THE JOURNAL OF FINANCE • VOL. LII, NO. 1 • MARCH 1997

Quotes, Order Flow, and Price Discovery

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ABSTRACT

The goal of this article is to examine the impact of 1975 Congressional mandate to integrate the trading of NYSE-listed stocks. The conclusions are: most of the time, the New York Stock Exchange (NYSE) quote matches or determines the best displayed quote, and the NYSE is the most frequent initiator of quote changes. Non-NYSE markets attract a significant portion of their volume when they are posting inferior bids or offers, indicating they obtain order flow for other reasons, such as "payment for order flow." Yet, when a non-NYSE market does post a better bid or offer, it does attract additional order flow.

A major goal and ideal of the securities markets and the securities industry has been the creation of a strong central market system for securities of national importance, in which all buying and selling in these securities could participate and be represented under a competitive regime. This goal has not as yet been attained.

The Institutional Investor Study Report
of the Securities and Exchange Commission
March 10, 1971, Volume 1, Page xxiv.

THE 1975 AMENDMENTS TO the Securities Exchange Act of 1934 made it U.S. policy to develop a national market system for the trading of securities. The underlying assumption is that "[t]he linking of all markets ... will foster efficiency, enhance competition, increase the information available to brokers, dealers, and investors, facilitate the offsetting of investors' orders, and contribute to best execution of such orders." In view of the potentially significant implications of this Congressional finding, there has been surprisingly little theoretical or empirical work that examines the underpinnings of the assumptions upon which this policy directive rests.[1]

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[1] Notable exceptions are Mendelson (1987) and Harris (1993).

As part of achieving this integration, the SEC approved and encouraged the establishment of several electronic systems to link the markets.[2] This article studies the effects of this particular integration on the trading of New York Stock Exchange (NYSE)-listed stocks with the goal of obtaining a better understanding of the current institutional structure; it makes no attempt to compare and contrast the current institutional structure to other possible structures.

The article begins in Section I with a description of the electronic systems that have been implemented to link the markets for NYSE-listed securities. The material in Section II describes the institutional structure of the markets for trading NYSE-listed stocks, discusses the growing practice of non-NYSE market makers to purchase the order flow of small traders, suggests why this practice is profitable, and proposes five empirical questions about the trading of NYSE-listed equities across markets. The questions themselves address the relative importance of the various markets in setting the best bid or offer, the effect of posting better bids and offers in attracting order flow, and the role of these markets in the process of "price discovery." The main empirical results are presented in Section III. The article concludes in Section IV.

I. The Electronic Systems

NYSE-listed stocks trade in both United States and foreign markets. The primary U.S. markets for the trading of NYSE-listed stocks are the New York Stock Exchange itself, the five regional stock exchanges (Boston, Chicago, Cincinnati, Pacific, and Philadelphia), and other organizations, not members of the NYSE, who stand ready to make markets or facilitate trades in NYSE-listed stocks. Examples of these other organizations include Bernard L. Madoff Investment Securities, Instinet, and Posit.

Boston, Chicago, Pacific, Philadelphia, and the NYSE are traditional exchanges with a physical floor where specialists and traders meet and transact business. Cincinnati does not have a traditional physical floor, but rather provides remote electronic interfaces in which multiple designated dealers can post quotes in a single stock and execute trades in conformity with preestablished priority rules. For NYSE-listed stocks, Nasdaq allows market makers who are generally not members of the NYSE to post bids and offers and to report trades executed in their offices. Both Madoff and Posit utilize Nasdaq to report trades executed in their markets, although Madoff also reports some trades through Cincinnati.

The primary domestic markets for trading NYSE-listed stocks are linked electronically through three major systems. The first is the Consolidated Tape Association (CTA), which reports the trading activity in NYSE-listed stocks on

[2] The development and refinement of the national market system is still ongoing. The most recent chapter in the evolving national market system is the recent release on "Order Execution Obligations" (SEC (1995)), which proposes rule changes on the dissemination of quotes, display of customer limit orders, and price improvement procedures.

the NYSE as well as the regional exchanges and Nasdaq. The second is the Consolidated Quotation System (CQS), which distributes current quotations on most U.S. markets for NYSE-listed stocks. The third is the Intermarket Trading System (ITS), which allows exchange members and dealers on Nasdaq to route an order to another market for execution at the quote of that market.

