	(0.051)
Years to maturity	0.038	-0.009	0.042
	(0.001)	(0.000)	(0.001)
Junior/Unsecured?	-0.225	0.060	-0.260
	(0.103)	(0.030)	(0.096)
Callable?	-0.027	0.048	0.021
	(0.009)	(0.006)	(0.011)
Credit enhancements?	-0.089	0.076	-0.053
	(0.009)	(0.008)	(0.009)
Constant	0.653	0.141	0.763
	(0.016)	(0.009)	(0.018)
Observations	2,628,724	2,628,724	1,710,842
R-squared	0.163	0.070	0.181

Table 10. Transaction costs, NAIC clients, and round prices.

Regressions in this table replicate Models 1 and 4 from Table 8, adding three new variables to be interacted with ID, PD, and UPD -- an NAIC client indicator, a indicator for round-quarter-dollar transaction prices, and the interaction of the two. As in Table 8, the sample excludes unpaired interdealer trades, trades over $1,000,000 in par value, but obviously includes trades placed by NAIC clients. Standard errors are heteroskedasticity robust and allow for clustering within issuer and trading date.

	Model 1			Model 2		
	Interactions with			Interactions with		
	ID	PD	UPD	ID	PD	UPD
Constant	0.478	0.737	0.162	1.883	0.782	1.073
	(0.024)	(0.011)	(0.025)	(0.123)	(0.025)	(0.194)
Ln(Quantity/$50,000), positive component	-0.103	-0.198	0.043	-0.122	-0.192	0.033
(Range = 0 to 3.0)	(0.011)	(0.005)	(0.015)	(0.012)	(0.005)	(0.021)
Ln(Quantity/$50,000), negative component	-0.117	0.072	0.074	-0.133	0.082	0.049
(Range = -3.9 to 0)	(0.007)	(0.004)	(0.012)	(0.007)	(0.004)	(0.012)
NAIC client indicator	-0.338		0.310	-0.311		0.233
	(0.070)		(0.078)	(0.073)		(0.081)
Indicator variable for even $0.25 price	0.292	-0.016	0.085	0.112	-0.007	-0.019
	(0.022)	(0.013)	(0.028)	(0.019)	(0.013)	(0.025)
NAIC*Even $0.25 price	-0.093		-0.283	-0.331		-0.323
	(0.160)		(0.224)	(0.161)		(0.209)
Main effects for variables listed above		X			X	
Controls (accrued interest, ETF returns)		X			X	
Variables included in Table 8, Model 4					X	
Observations		7,704,130			7,704,130	
R-squared		0.165			0.177	

