Anonymity, Adverse Selection, and the Sorting of Interdealer Trades

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This article uses unique data from the London Stock Exchange to examine how trader anonymity and market liquidity affect dealers' decisions about where to place interdealer trades. During our sample period, dealers could trade with each other in the direct, nonanonymous public market or use one of four anonymous brokered trading systems. Surprisingly, we find that adverse selection is less prevalent in the anonymous brokered markets. We show that this pattern can be explained by the way dealers "price" the adverse selection risk inherent in trading with other dealers. We also relate our findings to recent changes in dealer markets.

This article asks why London security dealers use more than one trading venue to trade with one another. We argue that differences in the exclusivity, liquidity, anonymity, and post-trade transparency of each system permit a more efficient sorting of interdealer trades than if there were just one system. Our evidence comes from detailed data on where London dealers chose to place interdealer trades. Contrary to intuition, we show that uninformed interdealer trades (as measured by subsequent price impact) *tend* to migrate to third-party brokered systems where trade is anonymous. By contrast, informed interdealer trades *tend* to migrate to the direct, nonanonymous public market. Additionally, we show that this distribution of trades is supported by differences in the price improvement dealers receive in the direct and brokered markets.

Our findings have implications for three strands of the market microstructure literature. First, they contribute to our understanding of the importance of anonymity and transparency in securities trading. Most theoretical models of the effects of anonymity and transparency predict that anonymous trading systems will attract more informed trades

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[e.g., Röell (1990), Fishman and Longstaff (1992), Forster and George (1992), Theissen (2001)]. Several empirical papers have recently explored the significance of anonymity and transparency in experimental settings [Bloomfield and O'Hara (1999, 2000), Flood et al. (1999)] and in real data [e.g., Foucault, Moinas, and Theissen (2003)]. These studies provide mixed evidence about the importance of anonymity and liquidity. Some studies find that anonymity and/or a lack of transparency can enhance liquidity at the expense of the informativeness of prices. Other studies conclude that anonymity and/or a lack of transparency can reduce liquidity but improve the informativeness of prices. With the exception of Bloomfield and O'Hara's (2000) study of trade reporting, these studies compare different market designs. That is, they do not examine what happens when traders have simultaneous access to different trading venues. Thus, the lessons that can be drawn from them for today's markets may be limited. By studying the choices of London dealers between anonymous and nonanonymous trading venues, we hope to add to our understanding of the role of anonymity in today's fragmented trading environments.

Second, this article has implications for recent discussions about competition in fragmented dealer markets, such as the Nasdaq Stock Market. In a recent paper, Barclay, Hendershott, and McCormick (2003) study competition between ECNs (anonymous) and Nasdaq dealers (nonanonymous). They find that ECNs are more active when there are greater informational asymmetries, and when trading volume and stock-return volatility are high. They also find that ECN trades have greater permanent price impacts than dealer trades. The authors conclude that anonymous ECNs attract informed traders for Nasdaq listed stocks. The main difference between ECNs and the anonymous brokered interdealer trading systems (IDBs) we study is that the London Stock Exchange only allowed dealers access to the IDBs. This meant that informed customers could not trade anonymously. This restriction appears to have improved the liquidity of the anonymous brokered market.

Third, this article contributes to the growing empirical literature on brokered interdealer trading. Several recent papers use GovPX data to study interdealer trading [e.g., Boni and Leach (2002, 2004), and Huang, Cai, and Wang (2002)]. However, the GovPX data do not cover direct trading and do not cover all interdealer brokers. Boni and Leach (2004), for example, estimate that only 71% of the total brokered volume in shorter-term Treasury securities is covered by the GovPX data set. Studies of interdealer trading in foreign exchange markets also have been affected by data limitations, including short time series or incomplete information on trades and trade counterparties [e.g., Lyons (1995), Yao (1998), and Bjønnes and Rime (2001)]. Thus, the data used in previous studies do not permit a comprehensive study of venue selection. By contrast, we have complete data for all brokered and direct interdealer trades conducted in London during our one-year sample period.

Sections 2 and 3 of the article detail our hypotheses and describe the London dealer market. During our study period, London dealers could either trade in the public market or post limit orders in one of four anonymous third-party trading systems. Public market trades were conducted by phone, and the initiating dealer had to reveal his identity as well as whether he was trading for a customer or his own account. That is, direct market trades were nonanonymous. In contrast, third-party IDBs were intermediated by independent brokers who guaranteed dealers anonymity (even after the trade was complete). Because only the dealers quoting prices in a security were allowed to make brokered trades in that security, each dealer knew their counterparty was another dealer trading for his own account. Although these brokered systems seemingly favored dealers over other brokers and the public, the U.K. regulators justified them on the grounds that they would reduce dealer inventory risk and thereby improve liquidity. The empirical evidence here and in Reiss and Werner (1998) lends support to this logic.

Sections 4 and 5 show that the participants in brokered interdealer trades receive significant price improvement relative to direct interdealer trades, taking into account trade size and the width of the public spread. Given that brokered trades occur at much better prices, there would seem to be little reason for dealers to ever trade with one another in the public market. This reasoning presumes, however, that the brokered market will be sufficiently liquid. There is no institutional reason why this should be the case when, as was the case in London, dealers are not required to supply liquidity to third-party systems. Thus, while an informed dealer would prefer to trade in the brokered market all else equal, he may not be able to. By contrast, the informed dealer can always execute his trade against a competitor's quotes in the direct market, albeit at an inferior price. This tradeoff between liquidity and immediacy is a familiar one in order-driven markets, but not in the dealer markets considered here.

Our empirical analysis of interdealer trade sorting documents how these tradeoffs affect both the prices of trades relative to prevailing quotes (price improvement) and the subsequent change in prices and quotes. We find that the participants in brokered interdealer trades receive significant price improvement relative to the prevailing quotes; direct interdealer trades receive little or no price improvement. When we evaluate the information content of the two types of interdealer trades, we find noticeable differences, but not in the direction predicted by many information-based microstructure theories [see, e.g., Röell (1990), Fishman and Longstaff (1992), Forster and George (1992)]. Most of these theories predict that we should see informed interdealer trades migrating to the anonymous brokered systems. We instead find that the average direct interdealer trade has more information as measured by price impact (approximately 60–70 basis points versus 10–20 basis points).

We interpret these price improvement and price impact findings as evidence that the liquidity dealers voluntarily supply to the brokered market is sensitive to dealers' perception of adverse selection risks. When other dealers are perceived to be better informed, liquidity declines in the anonymous markets as interdealer trades migrate to the direct market. As a result, the majority of informed interdealer trades execute in the nonanonymous, quote-based market.

In support of this conjecture, we show that direct interdealer trades of exactly the regulated minimum quote size have by far the largest price impact. This finding is consistent with quoting dealers refusing to supply additional size to (likely) informed dealers. In the presence of such limits, we expect that informed dealers would resort to order-splitting. That is, executing a rapid sequence of interdealer trades. Indeed, we find that rapid sequences of direct quote-based trades *in the same direction by the same dealer* are associated with significantly larger price impacts than single trades.

The nonanonymity of direct trades also permits us to examine related hypotheses about venue selection. In a direct interdealer trade, the dealer initiating the trade must identify himself and indicate that he wants to execute a principal trade. The receiving dealer at this point forms an idea of the likelihood that the trade is information-based. If the initiating dealer is a dealer with substantial customer order flow, receiving dealers are more likely to conjecture that the initiating dealer is impatient and trading on information. Indeed, we find that interdealer trades executed by dealers that receive substantial customer order flow have significantly larger information content. Moreover, sequences of direct trades by large dealers have a larger price impact.

We conclude by arguing that if interdealer trade sorting is to persist, dealers must be indifferent between the two types of interdealer trades. This means prices in the brokered and direct markets should adjust so as to offset expected differences in price impacts between the two venues. Indeed, we find that the prices posted by liquidity providers in interdealer trades do adjust for differences in the expected price impacts of the two types of interdealer trades.

1. Motives for Interdealer Trading

Interdealer trades provide an interesting context in which to investigate how order flow is affected by trader anonymity, order transparency, and market liquidity. Interdealer trades often account for a significant fraction of trade in dealer markets.[1] Dealers also almost always have access to

[1] See, for example, Smith (1999), Cheung and Chinn (1999), Reiss and Werner (1998), and Lyons (1995).

several different trading venues. These venues differ in important ways, including whether the venue is exclusively for dealers and whether the system affords the dealer anonymity. In London, dealers either could negotiate a trade based on a competing dealer's quotes over the phone, or post and hit limit orders in any of the four anonymous third-party brokered systems (Cedar, Garban, First Equity, and Tullett & Tokyo).

Many other dealer markets also allow dealers to conduct trades in more than one venue. In Nasdaq SuperMontage system, for example, a dealer can execute an interdealer trade directly by hitting another dealer's quote; alternatively, the dealer can hit (or post) anonymous limit orders in a third-party ECN. Some of the ECNs are accessible only to dealers and selected institutional traders (the original Instinet), and others are open to virtually all traders (e.g., INET). Similarly, foreign exchange dealers use a mix of direct voice-brokered trades, direct nonanonymous electronic trades (Reuters D2000-1), and anonymous electronic brokered systems (Reuters D2000-2 and EBS) to manage positions. In the U.S. Treasuries market, where a large volume of trading is between dealers, interdealer trades also can be direct (nonanonymous) or brokered (anonymous).

Before proceeding, we should clarify what we mean by anonymous trades. An anonymous trade is one where the participating dealers do not observe their counterparty's identity prior to, during, or after a trade. (Nonparticipating dealers only know, possibly with a delay, that a trade has occurred and not who the counterparties were.) Thus, when we say the brokered systems are anonymous, we mean that the displayed limit orders do not carry dealer identifiers, negotiations do not involve direct contact (they are voice mediated by a third-party broker employee), and trade reports do not identify participating dealers. This view of anonymity is closest to that of Foucault, Moinas, and Theissen (2003). They hypothesize that large traders in a transparent regime (i.e., where limit orders are nonanonymous) will post worse prices to reduce free riding by uninformed traders. They find support for this view from an episode in which spreads narrowed and depth increased following the Paris Bourse's removal of broker identities.

We should also clarify how some other features of the brokered systems affect trade transparency. First, dealers are only entitled to view the buy and sell limit orders in the securities in which they post prices in the public market. Thus, a dealer who quotes public market prices in Abbey National's stock, but not in Allied-Lyons', would only be entitled to see brokered limit orders for Abbey National. Second, although dealers communicate and consume limit orders in the brokered systems by phone or direct voice links, they receive the limit order information electronically. Third, the brokered systems do not report brokered trades on their systems; instead, they report them to the Exchange, which communicates them as part of its regular trade reporting process.[2]

There are at least two, to some degree overlapping, motives for interdealer trades — risk sharing and private information.[3] Risk sharing is particularly important in markets where quote minimums require dealers to accept large customer trades. In a transparent, competitive dealer market without information asymmetries, the demand for interdealer risk-sharing depends on differences in dealers' risk preferences, inventories, and uncertainties about security and market fundamentals [Ho and Stoll (1983)]. In these markets, quote-based interdealer trading efficiently reallocates inventory imbalances among dealers.