The CTA consists of two systems: System A collects all trades in NYSE-listed stocks that are reported by the NYSE, the AMEX, the regional exchanges, and Nasdaq, while System B collects the same data for AMEX-listed stocks and stocks with primary listings on the regional exchanges that meet the listing requirements of the AMEX. The CTA disseminates this trade information to the markets themselves and to outside vendors who distribute the information over their own systems. The specific information provided includes the number of shares traded, the execution price, and a condition code that qualifies the trade, such as reported out of sequence.

The CQS is an electronic system similar to the CTA except that it reports the quotes for NYSE-listed stocks from the NYSE, the regional exchanges, and Nasdaq market makers. Each market maker on the NYSE and the regional exchanges must transmit through CQS a firm quotation in each stock in which it makes a market.[3] A quotation consists of a bid and an offer. The bid includes a bid price and the depth (the number of shares that can be sold at that price); the offer includes an ask price and the depth (the number of shares that can be purchased at that price). As is the case with CTA, the quotation may include a condition code. Thus, CQS contains the information necessary to determine the market or markets with the best bid price and the best ask price—in short, the best displayed prices.

In contrast to CTA and CQS, which report previously executed trades and current quotes, ITS is an electronic communication system that facilitates trading among markets. Specifically, a market maker in one market can transmit electronically a "commitment to trade" to another market. If the commitment is sent to the NYSE, it must be accepted within two minutes; if the commitment is sent to a non-NYSE market, it must be accepted within one minute. If the order is not accepted, the commitment expires unexecuted. As such, it is not an automatic execution system. Indeed, Loss and Seligman (1990, p. 2566) cite evidence that only 78 to 80 percent of the commitments are actually accepted.

The rules of ITS require that a public market order submitted to any market be executed at a price no worse than the best price that is displayed on CQS, but it is important to note that these rules provide no guarantee that the market displaying the best bid or offer will be the contraparty to the transaction. Specifically, a market with an inferior quote that receives an order has two choices. First, the receiving market can send a commitment to trade to the

[3] Originally, the SEC required all market makers to post firm quotes, but in February 1982 changed its rules so as only to require the primary market maker to provide firm quotes. This change has had no impact on the regional exchanges since the rules of ITS require specialists on these exchanges to provide firm quotes in the stocks in which they make a market.

market with the best bid or offer, in which case the contraparty to the execution will be the market displaying the best bid or offer. Second, the receiving market can itself execute the order at the best displayed bid or offer or a better price, not its own inferior bid or offer, in which case the contraparty to the transaction will not be the market displaying the best bid or offer but instead the market that initially received the market order.

Another intent of the electronic integration of the markets was to preserve the regional exchanges as competitive forces to the NYSE. SEC (1972, p. 11) states: "The Commission believes that the liquidity needs of individual and institutional investors can best be provided by policies fostering the development of competition among dealers who are specialists, market-makers and block positioners. Such competition will mitigate the very difficult problem which now [e]xists of developing and enforcing rules designed . . . to prevent specialists from abusing their privileged position." It is not the purpose of this article to examine the effectiveness of this goal, but it might be noted that articles in *Securities Week* (1989) and *Securities Week* (1990) report that Goldman Sachs in late 1989 redirected some of its order flow from the NYSE to the Midwest Exchange, now known as Chicago, to pressure NYSE specialists to cut their fees.

II. Market Structure

At the beginning of the twentieth century, both oral and written communications over long distances were expensive and often so slow as to be nonexistent. Doede (1967) argues that these impediments to communication originally required the regional trading of securities; but with gradual improvements over time in communication systems, he goes on to suggest that trading will become more centralized as investors seek out additional liquidity. Consistent with this hypothesis, he finds that there were over 100 regional stock exchanges at the beginning of the twentieth century, 35 by 1935, and 15 by 1965. But even in 1935, Doede's figures show that the NYSE was still the dominant market with 86.6 percent of trading volume. Today, there are only five regional stock exchanges. In a slightly different setting, the evidence in Silber (1981) confirms the tendency of trading in a specific future contract to concentrate over time in one market.