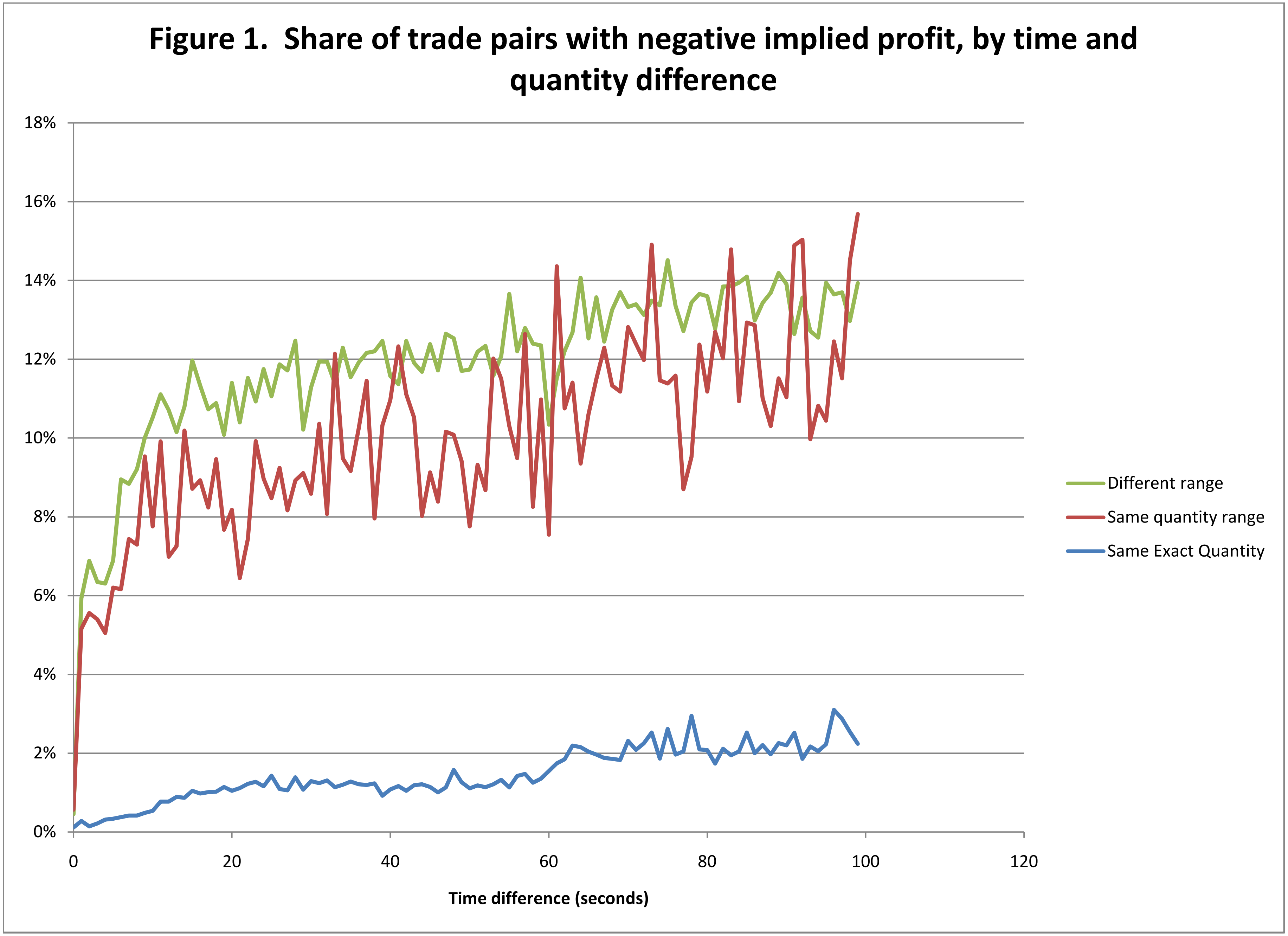


Figure 1. Share of trade pairs with negative implied profit, by time and quantity difference
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
0
20
40
60
80
100
120
Time difference (seconds)
Different range
Same quantity range
Same Exact Quantity