Information asymmetries, either between customers and dealers or among dealers themselves, can interfere with the simple objective of dealer risk-sharing. For our purposes, it is useful to distinguish between three cases: (1) a situation where dealers believe that customers, but not dealers, have private information; (2) a situation where a dealer has private information, but no other dealer suspects that one in their midst is better informed; and (3) a situation where dealers correctly or incorrectly perceive that one or more dealers have an information advantage. Note that in cases (2) and (3), the information advantage could have originated from a customer trade as in Naik, Neuberger, and Viswanathan (1999) and Saporta (1997), or it could be the result of in-house research. Alternatively, since there was delayed reporting of large trades in London during our sample [see Gemmill (1996)], the dealer may trade to exploit his information about future order flows [Vayanos (1999, 2001), Cao, Evans, and Lyons (2004)].

To see why information asymmetries may lead to a demand for separate IDBs, suppose that dealers only had access to a public quote-based system. If they believed that adverse selection was likely to come from customers, the public spread would be wide. The wide spread in the public market, however, would not signal what terms a dealer (or an uninformed customer) could get through bilateral negotiation. While London dealers do offer customers and dealers selective discounts, it seems clear that bilateral negotiations are an inefficient way of discovering which dealer would give the best discount [see Reiss and Werner (1995) and Bernhardt et al. (2004)].

[2] Prior work that has discussed pre-trade quote transparency include: Biais (1993), Bloomfield and O'Hara (1999), Flood et al. (1999), Madhavan, Porter, and Weaver (2004), de Frutos and Manzano (2002), Hendershott and Jones (2003) and Boehmer, Saar, and Yu (2004). Work discussing post-trade trade-reporting transparency includes: Board and Sutcliffe (1995), Madhavan (1995), Gemmill (1996), Naik, Neuberger, and Viswanathan (1999), and Bloomfield and O'Hara (1999, 2000).

[3] See, for example, Ho and Stoll (1983), Vogler (1997), Saporta (1997), Werner (1997), Naik, Neuberger, and Viswanathan (1999), and Viswanathan and Wang (2002).

Ideally, dealers would like to negotiate simultaneously with all competing dealers. One way to do this would be through a private communication network such as Nasdaq's SelectNet system. Most direct messaging systems, however, are not anonymous. This then raises a free-rider problem, such as that studied in Foucault, Moinas, and Theissen (2003). In their model, better-informed traders typically end up posting worse prices to prevent free riding. Perhaps for this reason, a key selling point for many third-party brokered systems is that they afford traders anonymity.[4] These systems also have found ways, such as through "iceberg" or reserve orders, to allow dealers to negotiate additional trades anonymously.[5] Finally, some interdealer broker systems limit participation to certain groups, such as registered dealers.

To summarize, having a separate, anonymous dealer-only market potentially permits dealers to trade more efficiently within the public spread. Dealers will supply liquidity to this market when they do not expect there to be significant information asymmetries among those with access. Since in London only those dealers registered to quote prices have access to the brokered market in that security, information asymmetries among registered dealers will have the greatest impact on liquidity. As the degree of information asymmetry among dealers increases, we expect orders posted within the spread in the brokered markets to shrink or disappear. As the liquidity in the brokered markets vanishes, dealers with private information can either post in the brokered market at the risk of not getting a fill, or turn directly to the public market to trade at the public quotes.

2. Hypotheses

We now translate these observations into hypotheses about interdealer trades. Our task is complicated by the fact that we only observe brokered limit orders that execute. This means that we must cast our hypotheses in terms of the times, prices, and sizes of executed orders.

Suppose that a London dealer has an inventory imbalance that he wishes to reduce through interdealer trading. During normal market hours, he can trade directly with another dealer at the public quotes. In this case, the liquidity-demanding dealer will buy at the inside ask instead of at the inside bid, that is, the cost is the quoted spread. Based on the intuition of sequential trade models [see O'Hara (1995) for a survey], the

[4] Other examples include interdealer broker systems operating in the U.S. government bond markets and many ECNs currently operating in the U.S. security markets.

[5] An "iceberg" order is an order wherein the broker or system displays only a fraction of the entire order. Once the displayed amount is consumed, additional portions are displayed until consumed. Nasdaq's SuperMontage, EuroNext, and the Toronto Stock Exchange currently allow brokers to make orders attributable (nonanonymous) or anonymous, and to submit iceberg orders. Boni and Leach (2002) study a related negotiation feature ("work-ups") of U.S. government bond markets using GovPX data.

public quoted spread reflects among other things the expected costs from trading with better informed dealers and/or better informed customers. If the dealer instead traded in the brokered markets, the spreads there should reflect only the adverse selection costs associated with trading with better informed dealers (since customers cannot trade in the brokered markets).

Given the same spread in both the public and brokered markets, a dealer may still prefer to use the brokered market simply because they want to adjust their inventory position anonymously. There are, however, at least two competing costs to the brokered systems. First, a liquidity-demanding dealer pays a fee of about five basis points to trade in the brokered systems. Second, dealers must separately monitor the four independent third-party systems to find the best price. These costs are large enough so that they may outweigh the benefits of anonymity when the public spread is narrow.

As the public spread widens, however, the brokered market may become more attractive than the direct market. How would this happen? First, if adverse selection primarily comes from trading with customers, the quoted public market spread might widen while the (cost-adjusted) spread in the brokered systems remains the same. Second, posting dealers who are afraid of quote-matching or front-running might prefer to post orders inside the public market spread in the anonymous brokered systems [Foucault, Moinas, and Theissen (2003)]. Third, it is possible that dealers are price discriminating against customers by posting excessive public market spreads [Dutta and Madhavan (1997)].

Taken together, these observations suggest the following hypotheses:

Hypothesis 1. *When the public market spread is narrow, we will see fewer brokered interdealer trades.*

Hypothesis 2. *Effective spreads in the brokered interdealer market will be smaller than the contemporaneous public market spreads.*

Note that Hypothesis 1 does not imply that we unconditionally predict an active brokered market when the public market spread is wide. The reason is that both the public market spread and the brokered market spread may be wide because of adverse selection among dealers. By contrast, Hypothesis 2 is unconditional. When we see trades in the brokered market, we expect dealers to be offering each other better prices than in the public market.

One important distinction between the direct and the brokered interdealer market is the degree of anonymity. Several theoretical models [e.g., Röell (1990), Fishman and Longstaff (1992), Forster and George (2002)] and conventional wisdom predict that less transparent trading systems, in this case the brokered market, should attract more informed trades. This prediction has recently been empirically confirmed by comparing the information content of (nonanonymous) Nasdaq and (anonymous) ECN trades by Barclay, Hendershott, and McCormick (2003). These results are puzzling since one would think that uninformed dealers with a choice of trading venue would try to avoid trading in a market if it has a systematically higher degree of adverse selection.

The fact that participation by uninformed dealers in the brokered systems is voluntary suggests an alternative hypothesis. While informed dealers would, all else equal, prefer trading in the anonymous brokered systems, their ability to do so is curtailed by the endogeneity of liquidity. When adverse selection is perceived to be high, limit orders are canceled and liquidity dries up in the brokered systems. Under these circumstances, informed dealers are forced to resort to direct interdealer trading to fill their orders. This leads us to contrast the following two mutually exclusive hypotheses:

Hypothesis 3A. *When (anonymous) brokered interdealer trades occur, they will have more information than direct interdealer trades.*

Hypothesis 3B. *When (anonymous) brokered interdealer trades occur, they will have less information than direct interdealer trades.*

Dealers could alternatively position their quotes inside the best public market bid and ask in an effort to attract order flow. We do not consider this possibility because prior work [e.g., Hansch, Naik, and Viswanathan (1999)] has shown that the prevalence of order preferencing and internalization make this a costly way of attracting order flow.

Underlying Hypothesis 3B is the presumption that when other dealers are perceived to be informed, there is likely to be little or no liquidity in the brokered market (other than what informed dealers offer). In this situation, the informed dealers face a familiar trade-off. If they post in the brokered system, their order may not be filled and their information may leak out. On the other hand, if they trade in the direct market, they will pay worse prices and their information may still leak out. In situations where dealers' private information is time sensitive, the second of these options is likely to be preferred to the first. That is, with time sensitive information, a dealer will opt to initiate direct quote based trades (possibly using a sequence of interdealer trades).[6] On the other hand, if the dealer does not have time-sensitive information, then brokered trading would be preferred.

Together, these arguments suggest a stronger version of Hypothesis 3B:

Hypothesis 4. *Direct interdealer trades at wide spreads are likely to be more informed and therefore have greater permanent price impacts.*

[6] It is also possible that the quoted market spread is wide because of collusion [Dutta and Madhavan (1997)]. Then, the brokered systems are even more likely to offer relatively attractive terms of trade.

Hypotheses 3B and 4 stand in stark contrast to Hypothesis 3A and the predictions of several theoretical models that suggest anonymous trading systems are *more likely* to attract informed trades [see, e.g., Röell (1990), Fishman and Longstaff (1992), Forster and George (1992)]. Our explanation for the difference again hinges on the exclusivity of the brokered systems. It is interesting to note that in the U.S., ECNs do not maintain this exclusivity. This perhaps explains why Barclay, Hendershott, and McCormick (2003) find that the U.S. ECN trades have greater permanent price impacts than dealer trades.