In view of this strong tendency to centralize the trading of a specific security in a specific market, the question naturally arises of why today there are any regional exchanges at all. One reason for their continued existence is that traders can sometimes use the regionals to avoid the rules of the NYSE. Investors in the 1950s through the mid-1970s used the less restrictive rules of the regionals to rebate a portion of trading commissions that were fixed substantially above what they would have been under a competitive regime.[4] Today, the upstairs market sometimes uses the regional stock exchanges to execute a cross of two orders put together in the upstairs market. If brought to

[4] Cf. SEC (1963) and SEC (1971).

the NYSE floor for execution, such a prearranged cross must sometimes be broken up to satisfy prior orders already represented on the floor, with the result that one side of the crossed trade is not fully executed; oftentimes the regional stock exchanges can provide a "clean cross"—an execution in which only the crossed parties participate. As another example, the rules governing short selling sometimes allow an institution to execute a short sale on a regional exchange, but not on the NYSE. Harris (1993) contains a more general discussion of reasons why an investor would avoid using the NYSE.

A. Payment for Order Flow

In recent years, the regional stock exchanges and other market makers that are not members of the NYSE have found an additional niche to compete with the NYSE by paying brokers to send them the order flow of small retail customers. This practice, known as "payment for order flow," is reported to involve a payment of $0.01 to $0.02 per share from the market maker to the retail broker for orders that the retail broker sends to the market maker.[5] According to the SEC's "Market 2000" (1994, II–10, 11), this activity, which typically involves only the 400 most actively traded stocks, accounted for 5.0 percent of the consolidated tape trades in 1989 and 9.3 percent in 1993. The largest market maker paying for order flow is Bernard L. Madoff Investment Securities, which, according figures cited by Weiss (1990), handled 80 percent of such trades in 1990. That "payment for order flow" persists is strong evidence of the profitability of this practice. The following suggests possible sources for this profitability.

The evidence presented in Blume and Goldstein (1992), Lee (1993), and Petersen and Fialkowski (1994) shows that trades on the NYSE often take place at better prices than the best bids and offers as displayed on CQS, a phenomenon that has become associated with the term "price improvement." The possibility of price improvement means that an investor who places a market order does not know the actual quote at the time of submission but only that it will be at least as good as the displayed quote. To illustrate, if the displayed quote is a bid of $20 and an offer of $20¼, an investor submitting a market order faces one of the following: (a) the displayed quote, (b) a bid of $20 and an offer of $20⅛, or (c) a bid of $20⅛ and an offer of $20¼.[6] The possibility of price improvement requires that the actual quote is either (b) or (c) with positive probability. In this example, an investor submitting a market sell order would receive either $20 or $20⅛, and an investor submitting a market buy order would pay either $20¼ or $20⅛, with the result that the expected or what has been termed the "effective" spread is less than the displayed spread.

[5] See Stern (1989), SEC (1989), and NASD (1991) for a more detailed discussion of this and related practices. Despite these reports, there is no authoritative survey of this practice in the public domain.

[6] It is theoretically possible for the bid and ask price to be the same if there is some imperfection that hinders immediate execution, and it sometimes does happen that the bid and ask of the best displayed quote across markets are the same. To simplify the example, this possibility is ignored.

If the effective spread is sometimes less than the displayed spread on a particular market, another market maker who is able to buy or sell consistently at the wider spread of the displayed quote will find it profitable to do so and therefore would have an incentive to pay for such order flow. To continue the example from the prior paragraph, assume that there is a market maker who is able to purchase order flow with the provision that it will always be executed at the bid or offer of the displayed quote. Upon receipt of a market sell order, that market maker would execute that order at the displayed bid of $20. Having executed the order, the market maker is assured a positive expected cash flow by sending a market buy order to a market where price improvement is possible. In this way, the total cash flow will be either zero or ⅛ per share.[7] This is only one strategy that produces a positive expected profit and could be inferior to others.

But even if all trades were always executed at the bid and offer of the displayed quote in every market, a market maker might still find it profitable to pay for order flow. The spread covers two costs: losses to informed traders and operating expenses such as inventory and clerical costs. If the market maker could be assured of obtaining primarily the order flow of uninformed traders, that market maker would face smaller losses to informed traders than implicit in the displayed spread, making it again profitable to pay for order flow.