Figure 2A. Distribution of implied dealer profit, paired trades

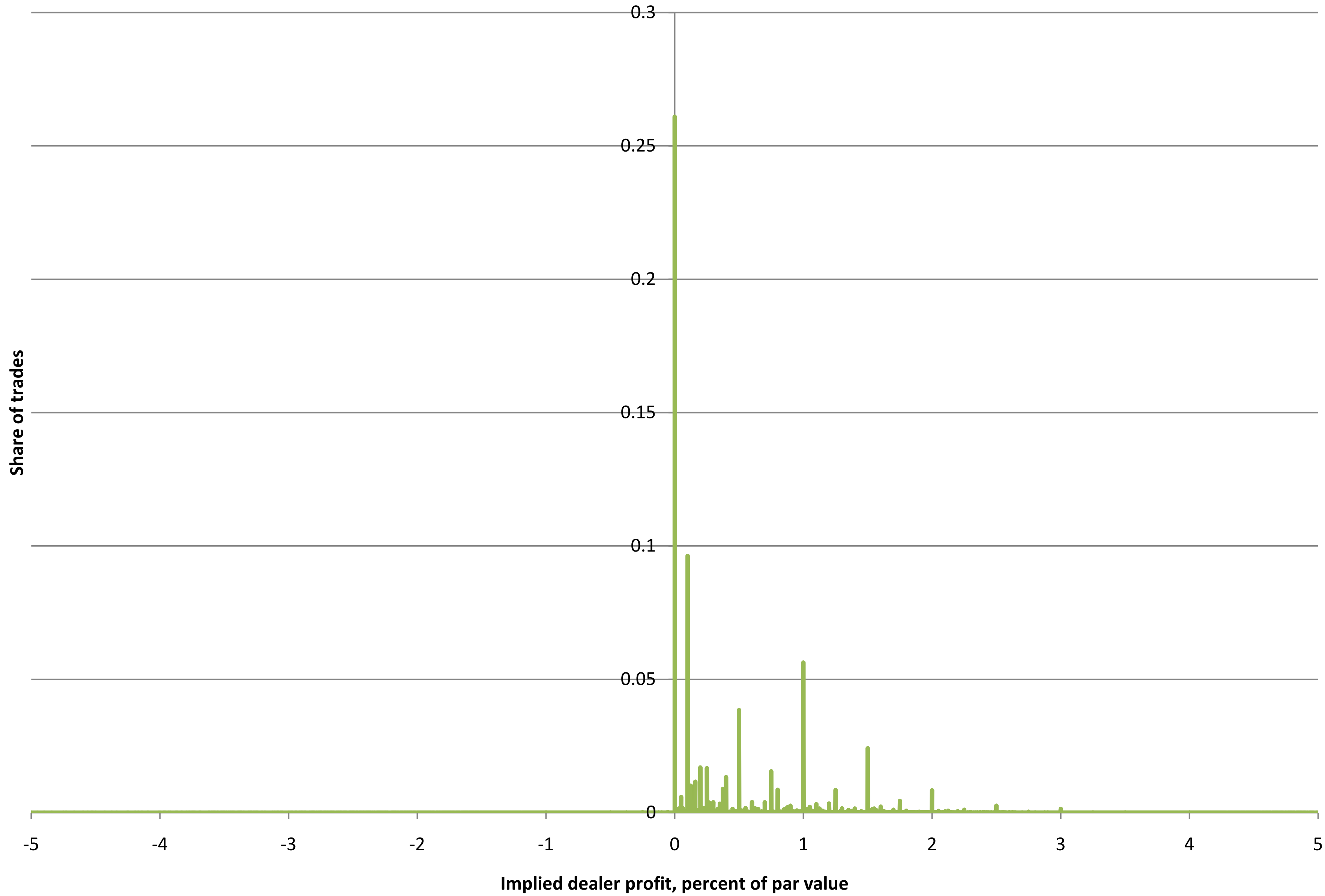
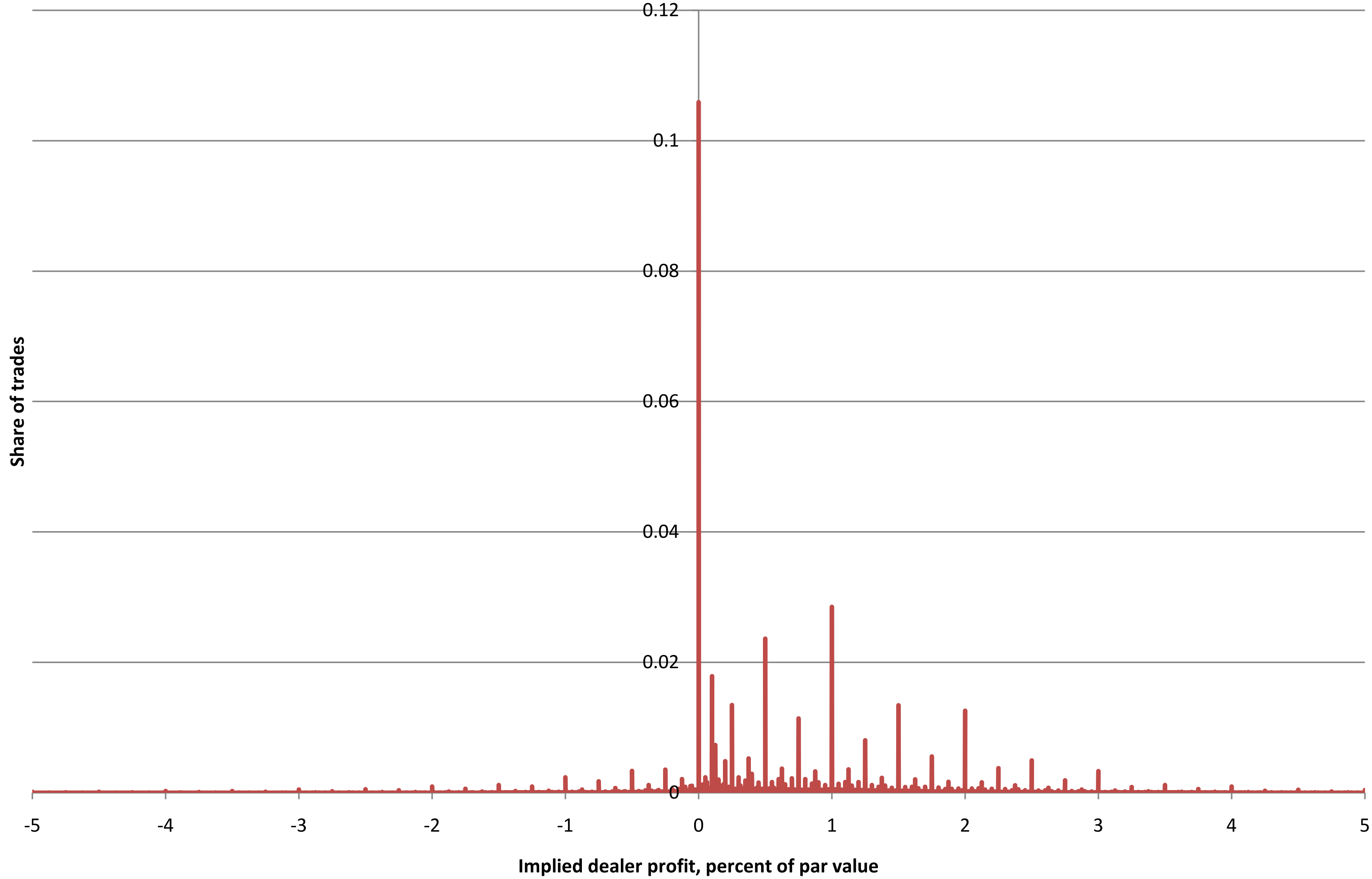