Our final three hypotheses pertain to the price impacts of different sizes of direct and brokered interdealer trades, and the price impacts of those originating from different types of dealers. Several theoretical papers suggest that informed traders with short-lived information will prefer to submit large orders to the market [e.g., Easley and O'Hara (1987), Glosten (1989), Seppi (1990)]. Although informed dealers may prefer to trade in size at current prices, a large order may adversely affect other dealers' quotes and overall liquidity. In London, the Exchange limits the amount a posting dealer is obliged to accept. This minimum quote size, or Normal Market Size (NMS for short), differs by security and is positively related to past trading activity in the security. Since dealers have the option but not the obligation to accept trades larger than one NMS, if they do accept greater than one NMS trade, it is likely because they believe the trader is uninformed. Alternatively, if the dealer only accepts one NMS, it could be because the dealer suspects the trader is informed and had (implicitly or explicitly) a request to trade more. Consequently, we expect direct trades of exactly the quote size to have significantly larger price impacts than interdealer trades of other sizes.[7]

Hypothesis 5. *Direct interdealer trades for exactly a dealer's quoted size will have greater price impacts than direct trades of other sizes; these direct interdealer trades for exactly a dealer's quoted size will also have greater price impacts than brokered interdealer trades of any size.*

If dealers receive information from large customer trades, then dealers might come to expect those dealers with significant order flow from large customers to be more informed [see, Saporta (1997), Naik, Neuberger, and Viswanathan (1999)]. This implies that when a dealer in the public market is hit by a large dealer, they are more likely to infer the trade is informed and more likely to move their quotes or cancel their limit orders in response. On the other hand, since dealer identities are not known in the brokered market, we would expect to see little immediate impact of a large

[7] Of course, prices and liquidity will adjust to perceived information asymmetries among dealers. This means than when dealers expect significant information asymmetries, we may never see large trades in brokered systems.

dealer trading, and only a delayed impact to the extent the large dealer was informed and able to trade in the brokered market. We examine the role of dealer identity and information by testing the following hypothesis:

Hypothesis 6. *Direct interdealer trades where the initiating dealer has significant customer order flow are more likely to be based on information. These "large" dealer trades are thus likely to have greater price impacts than direct trades initiated by other dealers, and the price impacts of brokered interdealer trades* (*regardless of the identity of the initiator*).

So far, we have focused on a single interdealer trade in isolation. However, there is a rich body of theoretical work that suggests that informed traders will split their orders over time [e.g., Kyle (1985), Foster and Viswanathan (1990), Holden and Subrahmanyam (1992), Vayanos (1999, 2001), Cao, Evans, and Lyons (2004)]. There also is work analyzing order-splitting across dealers [e.g., Bernhardt and Hughson (1997)]. Moreover, in a fragmented market, traders might split their orders across venues [e.g., Chowdhry and Nanda (1991)]. Relatedly, work on dynamic order submission strategies emphasizes that opportunities for trading on information depend on the type of market or limit order submitted [e.g., Angel (1994), Harris (1994), Bertsimas and Lo (1998)]. Generally, these theories predict that a dealer will trade aggressively using sequences of market orders (demand liquidity) if the information is short-lived. If the dealer has no information advantage, or the information is long-lived, the dealer will instead post limit orders in the brokered systems or use their quotes to avoid paying for immediacy. Thus, we expect London dealers with short-lived information primarily to use sequences of liquidity-demanding interdealer trades.

Hypothesis 7. *A sequence of direct* (*nonanonymous*) *interdealer trades will have a greater price impact than that of a single direct or brokered interdealer trade.*

In the next sections, we test each of our hypotheses based on a unique data set from the London Stock Exchange.

3. Data

We use 1991 data from the London Stock Exchange's trade settlement records to test our hypotheses. A key advantage of these data over other commonly used trade data is that the settlement records identify trade counterparties. Specifically, the data describe each trade's price, quantity, time of execution, and the identities of the brokers involved in the trade. Additionally, the data describe whether a broker is trading at a customer's request or on the broker's own account. This latter information is critical for identifying interdealer trades, which are by definition trades between dealers for their own accounts. The data also include information that allow us to determine where the dealers executed the interdealer trade (in the public market or through a third-party broker). In addition to using trade settlement data, we match the trade data to the Exchange's database of dealer quotes. The quote data record dealers' changes in quoted prices and depths throughout the trading day.[8]

To keep our tables manageable, we restrict attention to a sample of 25 FTSE-100 index securities from Reiss and Werner (1998). We chose these securities both for their liquidity and the fact that at the time they were not traded extensively overseas. Because dealers do not have to post firm quotes outside of normal market hours, we analyze only interdealer trades that occurred during normal market hours. (Less than 0.2% of interdealer trades occur outside normal market hours.) Our final sample includes 24,034 brokered interdealer trades and 15,753 direct interdealer trades. Although there are more brokered trades than direct trades, the direct trades are on average larger than interdealer brokered trades. On balance, each type of trade represents roughly half of all interdealer volume. (See Table 1.)

4. Results

4.1 Price improvements for interdealer trades

Our first two hypotheses address the relative frequency and pricing of brokered and direct interdealer trades. While we have complete data on dealer quotes and trades in the public market, we do not see the limit order books of the four interdealer brokers. Thus, we cannot directly compare the prices and liquidity of the brokered systems to the posted prices and liquidity of the public market. We do, however, know when trades execute in the brokered systems, and the price and sizes of these trades. This information permits us to compare the results of transactions in the two interdealer trading venues.

Figure 1 illustrates how we propose to measure and compare the prices dealers received on brokered versus direct interdealer trades. For ease of interpretation, we focus on the gross benefit the consumer or "hitter" of a brokered limit order receives. We define gross benefit as the price

[8] Reiss and Werner (1998) describe these data in more detail and the process by which we match the settlement data to information on dealers' quotes. The trade counterparty information is not public information. A data appendix describing our sample securities, sample trades, and how we identify brokered trades is available from the authors. In matching trades to quotes, there is a potential for timing errors because trade times are rounded to minutes while quote times are to the nearest second. To obtain some sense of the potential for error, we computed how often small direct interdealer trades, which are guaranteed execution at or within the spread, fell outside the prevailing bid and ask. Approximately 0.8% of small direct interdealer trades fall outside. Many of these instances are ones where the spread is narrow or the bid and the ask are locked.

improvement the hitter receives relative to the relevant prevailing public quote. In Figure 1, the two horizontal lines represent the prevailing public best bid and ask. The distance between these two lines is the public quoted spread, which in London is called the "Touch". In our sample, the average Touch is approximately 3 pence and the average price around 3.1 pounds sterling. During this period, there were no minimum tick sizes. Thus, the Touch could be (and in our data is) expressed in fractional pence (up to four decimal places).

To the left of the figure, there are two black dots representing customer buys. Many customer trades are executed at or near the best bid or ask. Immediately after the second customer buy, a dealer submits a limit buy order inside the public spread to one of the four interdealer broker systems. This limit buy order becomes the effective "ask" in the private brokered market and is only available to be consumed ("hit") by another dealer quoting prices in this security. Market participants who are not dealers in this security do not observe the submission time, price, or size of the limit order. In our data, we observe the price and size of the limit order if it subsequently executes (the third black dot). We also know both trade counterparties and can determine which dealer posted and which dealer "hit" the order.

Because the dealer who "hit" the brokered buy limit order could have alternatively sold shares at the prevailing public bid, we measure the hitter's gross price improvement as the difference between the limit

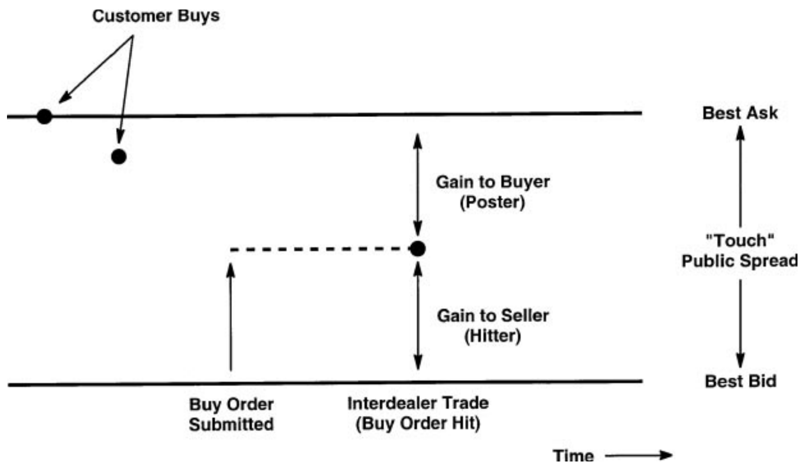

Figure 1
Calculation of trade price improvement
This figure shows how we calculate the price improvement obtained by a dealer who places ("posts") a limit buy order and the price improvement received by a dealer who "hits" the limit order. The dark circles represent trades.

order price and the public bid. This price improvement is a gross figure because the convention is for the hitter in the brokered systems to pay the broker an approximately five basis point fee for facilitating the transaction. In this example, the dealer who submitted the brokered limit order the "poster" — receives price improvement equal to the remaining spread, or the horizontal distance between the limit order price and the best ask. The posting dealer pays no broker fee.

Although we can identify the poster and hitter in a brokered interdealer trade, we are forced to use Lee and Ready's (1991) trade classification method for direct trades.[9] Table 1 provides statistics on the interdealer trades in our sample and the gross price improvements that the hitters received. The bottom of the table shows that while there are more brokered trades, these trades are smaller on average. By value, the two types of trades are roughly equally popular.

Our first hypothesis explores the propensity of dealers to use direct versus brokered interdealer trades. In aggregate, Table 1 shows that direct trades tend to occur at somewhat narrower average spreads than brokered trades.[10] Hypothesis 1 maintains that we should see fewer brokered interdealer trades when the public spread is narrow. The rows of Table 1 tabulate the distribution of interdealer trades by the Touch. Columns two, three and four reveal that direct trades, either by number or value, occur more frequently at narrower spreads. (This finding also holds for individual securities.) By contrast, dealers are more likely to resort to brokered trades when public spreads are wide. Thus, we cannot reject the hypothesis that there are fewer brokered interdealer trades when the public spread is narrow.

Columns five and six address our second null hypothesis, that price improvements are larger (effective spreads are lower) for brokered interdealer trades. Overall, a dealer who consumes ("hits") a limit order posted in a private brokered system receives a (median) price improvement equal to one-third of the prevailing public spread. Since the typical interdealer trade in our sample is done when the public spread is around 3 pence and the price per share is roughly 3.1 pounds sterling, this represents a 32 basis point savings ($\frac{1}{3} \times 0.03/3.1 \times 10{,}000$) to the hitter. By contrast, the median hitter in a direct interdealer trade receives no price improvement.

[9] This method classifies orders as buyer-initiated or seller-initiated based on whether the transactions price is above or below the midpoint of the contemporaneous public best bid and ask. Lee and Ready's classification method potentially imparts a downward bias to our price improvement statistics. This bias occurs because the classification rule limits the price improvement a dealer can receive to at most 50% of the spread. We can obtain some sense of how large this bias might be by using the Lee and Ready classification method on brokered trades (where we have independent information on whether these trades are buys or sells). We find for brokered trades that the weighted average discount falls from 38.8% (Table 1) to 35.6%. Since brokered trades are much more likely to be traded inside the spread, we conclude that the bias from using Lee and Ready's classification method is likely negligible.

[10] The standard errors of the average Touch are 0.008 (brokered), 0.01 (direct), and 0.007 (total).