As the industry is now structured, some markets may be able to separate partially the uninformed from the informed order flow. A market that pays for order flow usually enters into an agreement with a brokerage firm with the understanding that the brokerage firm will only send specific kinds of orders to the market, typically the orders of small retail customers, who are less likely to have information not already incorporated into market prices. The brokerage firm itself has an incentive to honor this agreement since the market can always stop the payment for order flow in the event of a violation of this understanding.[8]

There may still be another source of profitability from buying order flow. On any NYSE-listed stock with a price greater than one dollar, the minimum displayed spread is one eighth, which, according to the empirical research of Harris (1994), may be in excess of the competitive spread for some stocks. For these stocks, a market maker who matches the displayed spread, even if it is the minimum spread of one eighth, may be willing to pay for order flow,

[7] In response to the criticism that the orders are often executed within the displayed spread, Bernard L. Madoff Investment Securities and some regional exchanges have developed procedures that allow for the possibility of a trade being executed within the displayed quote. Madoff claims that its procedure for price improvement provides as much, or more, price improvement as obtained by orders submitted to the NYSE. Madoff sends written reports to its clients about the degree of price improvement, but these reports are not available publicly.

[8] If these arrangements cause a reduction in the uniformed order flows to the primary market, the remaining order flow in the primary market will have an increased percentage of informed order flow, possibly resulting in larger spreads and thereby making the payment for order flow even more profitable.

particularly if the market maker can be assured of receiving orders from uninformed investors.

Finally, the ITS system allows non-NYSE market makers to reduce the risk of unwanted inventory. If the market maker does not want an order, that order can be sent over ITS to the market with the best bid or offer. In this case, the market maker does not participate in the trade, but still must pay the sending broker for the order flow. In setting the level of the payment for order flow, a market maker will certainly take into account this potential cost.

B. The NYSE Floor

At first blush, it might seem that a competitive response of the NYSE to the loss of retail order flow to other markets would be to reduce the displayed spread, possibly with a corresponding reduction in the sizes of the displayed depths in conformity with Glosten (1994). This step alone would not be enough to remove all incentives to pay for order flow as long as non-NYSE markets are able to capture uninformed order flow, but reducing the displayed spread would certainly reduce the incentives.

The traditional ways in which NYSE stocks trade on the floor almost guarantee that trades will occur within the displayed quote. To make the displayed quote small enough so that virtually no trades would occur within the quotes would require major changes in how securities are traded on the NYSE—so major that the current incentives to trade on the NYSE floor that are inherent in the existing structure might vanish, destroying the very need for the floor itself.[9]

Orders that make their way to the floor of the NYSE are often much more complex than simple market or limit orders. As one example, floor traders often receive "not held" orders—orders which do not lend themselves for display through CQS and by their very nature often lead to a displayed spread of one quarter or more, even though many market orders would be executed within the spread. A "not held" order is an order—frequently used by institutional investors—that instructs a floor trader to use his or her discretion in how and at what price(s) to execute it; indeed, if the floor trader judges market conditions to be unfavorable, the floor trader can even choose not to execute the order. Such an order cannot be displayed through CQS as currently configured. Indeed, Grossman (1992) makes the broader point that no quote reporting system can provide sufficient detail to capture every feature of every possible type of order.

For most NYSE-listed stocks, the minimum displayed spread is one eighth, but as the empirical evidence below shows, the displayed spread is frequently one quarter or more, even though a large percentage of the trades actually occurs within the displayed spread. To understand this phenomenon, consider

[9] Some, such as Mendelson and Peake (1979), conclude that the current NYSE floor benefits only a small group of participants such as the specialists and that a fully electronic trading system without the floor would better serve investors and the financial markets. They raise some very controversial issues that have been debated continuously since the 1975 Amendments.

a stock with a currently displayed spread of one eighth with limit orders determining each side of its quote. A floor trader receives a large institutional "not held" buy order and decides to execute a portion of this order against the offer as represented by limit orders. As a result, higher priced limit sell orders come into play, and the displayed spread increases to, say, one quarter. Now, if a small market sell order were to arrive on the floor, the floor trader representing the "not held" order might step in and buy at a price within the best displayed prices. The trader must buy within the displayed prices as the priority rules on the NYSE require that the floor trader provide a better price than the displayed bid price.