Figure 2B. Distribution of implied dealer profit, other trade matches within 15 minutes



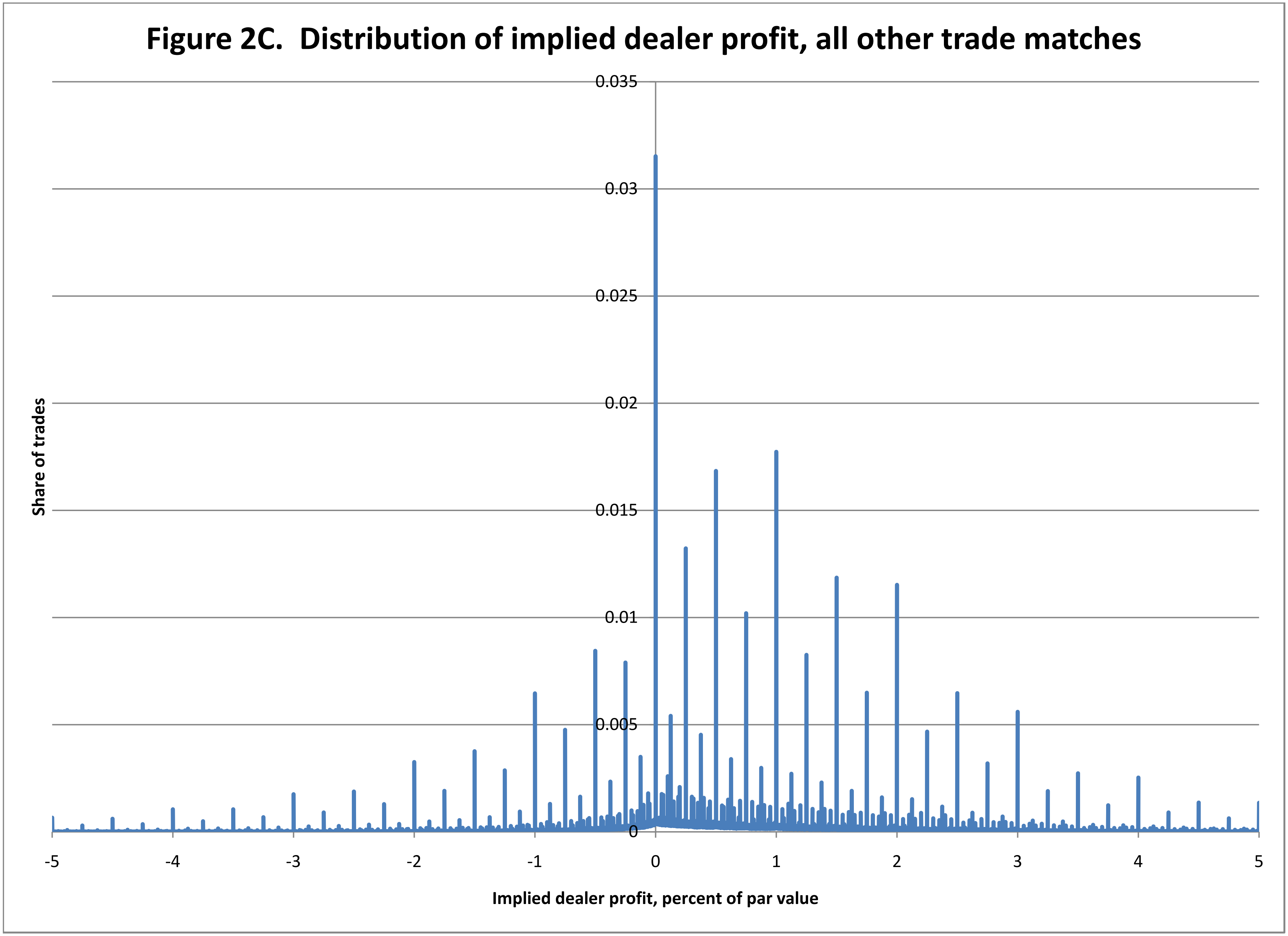


Figure 2C. Distribution of implied dealer profit, all other trade matches
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Share of trades
-5
-4
-3
-2
-1
0
1
2
3
4
5
Implied dealer profit, percent of par value