Table 1
Price improvement received by interdealer trade initiators

		Cumulative percentage of trades by		Gross price improvement to the trade initiator as a percentage of the prevailing touch					
							Median by NMS size		
Prevailing touch (pence)	Number of trades	Number	Value	Median	Value weighted mean	S.E. weighted mean	<1	1	>1
Brokered trades									
1.0	1,084	5	4	50.0	52.2	0.7	50.0	56.2	50.0
1.5	266	6	5	33.3	38.6	0.7	33.3	33.3[1]	33.3[1]
2.0	5,532	29	26	50.0	40.3	0.2	50.0	50.0	50.0
3.0	7,773	61	58	33.3	38.2	0.2	33.3	33.3	33.3
4.0	4,969	82	79	29.9	37.5	0.2	25.0	37.5	37.5
5.0	3,355	96	95	40.0	36.7	0.2	40.0	40.0	40.0
6.0	530	98	98	33.3	37.0	0.6	33.3	33.3	33.3
7.0	371	99	99	28.6	37.0	0.7	28.6	28.6	28.6
All	24,034	100	100	33.3	38.8	0.1	33.0	33.0	33.0
Direct trades									
1.0	1,631	10	11	0.0	2.6	0.4	0.0	0.0	0.0
1.5	178	11	11	0.0	15.8	1.3	0.0[1]	0.0[1]	0.0[1]
2.0	4,075	37	38	0.0	5.5	0.3	0.0	0.0	0.0
3.0	5,324	71	72	0.0	7.0	0.3	0.0	0.0	0.0
4.0	2,553	87	89	0.0	10.2	0.4	0.0	0.0	0.0
5.0	1,310	96	97	0.0	14.6	0.5	20.0	0.0	0.0
6.0	261	97	98	0.0	14.8	1.4	0.0[1]	0.0	16.7[1]
7.0	163	98	99	28.6	22.4	1.3	35.7[1]	14.3[1]	28.6[1]
All	15,753	100	100	0.0	7.5	0.2	0.0	0.0	0.0

	Total value (million pounds)	Avg. touch (pence)	Avg. trade size (thousand pounds)
Brokered	3,001	3.4	125
Direct	2,781	2.9	177
Total	5,782	3.2	145

We measure (gross) price improvement as the difference between the best public market quote and the price a dealer obtains by using an interdealer broker or by trading directly with another dealer. We denominate price improvement by the prevailing touch, provided the touch is greater than zero. (We exclude a small number of trades with zero spreads.) NMS is the minimum required quote size. The table does not tabulate a small fraction of trades with touch values other than 1.0 through 7.0 pence.

[1]Denotes statistic based on fewer than 100 trades.

That is, a (median) dealer who resorted to phoning another dealer directly received no price concession from the prevailing public bid or ask price. This picture does not change much if we compare the two types of trades based on (trade value-weighted) means (column six) or classify trades into different sizes (the last three columns).[11]

[11] Recently, the U.S. SEC has found qualitatively similar patterns when comparing Nasdaq's public quotes with bids and offers displayed on Instinet and SelectNet. Moreover, the new order handling rules that came into effect on January 20, 1997, among other things, required dealers to reflect their own trading interests in their public quotes (quote rule). Barclay et al. (1998) found that as a result, publicly quoted spreads fell by between 4 cents for equities with average spreads less than 30 cents and 21 cents for equities with average spreads greater than 30 cents following the change in the quote rule. This suggests that

The standard errors in column seven indicate that we cannot reject the hypothesis that the average price improvements are greater for brokered than direct trades.[12] The fact that brokered interdealer trades receive significantly more price improvement (pay lower effective spreads) is consistent with our hypothesis that trades in the brokered market facilitate risk sharing at prices inside the public spread.

4.2 Price impacts of interdealer trades

To understand whether the anonymity afforded dealers in the brokered market tends to attract informed dealer trades (Hypothesis 3A), we need to be able to separate trades into those likely to be informed and those likely to be uninformed. To do this, we follow the event-study literature and use post-trade cumulative excess returns as a measure of whether a particular interdealer trade reflected an informational advantage. For example, if a dealer has obtained information that the price of a security is likely to fall on pending news, then we would expect him to sell shares (possibly short) before the price falls. If sufficient liquidity is available in the brokered systems, this informed dealer might simply hit all available brokered limit orders. If there is little or no liquidity in the four brokered systems, the dealer must use the public market to trade. In either case, we expect the price at which he sells to be higher than the price level after the information has become public. In other words, we should see a negative price impact of the interdealer trade. Correspondingly, we expect to find positive price impacts for interdealer buys.

As a robustness check, we measure the price impact of interdealer trades in two ways. The first way adopts the standard approach in the event-study literature by comparing the "event" (interdealer) trade's price to the prices of surrounding (interdealer or customer) trades. However, in contrast to the standard approach, here we only compare buyer-initiated (seller-initiated) event trade prices to nearby buyer-initiated (seller-initiated) trade prices. We do this to avoid contaminating the price impact measure with spurious price movements that are the result of the mix of buys and sells surrounding the trade — what some call the bid–ask bounce effect [see, e.g., Board and Sutcliffe (1995), Koski and Michaely (2000), Reiss and Werner (2002)]. We find that this adjustment substantially improves inferences about price impacts.

Our second method for measuring price impact is based on the observation that trading can be uneven around interdealer trades. For example, in some instances we have dozens of trades within a minute or two of an

ECNs, such as, for example, Instinet often had limit orders that implied a tighter spread than the public quotes displayed by Nasdaq dealers. More recent evidence of tighter quotes in ECNs is provided in Huang (2002).

[12] The statistics and tests are based on conventional independent and identical sampling assumptions.

interdealer trade; in other cases we may only have a few. Our second approach measures price impact by tracking movements in dealers quotes at regular intervals surrounding an interdealer trade.

4.2.1 Price impacts using comparable trades. Figure 2 illustrates our first way of measuring the price impact of interdealer trades. As in Figure 1, the top horizontal lines represent the public best bid and ask. The black circles are customer buys and the white circles represent customer sells. The middle white circle represents an interdealer "sell" in which a dealer consumes a limit buy order. This is the event trade, which we label trade 0. To calculate the price impact of this interdealer "sell," we ignore all nearby buy transactions (the black dots), focusing instead on sell transactions (the white dots). By ignoring the buys, we avoid price movements solely due to the ordering of buys relative to sells. We index the sells preceding the interdealer sell by negative trade numbers, with −1 being the immediately preceding customer or interdealer "sell"; the sells after the event interdealer trade are labeled with positive numbers.

The graph at the bottom of Figure 2 displays how the sells in the top portion of the figure translate into a cumulative price impact measure. Both trades −4 and −3 take place at the same (bid) price, and thus there is no price impact to cumulate. Trade −2 takes place inside the best bid, and thus results in a positive price impact of Δ_{-2} relative to trade −3. Since trade −1 is at the bid again, the instantaneous impact of that trade from

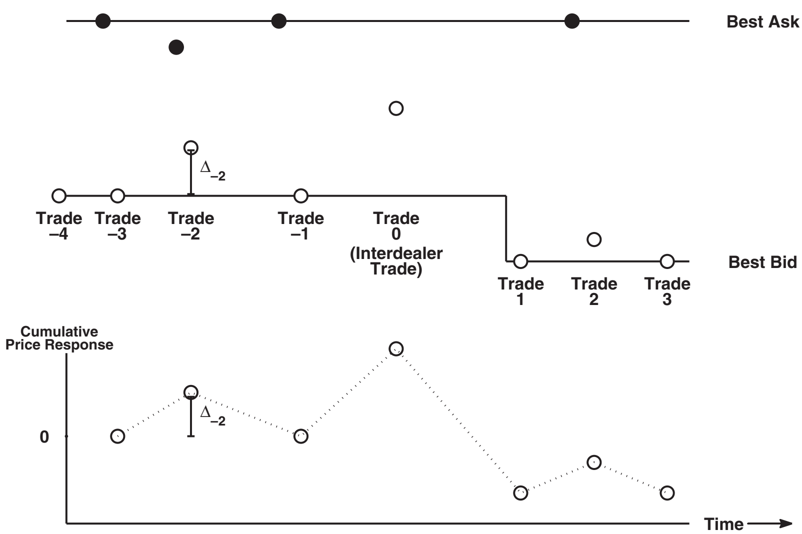

Figure 2
Calculation of trade price impact
This figure shows how we calculate the price impact of an interdealer sell using neighboring sell orders. Dark circles are buys and white circles are sells.

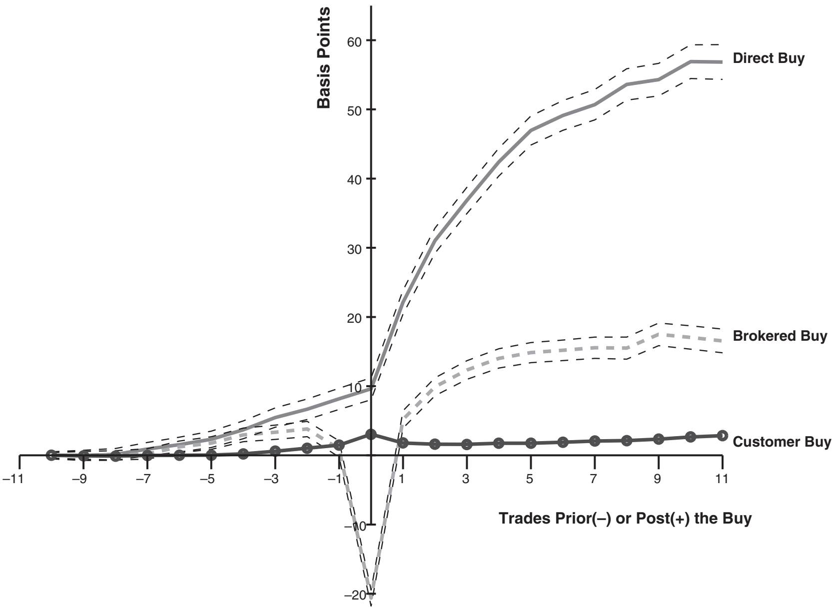

Figure 3
Median price impacts of interdealer and customer buys
Median percentage change in cumulative excess returns beginning 10 trades prior to an interdealer or customer buy. The dashed lines are two estimated standard error bands.

trade -2 is $-\Delta_{-2}$. Thus, the cumulative price impact from trades -4 to -1 is zero. As with trade -2, trade 0 illustrates how transactions within the public spread will tend to affect our price impact measure. In this case, trade 0 is the event trade — a brokered sell. It takes place inside the spread, which is consistent with the price improvement granted brokered trades. (See Table 1.) If nearby trades are not granted much, if any, price improvement then we should see only a one-period price impact of the interdealer trade. If, as in this example, the interdealer sell also is coincident with a subsequent decline in the prices at which sells occur, then we should see a longer-term (cumulative) price impact.

Figure 2 presumes that there are no market factors that might cause prices to change. Because we want to isolate the impact of private information in the trade, we follow the event study literature and adjust our price impact measure for changes in the overall market.[13] Figures 3 and 4 display median cumulative abnormal returns from trades surrounding brokered and direct interdealer buys and sells, respectively. For

[13] We use a conventional market-model adjustment. The security betas come from the London Business School Risk Measurement Service and are adjusted quarterly. We measure the market returns using intraday quote midpoints on FTSE-100 securities.