The floor trader with such a "not held" buy order may decide not to make a firm bid within the displayed spread, even for a portion of the order. First, the floor trader may not want to reveal his or her buying interest to traders off the floor of the NYSE. Second, the floor trader maintains a "last move" advantage—a potentially valuable option. Following Rock (1990), the floor trader or the specialist may be able to make an inference about the information conveyed in a market order, and based upon this information, decide whether to trade or not. In Rock's model, the size of the market order conveys this information. In a more general model, factors in addition to size may convey information. For instance, the past sequence of trades as well as the activity among the crowd at a specialist's post may convey information. Third, there is always some lag between the placing of a market order by an investor and its receipt on the NYSE floor. During this time period, market conditions could change, and without having made a firm offer to buy, the floor trader is not obligated to be the contraparty to the next market sell order. This third example is really a form of a "last move" advantage.[10] If the floor trader chooses not to post a better bid and the NYSE specialist does not post a better bid, the displayed spread will remain at one quarter or more even though there is a high probability that a market sell order will be executed within the displayed spread.

The above was couched in terms of a "not held" buy order, but there are other practices on the NYSE that increase the likelihood of an execution occurring within the displayed spread when that spread is one quarter or more: to name a couple, stopped orders as described in Petersen and Fialkowski (1994) and small limit orders that the specialist chooses not to display as documented in McInish and Wood (1995).[11]

[10] Counterbalancing these advantages of not posting a firm order is the possibility that posting a firm bid may attract additional order flow. The importance of this possibility must be determined empirically.

[11] For an inactively traded stock in which there is little trading interest, there is another reason that the displayed spread might often exceed the effective spread. For such a stock, an NYSE specialist may not wish to take the time to monitor his or her quote and by posting a quote with an artificially large spread avoids the need to monitor the quote continuously. When an actual order arrives, the specialist could then assess the correct price at which to execute the order, which might be within the spread.

Additionally, the design of CQS allows only one combination of bid price and depth at that price and one combination of ask price and depth at that price, whereas the work of Glosten (1994) suggests that just two combinations are inadequate to describe fully the trading interest in a market. He goes on to argue that a full description of the trading interest in a market requires an entire schedule of bid prices and ask prices for different size orders, with smaller spreads for smaller orders. If a market maker chooses to display quotes only with substantial depth, a market order for a smaller number of shares might be executed within the displayed quote.

Regardless of the reason, an important question is how frequently does the best displayed spread exceed the minimum tick size of one eighth. If the displayed spread is often greater than one eighth, a market will have many opportunities to better the quote when it wishes to attract additional order flow. Similarly, when the spread is greater than one eighth, floor traders and specialists will find it easier to exercise a last move advantage.

C. Some Issues

The trading of NYSE-listed securities is a complex process and involves many different types of players with various goals and strategies. The importance of each of these players and the effects of their strategies on the trading of NYSE-listed stocks are ultimately empirical questions.

First, how often does one or both sides of a quote of a particular market match or determine the best displayed bid or ask price? This question addresses two issues. The first is the role of the various markets in price discovery. The second pertains to the relative importance of price and nonprice competition in attracting order flow, and one variable in assessing this competition is the proportion of time that a market displays an inferior quote.

Second, what percentage of a market's order flow occurs when both sides of its quote are inferior to the best displayed prices? If investors always send their orders to the market with the best quote, then markets with inferior quotes will receive no orders. On the other hand, if investors use one market to avoid the rules of another or markets attract order flow for nonprice reasons, such as payment for order flow, markets would still receive order flow even when posting inferior quotes.

Third, how often is the best displayed spread one quarter or more? It has been suggested that the trading practices on the NYSE would frequently cause the NYSE spread to be one quarter or more— even for the largest, most active stocks. For example, as floor traders work large orders, they will take out all the limit orders at a specific price, thereby increasing to one quarter or more the NYSE spread as displayed on CQS. If non-NYSE markets choose not to better this spread, the best displayed spread will remain at one quarter or more.

Fourth, does bettering one side of the best displayed quote increase the probability of attracting order flow, and by how much? If the best displayed spread is frequently one quarter or more (as the data indicate), a market can

temporarily increase its bid price or decrease its ask price in the hope of attracting order flow.

Fifth, does a market that often posts an inferior quote contribute nonetheless to price discovery on those occasions when it does better the bid or ask price of the best displayed prices? One possibility is that a market with an inferior quote will temporarily better its bid or ask price to attract order flow and, after attracting such order flow, withdraw its better price. A second possibility is that, instead of withdrawing this better price, other markets improve their quotes to match this better price. In this second case, it could be said that the first market was contributing more directly to price discovery.

III. The Empirical Analysis

After a brief description of the data, this section presents empirical evidence on each of these five questions.