Figure 3. Round number pricing, by type of trade

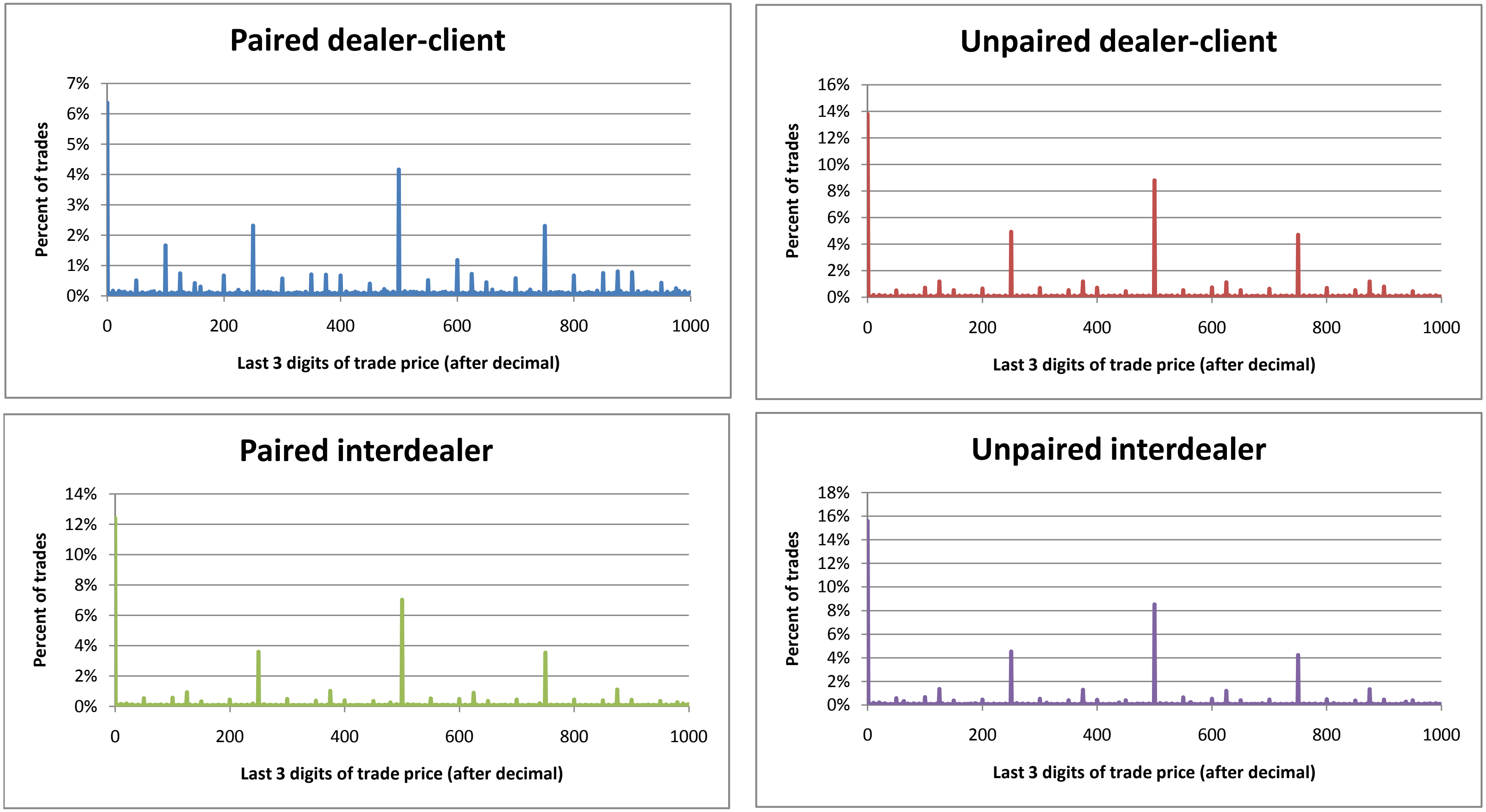


Figure 4. Trade size and trading costs