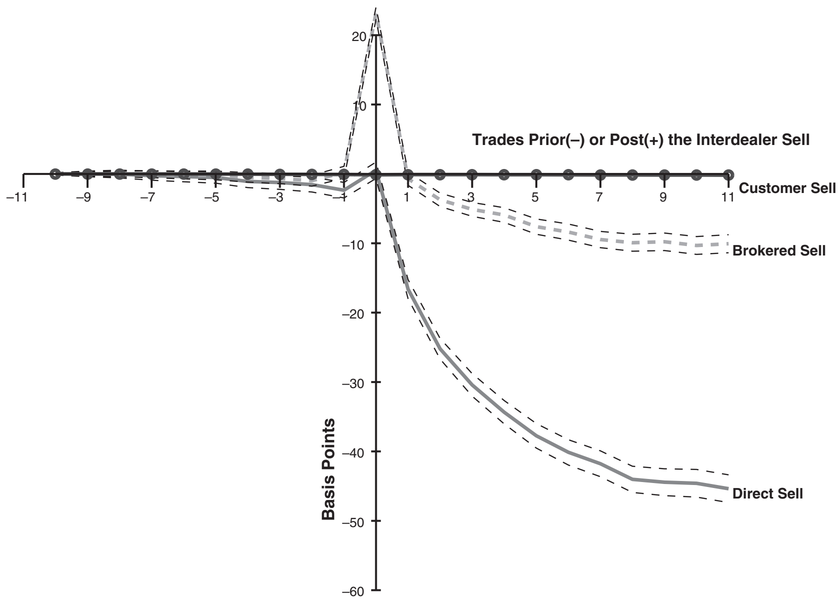

Figure 4
Median price impacts of interdealer and customer sells
Median percentage change in cumulative excess returns beginning 10 trades prior to an interdealer or customer sell. The dashed lines are two estimated standard error bands.

comparison, we also include cumulative abnormal returns for over half-a-million customer trades, where we would expect little or no short-term or long-term price impact.[14] Figures 3 and 4 reveal that the median cumulative price impact of direct interdealer trades is significantly larger than the median price impact of brokered trades, both for buys and sells. The cumulative price impact measured 10 trades after the event is 57 (−45) basis points for direct buys (sells) compared to 17 (−10) basis points for brokered buys (sells). Because, the two-standard error bands (dashed lines) are very tight around each price impact curve, we reject Hypothesis 3A in favor of Hypothesis 3B — direct nonanonymous interdealer trades are on average more informed than the anonymous brokered trades.

The figures also reveal other interesting patterns. For direct interdealer trades, prices begin to move before the event trade. This could occur because the dealer is trading on news or because other interdealer trades may have preceded the direct trade — an issue we explore in later analyses. Most of the price impact of the average interdealer trade occurs within the first few trades. For example, the cumulative impact five trades after the

[14] We favor median cumulative abnormal returns because these are less sensitive to outliers. The results for mean cumulative abnormal returns, however, are not that different from the medians.

event is 47 (−38) basis points for direct buys (sells) compared to 15 (−8) basis points for brokered buys (sells). The figures also show that there is a reversal in the cumulative abnormal returns coincident with brokered interdealer trades. This reversal corresponds to the price improvement granted the brokered trade in Figure 2. Specifically, we find that compared to preceding customer, broker or dealer trades in the same direction, the average brokered interdealer buy is granted about 20–25 basis points in price improvement.[15]

The price impacts of buys are noticeably bigger than those of sells. This is something that has been noted before for large customer trades in London [e.g., Board and Sutcliffe (1995) and Gemmill (1996)] and in other markets [e.g., Chan and Lakonishok (1993)]. Its cause is a matter of debate. Saar (2001) develops a model that provides an explanation for why customer-initiated block buys have a larger permanent price impact than customer-initiated block sells. His story hinges on an unwillingness (or inability) of traders to take short positions. Unfortunately, this story is less suited for explaining the asymmetric price impacts of interdealer trades. London dealers have no problem taking extensive short positions [Reiss and Werner (1998)], and short selling (stock loans) is inexpensive. It is possible that the asymmetry we observe is related to customer block trades that might have motivated the interdealer trades in the first place. We are exploring this hypothesis in other work [Reiss and Werner (2002)]. Finally, in both Figures 3 and 4, we see that customer trades have little price impact.

While the evidence in Figures 3 and 4 suggests that the anonymous brokered systems do not attract more informed trades than the direct market (Hypothesis 3B), these figures do not recognize that brokered limit orders are supplied voluntarily. Thus, they do not capture the possibility that the price impact of an interdealer trade may be dependent upon dealers' unobserved perceptions of the likelihood that a competing dealer is informed. One way to examine this possibility is to focus on the price impact of direct interdealer trades when the public spread is narrow versus wide (Hypothesis 4). When the public spread is narrow, the asymmetric information risk from customers or other dealers is (arguably) perceived by dealers to be smaller than when the public market spread is wide.

Figures 5 and 6 display the price impact of direct interdealer buys and sells conditioned on the width of the Touch in the public market. In these figures we classify a security's spread as narrow if the spread is less than

[15] Table 1 indicates that brokered interdealer trades on average receive 35–40 basis points of price improvement. We find that the average price improvement across all customer, dealer, and broker trades is about 10–15 basis points. The difference between the two (before adjustment for the market return) is therefore between 15–25 basis points.

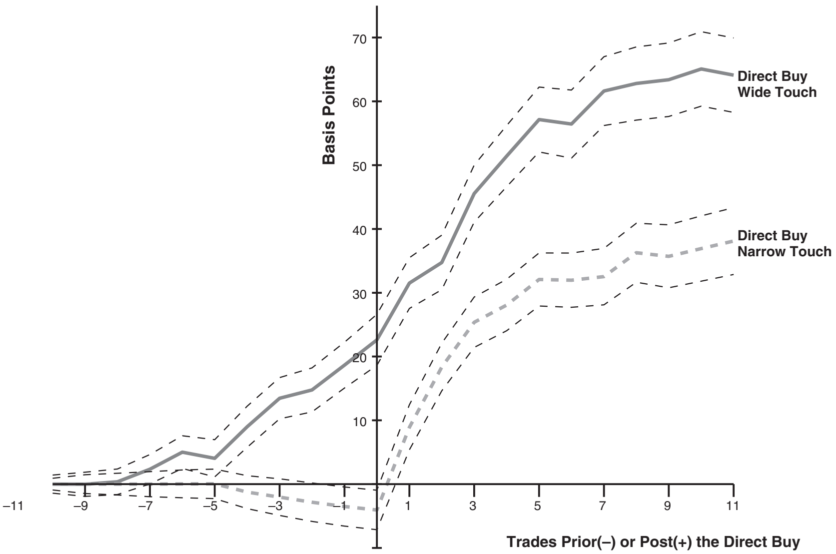

Figure 5
Median price impacts of interdealer buys by width of the Touch
Median percentage change in cumulative excess returns beginning 10 trades prior to a direct interdealer buy according to the width of the Touch. The dashed lines are two estimated standard error bands.

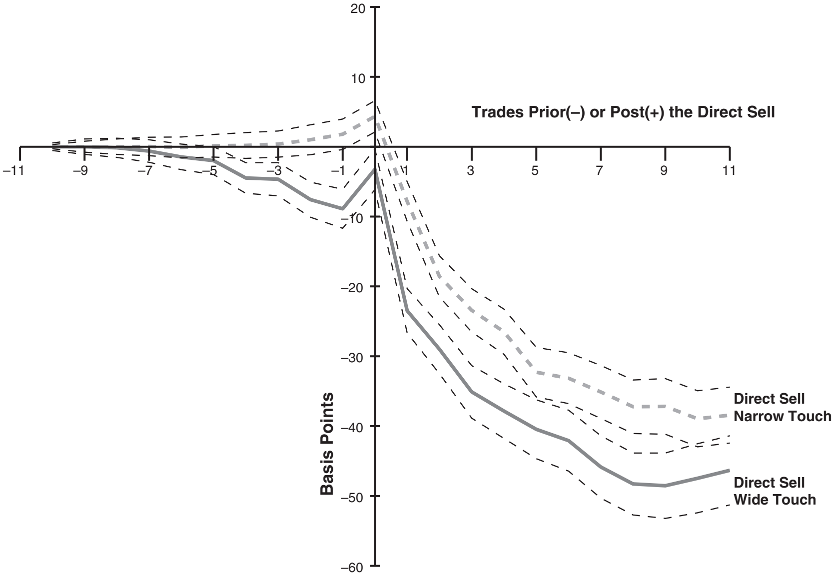

Figure 6
Median price impacts of interdealer sells by width of the Touch
Median percentage change in cumulative excess returns beginning 10 trades prior to a direct interdealer sell according to the width of the Touch. The dashed lines are two estimated standard error bands.

the security's modal spread(s) and wide if the spread is greater that the security's modal spread(s).[16] The figures reveal that the permanent price impact of direct buys and sells does differ according to the width of the public spread (Hypothesis 4). Based on the two standard error bands (the dashed lines) we conclude that when the public spread is narrow, the permanent impact is significantly smaller than when the public spread is wide. When we repeat this exercise for brokered interdealer trades, we find very similar results although the magnitude of the price impacts (both for wide and narrow spreads) is much smaller. These findings are consistent with the hypothesis that hitters who end up paying a wide public spread are more likely informed.

4.2.2 Price impacts using quotes. Most of the price impact literature takes trade time as the relevant period for gauging the price impact of "events." While trade "time" captures the idea that market participants learn when trades occur, participants in dealer markets also observe other information in real time, such as electronically displayed quote information. An additional problem with trade prices in dealer markets is that customers and dealers may split large orders to minimize their price impact. To see whether these differences might matter for our analysis, we also examined the movement of the inside bid and ask quotes at regular time intervals around interdealer trades. Specifically, we record the inside market quotes in 15-minute intervals for up to roughly 3 hours before and after the event interdealer trade. We also record the inside quotes that were first updated more than 15 minutes into the next trading day.[17] Because bid and ask prices need not move in unison, we represent the price impact of the trade differently from the way we did in Figures 3 through 6. Specifically, we express the bid and ask at any point in time in percent deviations (in basis points) from the quote midpoint that prevailed at the time of the trade. This standardization preserves the relative positioning of the bid and ask while removing price differences across securities.