A. The Data

The Trade and Quote (TAQ) Database, which is distributed by the NYSE, is the main source of data for this study. Several filters were applied to these data to remove observations that may be subject to error.[12]

The analysis below is based upon those 2023 common stocks for which the TAQ Database reported at least one trade during the twelve months ending June 1995 and which, according to the Center for Research in Security Prices (CRSP), represent U.S.-domiciled companies listed on the NYSE as of June 30, 1994 with a closing price on June 30, 1994 of one dollar or more. The analysis below uses these closing prices and the associated mid-1994 market values of the common stock as control variables. To ensure that the minimum spread is one eighth, any stock for which the opening NYSE bid is less than one dollar is excluded from the analysis for that day. Finally, any trade or quote with a special code other than an opening or closing indication is excluded. The array of quotes on CQS is used to determine the best displayed bid and ask prices and the market or markets displaying these prices.[13]

[12] The analysis eliminates the following possible data errors: 126,524 quotes in which the best ask price differs from the prior best ask price by more than 50 percent, 122,060 quotes in which the best bid prices differs from the prior best bid price by more than 50 percent, 245,663 quotes where the spread of the best displayed quote exceeds 20 percent of the midpoint of that quote where the midpoint was $10 or more, 29 quotes where the spread of the best displayed quote exceeds $2 and the midpoint of the spread is less than $10 (cf. Keim [1989] for a justification of this filter), 135 observations with trade prices that differ from the prior trade by more than 50 percent, and 130 trades in which the trade price is more than $5 away from the midpoint of the best displayed quote. We also exclude Berkshire Hathaway and Capital Cities/ABC, both very high priced stocks with extremely large bid-ask spreads. When we eliminate a quote, we also eliminate subsequent transactions until a new valid quote is obtained. (In interpreting the number of quotes and trades eliminated, it should be kept in mind that some data points were eliminated for more than one reason.)

[13] Bids or offers with depths of 100 shares play a special role in ITS. In the case of a bid, a market displaying an inferior bid is required to execute a market sell order at the better quote

The comparison of trades with quotes requires that the data from CTA and CQS be merged. For various technical reasons, the actual time that a quote is posted or a trade takes place precedes the time stamp reported by CTA and CQS. First, the time stamp is added to the quote or trade record after it is processed through various computer systems, not when the quote was changed or the trade took place. Second, since there are various separate computer systems, the computer time to process a quote or trade can be different and can vary with the computer loads. Third, trades in some stocks are entered into the computers both electronically and manually, and these processes are subject to differential delays that on occasion can be a minute or more. Thus, not only can the time stamps be in error but the very sequencing of trades in the same stock can be wrong.

Lee and Ready (1991) were the first to present indirect evidence of such errors in the time stamps of quotes and trades. Hasbrouck and Sosebee (1992) later confirmed this hypothesis using the Trades, Orders, Reports and Quotes (TORQ) data set and in the process directly calculated delays in the reporting of trades on the floor of the NYSE. The TORQ data set, which is described in Hasbrouck (1992), contains additional information about the time of a trade not previously available to academic researchers, but is limited to 144 stocks for the three months November 1990 through January 1991. The median delay for NYSE stocks was 16 seconds. Using the same algorithm as used by Hasbrouck and Sosebee, this study estimates the median delays for the regional exchanges and Nasdaq.[14] A partial adjustment for these errors in time stamps of trades is to adjust downwards the reported time stamps by these median delays, and this study employs this adjustment.

B. The Best Displayed Prices

The bid or ask prices displayed on CQS by the NYSE equal the best displayed prices much more frequently than those of the other markets. For the twelve months ending June 1995, the NYSE reports trades for each of the 2023 common stocks identified above. The percentage of trading time that the NYSE quotes equal one or both sides of the best prices varies across stocks from 95.1 percent to 100.0 percent (not shown in a table) with an average of 99.9 percent

displayed on CQS or send a commitment to trade to the market with the best bid, but this requirement is waived when the better bid has a depth of 100 shares. The same is true for the offer. Thus, a market can effectively withdraw from participation in ITS by posting a bid or an offer with a depth of 100 shares. Such bids or offers are frequently entered automatically by computers and in these cases termed "auto-quotes." The calculation of the best displayed bid or offer does not include a bid or an offer for a market when that bid or offer has a depth of 100.

[14] The same filters used on the TAQ data were also applied to the TORQ data set. The median delays in seconds are: 16 for the NYSE, 34 for Boston, 16 for Chicago, 3 for Cincinnati, 5 for Pacific, 29 for Philadelphia, and 31 for Nasdaq.