Figures 7 and 8 each have four lines. The solid lines represent the movement in the scaled asks (upper solid line) and scaled bids (lower solid line) of brokered interdealer trades. The dashed lines represent the corresponding scaled asks and bids of direct interdealer trades. In Figure 7 we see that both for brokered and direct interdealer buys, the ask is roughly 50 basis points above the quote midpoint prior to a buy (although

[16] For example, Abbey National trades at spreads between 0 and 4 pence. Since the vast majority of Abbey National trades take place at spreads of 2 and 3 pence, we label spreads less than 2 pence as narrow and greater than 3 as wide.

[17] We choose 15 minutes to avoid any initial price discovery or delayed opening pricing anomalies.

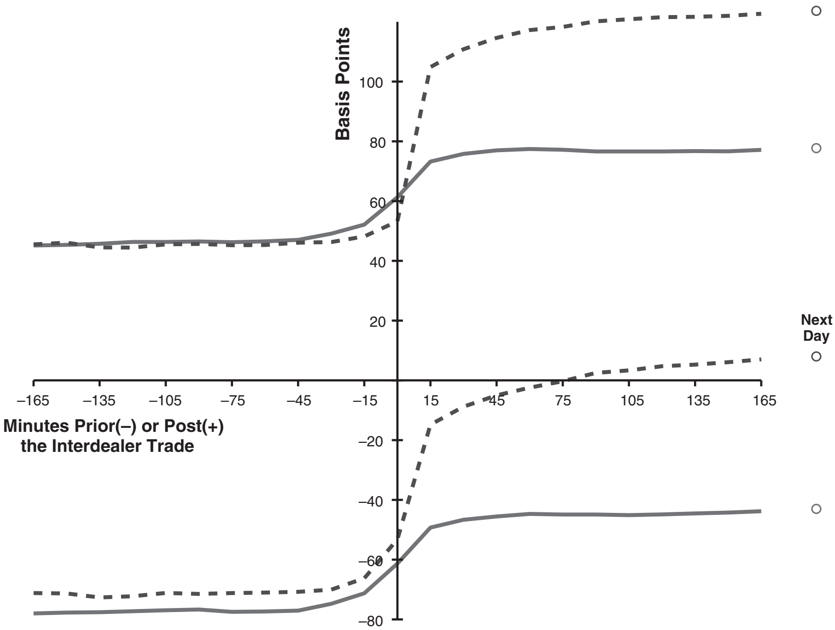

Figure 7
Average (scaled) bid and ask price surrounding interdealer buys
Average bid and ask prices in 15-minute intervals surrounding an interdealer buy. Prices are expressed as basis point deviations from the quote midpoint at the time of the interdealer trade. The dashed lines represent direct trades and the solid lines brokered trades. The circles correspond to the first bids and asks updated 15 or more minutes into the next trading day.

there is a slight rise 15 minutes prior to the interdealer trade). On the other hand, the prior bids for direct and indirect trades are more than 60 basis points below the quote midpoint at the time of the buy, with both brokered and direct bids rising more than the ask just prior to the buy. Thus, it appears (and indeed we find it to be true in looking at dealer quote data) that hitters on average increase the bid slightly prior to when they buy. After the interdealer buy, and consistent with Figures 3 through 6, both bids and asks rise steeply over the next half hour, with direct trades having a larger price impact than brokered trades. Moreover, the absolute movement of the bids and asks from the time of the trade to roughly an hour afterwards is very similar (in basis points) to the price impacts observed in Figure 3. Finally, the parallel rise of both the bid and the ask suggests that the price impact of interdealer trades is not the result of dealers trying to "punish" another dealer who has temporarily narrowed the spread, as has occasionally been alleged in the London market.[18]

[18] See Neuberger and Schwartz (1989).

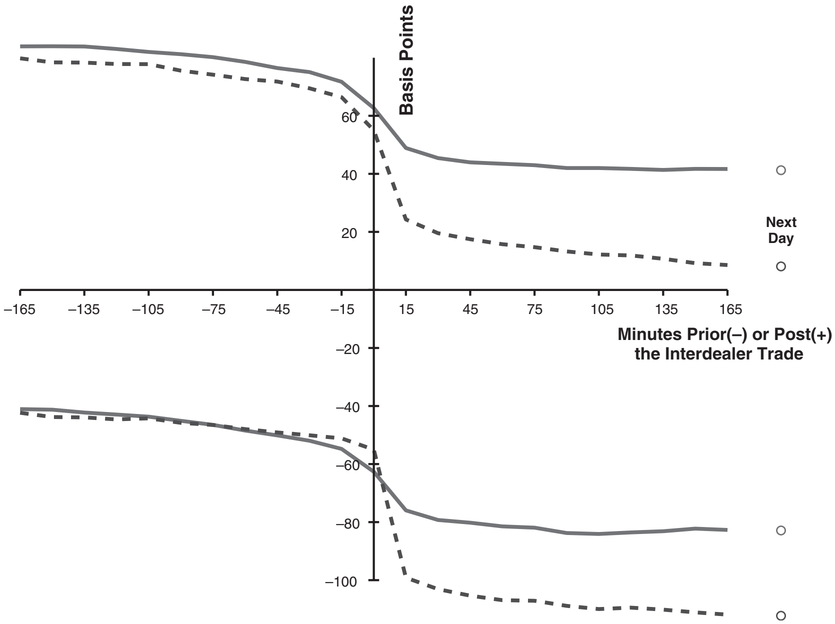

Figure 8
Average (scaled) bid and ask price surrounding interdealer sells
Average bid and ask prices in 15-minute intervals surrounding an interdealer sell. Prices are expressed as basis point deviations from the quote midpoint at the time of the interdealer trade. The dashed lines represent direct trades and the solid lines brokered trades. The circles correspond to the first bids and asks updated 15 or more minutes into the next trading day.

Figure 8 displays the same information for interdealer sells. Here there is a slight drift downward in both the bids and the asks for brokered and direct sells. As in Figure 7, however, the implied spread is narrower for direct trades and in this case the ask drops relatively more than the bid prior to the sell. Again, the movement of the bids and asks from the time of the trade to an hour afterwards is similar to the price impacts displayed in Figure 4.

The figures also reveal that quotes in London respond relatively slowly to the information in direct interdealer trades. For example, it takes about 30–60 minutes for dealers' quotes to incorporate most of the information. This is surprising since a greater than average number of interdealer trades cluster around quote changes. About one-third of all direct trades are followed within one minute by a change in the public best bid and offer, compared to 10.8% of all brokered trades. Moreover, 16% of direct trades (by value) occur less than one minute after a change in the public best bid and offer, compared to 8.7% for brokered trades. In related work, Jones and Lipson (1999) study the reactions of Nasdaq quotes to Nasdaq trades. Although they are unable to distinguish between customer and interdealer trades, they find similar delayed adjustment patterns. Finally, Figures 7 and 8 show that quotes do not revert to their pre-trade levels in the long run, which we take as shortly after the opening on the following day.

To summarize the price impact information in Figures 3 through 8, we find that both trade-based and quote-based price impact measures give roughly the same answer: nonanonymous direct interdealer trades appear to have the largest information content.

4.3 Price impact and trade size

In this section we provide a test of Hypothesis 5 — that direct trades for exactly the minimum quote size (one NMS) have the largest price impact, and that brokered trade price impacts decrease in trade size. Table 2 begins by reporting information on the size distributions of direct and brokered interdealer trades. If, as we conjectured in Section 2, dealers with time-sensitive private information prefer to use direct trades, then we expect to see them trading for the maximum amount the dealer could obtain under Exchange rules (here one NMS). As is apparent from comparing the size distribution rows for buys and sells, approximately half of all direct trades are for exactly one NMS! This compares with only about one-fifth of brokered trades and a tiny fraction of customer trades (not reported). While this finding is not necessarily evidence that many direct trades are informed, it establishes that there is something unusual about the size of direct interdealer trades compared to other types of interdealer and customer trades.

The remaining rows of Table 2 tabulate median price impacts of interdealer buys and sells by four size categories: Those less than one NMS, those equal to one NMS, those between one and three NMS and those more than three NMS. Examining the median cumulative abnormal returns of brokered trades by size, we see little evidence of either a size effect (i.e., larger trades have larger impacts) or of a larger impact for one NMS trades. There is weak evidence of a larger price impact for small brokered buys, but this is not true for sells. This is as one might expect, since dealers decide when and how much to offer in the brokered market.

Turning to the nonanonymous direct market, we see differences in price impacts by the size of the trade. There is clear evidence that direct interdealer trades for exactly one NMS have significantly larger price impacts — roughly a median of 71 (−63) basis points, 11 trades following a direct interdealer buy (sell). But there is no evidence of a monotone size effect with direct interdealer trades; for example, the smallest and largest direct interdealer trades have roughly 30–45 basis point median cumulative excess returns 11 trades out. (These cumulative excess returns for direct trades are nevertheless substantial, exceeding what we observe for brokered trades.)

Table 2
Median cumulative excess returns by trade size before and after interdealer buys and sells

	SIZE < 1 NMS		SIZE = 1 NMS		1 < SIZE ≤ 3 NMS		3 NMS < SIZE	
Trade position	Brokered	Direct	Brokered	Direct	Brokered	Direct	Brokered	Direct
Cumulative abnormal returns for buyer-initiated trades								
−10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
−5	0.01	0.01	0.03	0.04	0.04	0.01	0.00	0.00
−4	0.02	0.00	0.04	0.06	0.05	0.02	0.01	0.00
−3	0.03	0.02	0.04	0.09	0.05	0.03	0.02	0.00
−2	0.03	0.03	0.05	0.11	0.04	0.02	0.01	0.01
−1	0.02	0.03	0.01	0.13	−0.01	0.03	−0.06	0.02
0	−0.22	0.06	−0.18	0.15	−0.20	0.03	−0.20	−0.01
1	0.04	0.14	0.06	0.27	0.06	0.17	0.07	0.08
2	0.10	0.15	0.10	0.39	0.12	0.26	0.07	0.14
3	0.13	0.24	0.12	0.46	0.12	0.31	0.04	0.14
4	0.14	0.28	0.14	0.53	0.14	0.34	0.11	0.19
5	0.16	0.29	0.14	0.59	0.15	0.36	0.06	0.23
11	0.20	0.45	0.14	0.71	0.13	0.41	0.11	0.32
Number	6,409	640	2,616	3,865	2,825	2,419	713	509
Percent	51	9	21	52	22	33	6	7
Cumulative abnormal returns for seller-initiated trades								
−10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
−5	0.00	0.00	−0.01	−0.02	0.00	0.00	−0.01	−0.01
−4	0.00	0.01	−0.02	−0.03	0.00	0.00	0.00	−0.01
−3	0.00	0.01	−0.02	−0.05	−0.01	0.00	−0.01	−0.01
−2	−0.01	0.01	−0.01	−0.06	−0.01	0.01	−0.03	0.00
−1	0.00	0.02	0.00	−0.08	0.01	0.00	0.01	0.00
0	0.25	0.08	0.19	−0.05	0.21	0.03	0.21	0.03
1	0.00	0.01	−0.03	−0.24	−0.02	−0.15	−0.06	−0.09
2	−0.02	0.01	−0.08	−0.35	−0.04	−0.22	−0.04	−0.12
3	−0.04	0.00	−0.08	−0.43	−0.06	−0.25	−0.07	−0.15
4	−0.05	0.00	−0.10	−0.48	−0.05	−0.29	−0.12	−0.16
5	−0.06	−0.01	−0.13	−0.52	−0.07	−0.32	−0.10	−0.22
11	−0.08	−0.07	−0.14	−0.63	−0.09	−0.38	−0.12	−0.31
Number	6,276	849	2,352	3,941	2,297	2,917	546	613
Percent	55	10	21	47	20	35	5	7

Excess returns are calculated using a market model. The market return is a FTSE-100 index based on midquote prices. NMS is the minimum trade size the market maker must guarantee at his posted quotes. SIZE is the size of the interdealer trade. The category SIZE < 1 NMS consists of all interdealer trades smaller than the minimum trade size guaranteed by the market maker. The other size categories have similar interpretations. The percentages are calculated as a fraction of brokered or direct trades.

Table 2 also reveals that most of the information leakage prior to direct interdealer trades observed in Figures 3 and 4 is attributable to information leakage prior to one NMS direct trades. For example, by the time of the buy prior to an direct buy (i.e., trade −1), the median price has drifted up by 13 basis points, compared to less than 3 basis points for other direct interdealer trades and less than 2 basis points for brokered interdealer buys. This lends additional support to our hypothesis that dealers with time-sensitive private information are more likely to resort to (sequences) of direct trades of exactly one NMS.

Taken together, these results strongly suggest that trades placed in brokered systems have much less information content than trades negotiated with competing dealers. This evidence thus supports the sorting mechanism outlined in our section on hypotheses.

4.4 Price impacts of large and small dealers

The previous section showed that direct interdealer trades have greater price impacts than brokered interdealer trades. We argued that these price impacts reflected an equilibrium wherein dealers with timely information traded in the direct market. Moreover, we found that trades for the maximum guaranteed size at the posted quotes (one NMS) produced the largest price impacts.

Hypothesis 6 asserts that dealers that capture more customer order flow are more likely to be informed, and we should see larger price impacts of these dealers' trades in the direct (nonanonymous) market than in the brokered market. We base the specific form of our test on conversations with London dealers and prior market microstructure research [e.g., Naik, Neuberger, and Viswanathan (1999)]. During the period of our sample, London dealers were known to solicit large customer orders, even if the terms were unfavorable. The explanation most often given for this behavior was that dealers were "purchasing" information in large customer orders. That is, the logic was: The more large customer volume a dealer could capture, the greater the informational advantage they could achieve. If large customer orders do convey an information advantage, then we would expect to see that direct interdealer trades initiated by "large" dealers would have a greater price impact.

During the period of our study, there were approximately 20 equity dealers that conducted significant business on the Exchange. Of these, six managed to obtain roughly 8% or more of the total customer volume in these 25 FTSE securities. We classify these dealers as "large." Together, these "large" dealers account for more than 70% of customer orders and 60% of interdealer orders (by value). Table 3 reports estimates of the price impact of interdealer trades by trade size and dealer classification. To condense the table, we report the price impact of the associated trades 60 minutes after the interdealer trade. We compute the price impact based on the cumulative change in the midpoint 60 minutes after the interdealer trade compared to the quote midpoint at the interdealer trade. (See Figure 2.)

The columns of Table 3 report average price impacts for brokered buys and sells, and direct buys and sells. We use averages in this table to facilitate hypothesis tests. The first panel of Table 3 shows that the average 60 minute price impact for brokered buys (sells) is 41.7 (−36.7) basis points that is substantially smaller than the average price impact of direct buys (sells) of 74.5 (−58.8) basis points. These numbers are consistent with

Table 3
Price impact of interdealer trades by dealer and trade size

	Brokered		Direct	
	Buys	Sells	Buys	Sells
Trades (valid quotes the next day)	12,401	9,924	7,334	7,563
Mean return (basis points)				
One hour after trade	41.7	−36.7	74.5	−58.8
Next day after 45 minutes	41.0	−34.4	87.2	−72.4
Mean return after one hour (basis points)				
Small dealer < 1 NMS	31.2	−25.7	45.1	−20.4
Small dealer = 1 NMS	34.1	−30.8	79.3	−52.9
Small dealer > 1 NMS	33.2	−24.6	62.3	−39.7
Large dealer < 1 NMS	55.7	−53.1	80.9	−23.9
Large dealer = 1 NMS	40.3	−39.0	92.5	−96.9
Large dealer > 1 NMS	44.4	−37.4	61.8	−52.7
T-statistics for difference in large dealer versus small dealer mean returns				
<1 NMS	6.8	−8.3	2.4	−0.2
=1 NMS	1.1	−1.4	2.4	−8.9
>1 NMS	1.9	−2.1	−0.1	−2.4
T-statistics for difference in direct versus brokered mean returns				
Small dealer < 1 NMS			2.0	1.0
Small dealer = 1 NMS			7.1	−3.6
Small dealer > 1 NMS			4.1	−2.2
Large dealer < 1 NMS			1.9	2.2
Large dealer = 1 NMS			11.0	−12.4
Large dealer > 1 NMS			3.3	−3.5

Price impacts are computed as the average cumulative basis point change in the best bid and ask starting up to three hours before the trade and ending one hour after the interdealer trade. NMS is the dealer minimum quote size. The six large dealers account for 70–80 percent of customer volume. The small dealers are all other dealers.

the results in previous sections. In the next panel, we jointly control for the identity and the size of the trade. For example, a small buy initiated by a small dealer changes price by 31.2 basis points. By contrast, a brokered buy by a large dealer that is smaller than one NMS has a significantly larger price impact of 55.7 basis points. The patterns for direct trades are similar. For example, a direct one NMS sell by a small dealer has a price impact of −52.9 basis points, compared to −96.9 basis point change following a one NMS direct sell by a large dealer.

In general, the (absolute) price impacts for a large dealer tend to be greater than those for a small dealer. The third panel of Table 3 reports *t*-statistics for differences in 60 minute price impacts for trades initiated by large and small dealers by trade size. Here, we see that brokered trades smaller than one NMS, brokered trades larger than one NMS, direct buys less than or equal to one NMS, and direct sells larger than one NMS have statistically significant differences in price impacts favoring large dealers. The results for the one NMS direct trades are again consistent with the supposition that larger dealers with more information will ask for the minimum quote size. The main surprise in the table is that small interdealer trades by dealers with large order flows tend to have much greater impacts than those by small dealers. It suggests that larger dealers with information may hit small brokered limit orders before they resort to direct trades. We elaborate on this issue in the next subsection.

For completeness, we also report *t*-statistics for the difference between price impacts following direct and brokered interdealer trades by dealer identity and trade size at the bottom of Table 3. Sixty-minute price impacts following direct trades are significantly larger than for brokered trades. (The one exception is for large dealer sells less than one NMS, where we have few trades.) This is further evidence of the robustness of our finding that direct interdealer trades have greater price impacts.

4.5 Price impact and clustering

Our final hypothesis examines whether the clustering of interdealer trades is associated with unusual price impacts. In particular, we hypothesize that dealers with short-lived private information are more likely to use several rapid direct interdealer trades to change their position.[19] We therefore expect sequences of direct interdealer trades to have larger price impacts than a single, isolated interdealer trade.[20]

We define a “rapid” sequence of interdealer trades as an instance in which a dealer makes at least one other interdealer trade in a five-minute window surrounding the “event” interdealer trade. We pick five-minute windows on either side to allow the dealer enough time to have placed several (phone) orders. We limit the window to five minutes to minimize the impact of other information and because direct interdealer trades this close together are more likely to have an information impact.

To measure the effect of having more than one interdealer trade in the event window, we regress the change in the midpoint quote from the time of the trade until one hour afterward. Following the logic of Table 3, we include six zero-one indicator variables that control for whether the initiating dealer is small or large, and whether the trade is for less than one NMS, exactly one NMS, or more than one NMS. Next we include zero-one indicator variables describing a sequence of interdealer trades in the *same* direction by the *same* dealer. Specifically, we include zero-one indicator variables for whether the same dealer

[19] Dealers could use several interdealer trades to manage competing dealers’ beliefs or because competing dealers only have to accept trades of up to one NMS.

[20] We thank Joel Hasbrouck and an anonymous referee for suggesting that we investigate in greater detail price impacts associated with sequences of interdealer trades.

Table 4
One-hour price impact regressions conditional on dealer size, trade size, and numbers of surrounding interdealer trades.

	Brokered		Direct	
	Buys	Sells	Buys	Sells
Interdealer trade variables				
Small dealer < 1 NMS	12.02	−12.81	18.51	−15.92
	(8.80)	(−9.59)	(4.52)	(−5.03)
Small dealer = 1 NMS	10.31	−10.68	41.84	−18.84
	(4.43)	(−4.26)	(17.46)	(−8.64)
Small dealer > 1 NMS	6.69	−9.63	34.72	−20.59
	(3.05)	(−3.76)	(13.75)	(−9.17)
Large dealer < 1 NMS	23.08	−26.63	7.76	−0.68
	(16.77)	(−19.21)	(0.81)	(−0.11)
Large dealer = 1 NMS	16.07	−19.00	42.92	−38.74
	(8.85)	(−10.53)	(19.38)	(−18.92)
Large dealer > 1 NMS	14.41	−15.96	37.83	−32.26
	(9.62)	(−10.04)	(19.49)	(−18.86)
Same dealer hits in the same direction within five minutes				
Brokered trades				
1 Trade	5.30	−1.02	−1.08	−6.56
	(3.18)	(−0.58)	(−0.27)	(−1.61)
2 Trades	5.60	−2.78	30.03	−16.65
	(1.54)	(−0.73)	(2.47)	(−1.48)
3+ Trades	4.54	6.22	31.09	−17.89
	(0.06)	(0.96)	(1.09)	(−0.70)
Direct trades				
1 Trade	29.99	−32.99	26.37	−31.87
	(7.14)	(−8.03)	(10.36)	(−13.61)
2 Trades	55.20	−30.46	37.38	−36.35
	(7.34)	(−3.74)	(11.81)	(−11.70)
3+ Trades	52.48	−52.45	55.56	−63.82
	(4.25)	(−4.00)	(19.20)	(−21.85)
Different dealer hits in the same direction within five minutes				
Brokered trades				
1 Trade	−4.85	2.80	3.49	−9.09
	(−2.99)	(1.67)	(0.86)	(−2.33)
2 Trades	−10.79	12.32	12.95	−12.31
	(−4.21)	(4.29)	(1.51)	(−1.29)
3+ Trades	−17.86	−18.30	−37.58	−41.49
	(−4.39)	(−3.24)	(−2.43)	(−2.54)
Direct trades				
1 Trade	14.34	−25.01	14.73	−2.34
	(4.00)	(−6.54)	(4.85)	(−0.74)
2 Trades	44.79	−41.57	17.63	−4.35
	(5.60)	(−4.57)	(2.74)	(−0.60)
3+ Trades	75.82	−41.18	−61.62	−37.82
	(6.25)	(−4.02)	(−7.14)	(−3.70)
Regression *F*	57.1	65.2	254.5	215.6
Trades	10,755	9,507	6,571	7,404

Price impacts are computed as the change in the quote midpoint from the time of the trade until one hour later. We lose some observations at the end of the day and because of missing quotes. *T*-statistics are in parentheses. NMS is the dealer minimum quote size. The six large dealers account for 70–80% of customer volume. The small dealers are all other dealers.

initiates 1, 2, or 3, or more brokered or direct interdealer trades in the same direction in the event window. We also include for completeness zero-one indicator variables for whether a *different* dealer initiated interdealer trades in the *same* direction. The top panel of Table 4 reports the estimated price impacts in basis points for a single interdealer trade in a five-minute window. This is the effect of a single interdealer trade during the event window. Comparing these price impacts to those in Table 3, we see that the price impacts in Table 4 are somewhat smaller in absolute value. This suggests that the price impacts in Table 3 are larger because they include the price impacts of nearby interdealer trades.