(Table I).[15] The NYSE accounts for the bulk of the volume in each of these 2023 stocks with an average market share of 83.0 percent.

The number of these 2023 common stocks in which non-NYSE markets reported trades varied from 2022 for Nasdaq to 617 for Cincinnati. In those stocks in which trades were reported, the percentage of time that one side of its quote matched the best displayed prices varied widely across markets. At one extreme, the quotes of Cincinnati matched on average at least one of the best prices 54.4 percent of the time, those of the Pacific 52.6 percent, and those of Chicago 37.5 percent. At the other extreme, the quotes of Boston matched at least one of the best prices 2.9 percent of the time, and those of Philadelphia 2.6 percent. A possible explanation of these differences among the nonelectronic regional exchanges is that both the Chicago and Pacific Exchanges evaluate their specialists in part by the proportion of time that they match or determine one or both sides of the best bid and ask prices, while Boston and Philadelphia do not use this measure in evaluating their specialists.

With the exception of the Chicago and Pacific Exchanges, non-NYSE markets are more likely to be part of the best bid and ask prices for stocks with larger market values than those with smaller market values. This tendency is particularly pronounced on the Cincinnati Exchange and Nasdaq, and is consistent with the reported use by Madoff of these markets in its market-making activities in the larger NYSE-listed stocks. The Pacific pattern is more complex—matching the best bid or ask prices more often for both large and small companies than for mid-size companies. The Chicago pattern is similar to the Pacific, but not as pronounced.

Both sides of the quotes displayed by the NYSE typically match the best displayed prices. The NYSE bid price equals on average the best bid price 97.1 percent of the time, and the NYSE ask price equals the best ask price 96.9 percent of the time. These high percentages could occur only if both the NYSE bid and ask prices equal the best prices most of the time.

The story is quite different for non-NYSE markets. To illustrate, the Cincinnati bid price equals the best bid price 31.6 percent of the time, and its ask price equals the best ask price 34.5 percent of the time. If these matches typically occurred on both sides of the quote at the same time, the joint event of matching both the bid and ask prices would be 31.6 percent or slightly less. In actual fact, Cincinnati has the best bid or best ask price 54.4 percent of the time, indicating that it generally does not post both the best bid and the best ask prices at the same time.

[15] The trading time used in these calculations is the time from the opening quote on the NYSE to the close of trading on the NYSE. The major effect is to exclude quotes on the Pacific for the half hour following the close of the NYSE when only the Pacific is still open for trading. Another effect is to exclude the time period between an opening quote on a non-NYSE market and a later opening on the NYSE—a rare occurrence. All of the calculations for the non-NYSE markets use this same time convention for measuring total trading time.

Table I

Percentage of Trading Time that the Bid or Ask Prices of Each Market Matches or Determines the Best Displayed Prices

The percentage is calculated for each New York Stock Exchange (NYSE)-listed stock for which a market reports a trade during the twelve months ending June 1995. Averages of these percentages are presented cross-classified by market and size categories as determined by the market value of the company's equity as of mid-year 1994. In addition, the rank order correlations between these percentages and size categories (with a rank of 5 for the top 50 to a rank of 1 for the smallest 1023) are shown by market. Those correlations in boldface are significant at the one-percent level. Panel A presents averages of the percentage of the trading time that the price of at least one of the two quotes (bid or ask) posted by that market matches or determines the respective best intermarket quote price, where the average is over all stocks included for that market. Panel B (C) presents similarly calculated averages of the percentage of the trading time that the bid (ask) price posted by that market matches or determines the best intermarket bid (ask) price averaged over the stocks included for that market. Because of differing numbers of stocks in each average, the percentages do not sum to 100.0. Panel D indicates by market and size category the number of stocks for which there was at least one trade on the indicated market during the twelve months ending June 1995. Panel E presents the market share of that market's dollar volume averaged over the stocks included for that market. The total dollar volume for all stocks is $2,459 billion, distributed as follows: $707 billion for the top 50, $894 billion for the next 200, $436 billion for the next 250, $305 billion for the next 500, and $118 billion for the last 1023.[a]