In the middle panel of Table 4 we report the estimated effects of one or more additional direct or brokered interdealer trades by the same dealer in the same direction as the event trade. The price impacts of additional direct trading initiated by the same dealer and in the same direction are striking in magnitude and significance. For example, a sequence of two direct buys in the same direction as a one NMS brokered buy by a large dealer has an additional price impact of 55.2 basis points, for a total price impact of 71.3 (16.1 + 55.2) basis points. These effects are particularly strong when a rapid sequence of direct trades occurs during the same window as a brokered trade (the first two columns). For example, a sequence of three or more direct sells in the same five-minute window as a brokered one NMS sell by a large dealer is associated with an additional price impact of −52.5 basis points, for a total price impact for the sequence of −71.5 (−52.5−19.0) basis points. This is consistent with a dealer first trying to consume liquidity in brokered systems, but then resorting to more expensive direct quote-based trading. By contrast, additional brokered trades initiated by the same dealer in the same direction have a considerably smaller, albeit occasionally significant, price impact.

The third panel of the table reports the additional price impact attributable to direct or brokered interdealer trades (in the same direction) made by other dealers. Additional direct trading by other dealers in the event window adds to the price impact. Thus, it is not merely a sequence of direct trades by the dealer that initiated the event trade that has an effect. Moreover, we see that the magnitudes of the additional price impacts are about the same as for additional direct trades by the initiating dealer. By contrast, additional brokered trades initiated by other dealers (in the same window and same direction), sometimes mitigate the price impact of the original trade. The impacts of additional brokered trades initiated by competing dealers around a direct quote-based interdealer trade also is mixed.

In summary, rapid sequences of direct quote-based trades in the same direction are associated with substantially larger price impacts than isolated direct or brokered interdealer trades. This is true whether or not the additional trading is initiated by the same dealer or by competing dealers. The evidence is mixed for additional brokered trades in the same direction as the event trade. Overall, these patterns are consistent with our hypothesis that informed dealers will primarily use sequences of direct quote-based trading to benefit from their superior information. They are also consistent with the recent finding of Bjønnes and Rime (2001) who study interdealer trading in foreign exchange markets.

5. Profitability of Interdealer Trading for Hitters and Posters

The prior sections have shown that the two types of interdealer trades have different immediate execution costs and long-term price impacts. An obvious next step is to ask whether these differences effectively balance the adverse selection risks facing the posters and hitters in interdealer trades. The evidence presented so far clearly suggests that the initiating dealer (the hitter) benefits on average from both brokered and direct interdealer trades. The question then is, does this come at the expense of posting dealers?

We measure the benefits from interdealer trades by imagining that dealers adopt a buy (sell) strategy for a fixed time period. Although this measure has some drawbacks, it nevertheless provides an idea of the capital gains or losses dealers could capture. We assume for the purposes of the calculation that the dealer keeps a long (short) position for a fixed time window and then closes out the position at the market ask (bid). We vary the time window from one hour to the next day to gauge the sensitivity of our findings to the fixed holding period. This particular definition thus imagines that returns accrue from the way the hitter and poster split the public spread during the period that price is adjusting to the information impounded in the interdealer trade.[21] In computing the returns of dealers in brokered trades, we also account for the interdealer broker's fee (paid by the hitter).

Table 5 reports the estimated returns broken down by brokered and direct trades. As a benchmark, the average spread for a security in our sample is roughly 110 basis points (of price). The results show that for each strategy, hitters receive greater returns from direct trades than brokered trades. The difference between direct and brokered trades is larger for buys than for sells; it also increases the longer the dealer holds the position. The day following the interdealer trade, the median gain is 77.5 (68.2) basis points for direct buys (sells) compared to 50.1 (55.1) basis points for brokered interdealer buys (sells). We next examine whether hitters profit entirely at the expense of posters. According to Table 5, the posters do profit in interdealer trades, but not as much as hitters. Based on the next day's quotes, the poster typically gains 52.5 (53.8) basis

[21] Alternatively, one could compare the purchase (sale) price of an interdealer trade with a future market bid (ask). Our definition of buyer (seller) revenue would equal the seller (buyer) cost with this alternative definition.

Table 5
Gains to posters and hitters

	Median percent gain to dealer after							
	One hour		Two hours		Three hours		Next day	
	Hitter	Poster	Hitter	Poster	Hitter	Poster	Hitter	Poster
Buyer-initiated interdealer trades								
Brokered	49.9	50.0	49.2	51.8	49.7	50.3	50.1	52.5
Direct	61.7	45.8	67.1	40.4	70.0	42.2	77.5	27.1
H0: Gain(Direct) = Gain(Brokered)								
Z-value	8.6	−4.5	8.3	−7.9	6.7	−3.5	9.5	−8.1
p-value	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Seller-initiated interdealer trades								
Brokered	47.7	53.8	50.2	54.0	50.9	51.5	55.1	53.8
Direct	53.3	53.2	57.2	50.3	62.5	47.5	68.2	47.5
H0: Gain(Direct) = Gain(Brokered)								
Z-value	7.9	−1.2	6.0	−3.3	4.3	−2.9	3.6	−4.1
p-value	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0

This table reports the median gains for hitters and posters in interdealer trades. When the hitter buys, the gains are calculated as 100 times the ask price (at the stated reference time) minus the purchase price. When the hitter sells, the gains are calculated as 100 times the sale price minus the bid price (at the stated reference time). We use four reference times: one hour; two hours, three hours, and the opening quotes the next day. The hypothesis tests are Brown–Mood two-sample tests of medians.

points following a brokered buy (sell) and 27.1 (47.5) basis points following an direct buy (sell). Perhaps not surprisingly, the poster consistently is better off being involved in brokered trades than in direct trades. Moreover, the difference in gains between brokered and direct trades increases the longer the posting dealer holds onto his position.

While these results suggest the gains to hitters and posters are closer than one might have initially expected, they also suggest that dealers should be unwilling to participate in direct trades. This argument misses three important points. First, London dealers cannot avoid direct trades less than or equal to one NMS from a competing dealer. If we exclude direct trades less than or equal to one NMS, the difference decreases considerably (not reported). Second, the dealers typically do earn positive returns from taking direct customer trades. Third, there is an unrecorded benefit to posting dealers that we do not capture — any risk-sharing benefits. If dealers posting attractive quotes tend to be the ones with large inventory imbalances, they are likely to receive additional benefits from taking an interdealer trade.

In sum, both the hitter and the poster strategies generate positive returns from participating in interdealer trades. The returns for hitters are smaller than the cumulative abnormal returns in Figures 3 and 4. The reason for this is that the price improvements in brokered trades offset a large part of the difference in price impacts between direct and brokered trades. In other words, the posting dealers try to price out the adverse selection component of interdealer trades! That the offset is not perfect is not surprising given the potential benefits of risk sharing. These results are consistent with the risk-sharing nature of interdealer trading found empirically in Reiss and Werner (1998).

6. Conclusions

Market makers in dealer markets such as London and Nasdaq often have access to several different trading systems. Dealers in London, for example, had two equally popular ways that they could use to trade with one another. These trading systems differed along several key dimensions, which included cost, anonymity, liquidity, and transparency. We find that these differences appear to facilitate (imperfect) sorting of informed interdealer trades.

Our findings provide insights into the role of anonymity and endogenous liquidity of trading systems in fragmented markets more generally. Many theoretical models and several empirical studies suggest that informed traders will prefer to trade in anonymous trading systems. Barclay, Hendershott, and McCormick (2003), for example, found that informed trades in Nasdaq listed stocks tend to migrate to anonymous ECNs. By contrast, our results show the opposite — the direct market appears to attract more informed interdealer trades.

Our explanation for this difference centers on who has access to the anonymous systems. London Stock Exchange rules deliberately denied other brokers and customers access to the anonymous systems, thus, making the system a risk-sharing device largely for registered market makers. Although brokered systems in bond markets and foreign exchange markets are less regulated, these systems also tend to limit access to dealers. In the U.S., the SEC, when faced with the issue of how to regulate alternative trading systems, has instead promoted open access in the interest of price competition. Anonymous ECNs, however, have not uniformly embraced open access. For example, Instinet has continued to limit access to dealers and select institutional traders while the Island ECN is open to virtually everyone. Hence, like the London brokered systems, Instinet caters to risk-sharing among dealers and large institutions.

Based on our results, we expect that trades on Instinet would be less informative on average than those that occur on the Island ECN. Unfortunately, Barclay, Hendershott, and McCormick (2003) are unable to separate out different ECNs. However, in a recent paper Tuttle (2004) finds (unconditionally) that trades in Nasdaq listed stocks that execute on the Island ECN have significantly higher information content than trades that execute in other venues. This suggests that in order for informed traders to be able to regularly execute trades in an anonymous market, it may be necessary to have a sufficient number of uninformed (retail) traders.

Our results also suggest several interesting avenues for further research. The most obvious extension is to model the process that leads to an interdealer (or sequence of interdealer) trade(s). By observing events such as large block customer trades, one could begin to trace how information may diffuse through a dealer market, and how differences in dealers' trading strategies may affect this diffusion. For example, our results suggest that the price impacts of large customer trades may differ according to the strategy that the dealer uses to lay off the block. While the dealer's strategy and the decision to accept the block are obviously joint decisions, the availability and liquidity of alternative trading venues will likely have a critical impact on how quickly information is transmitted.

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