	NYSE	Boston	Chicago	Cincinnati	Pacific	Philadelphia	Nasdaq
Panel A. Bid or Ask Price—Percentage of Time							
Averages over Stocks							
All Stocks	99.9	2.9	37.5	54.4	52.6	2.6	19.7
By Size							
Top 50	99.9	8.8	49.7	87.3	55.3	6.5	64.0
Next 200	99.9	4.7	38.5	68.1	43.3	3.9	50.3
Next 250	99.9	3.0	34.8	56.7	43.5	2.8	33.6
Next 500	99.9	2.3	37.1	38.4	50.5	2.3	15.9
Last 1023	99.9	2.2	37.5	29.7	64.7	2.1	10.1
Correlation with Size	**−0.31**	**0.17**	0.03	**0.47**	**−0.26**	**0.21**	**0.41**
Panel B. Bid Price—Percentage of Time							
Averages over Stocks							
All Stocks	97.1	1.6	23.7	31.6	31.9	1.5	10.9
By Size							
Top 50	96.5	4.3	25.8	55.3	30.8	2.7	31.7
Next 200	96.7	2.5	21.2	40.4	24.8	1.7	24.9
Next 250	97.0	1.6	19.9	32.5	25.3	1.5	17.7
Next 500	96.8	1.2	23.0	20.7	30.7	1.5	9.5
Last 1023	97.4	1.3	25.6	16.4	40.9	1.3	6.2
Correlation with Size	**−0.23**	**0.16**	−0.04	**0.49**	**−0.27**	**0.18**	**0.39**
Panel C. Ask Price—Percentage of Time							
Averages over Stocks							
All Stocks	96.9	1.7	24.4	34.5	32.3	1.6	11.4
By Size							
Top 50	95.5	5.3	32.1	60.7	34.0	4.2	36.7
Next 200	96.1	3.0	24.5	45.1	26.2	2.7	29.1
Next 250	96.6	1.8	21.6	35.2	26.1	1.8	19.4
Next 500	96.6	1.4	23.9	22.6	30.4	1.4	9.5
Last 1023	97.3	1.3	25.0	16.4	40.9	1.2	5.7
Correlation with Size	**−0.28**	**0.20**	0.02	**0.51**	**−0.25**	**0.27**	**0.42**

Table 1—*Continued*

	NYSE	Boston	Chicago	Cincinnati	Pacific	Philadelphia	Nasdaq
Panel D. Stocks with Reported Trades							
Number of Stocks							
All Stocks	2023	1588	1912	617	1240	1814	2022
By Size							
Top 50	50	50	50	49	50	50	50
Next 200	200	200	200	179	200	200	200
Next 250	250	250	250	156	239	250	250
Next 500	500	470	495	150	368	479	500
Last 1023	1023	618	917	83	383	835	1022
Panel E. Market Share for Stocks with Reported Trades							
Averages over Stocks							
All Stocks	83.0	1.3	4.4	1.5	2.9	1.2	8.6
By Size							
Top 50	84.1	1.5	2.5	3.4	2.0	1.3	5.3
Next 200	87.3	1.1	2.6	1.7	1.7	0.9	4.9
Next 250	86.3	1.1	3.3	1.2	2.0	0.9	5.7
Next 500	83.5	1.2	4.2	1.0	2.7	1.0	8.1
Last 1023	81.0	1.6	5.3	1.2	4.3	1.3	10.5

[a] A two-way analysis of variance with an interaction term rejects the null hypothesis of no effects at the one-percent level for each of the Panels A, B, and C. For Panel A, $F(34, 11181) = 953.9$; for Panel B, $F(34, 11181) = 1921.30$; and for Panel C, $F(34, 11181) = 1890.45$. On the basis of a Type III test as outlined in SAS/STAT User's Guide (1990), the firm size effect, the market place effect, and the interaction effect are each significantly different from zero at the one-percent level.

C. Trading Volume

The NYSE executes only 0.08 percent of its total dollar volume on average when neither its bid or ask price matched the best prices (Table II). Like the averages in Table I, these averages are over the stocks for which a market reports some volume in the twelve months ending June 1995. In contrast, non-NYSE markets executes on average anywhere from 34.7 percent for Cincinnati to 92.1 percent for Philadelphia of their dollar trading volume when not part of the best prices. This result is consistent with the suggestion that non-NYSE markets capture a significant portion of their trading volume for nonprice reasons—for example, from traders who wish to avoid rules of the NYSE or from brokerage houses who receive payment for order flow.

On some non-NYSE markets, the proportion of a market's dollar volume when neither side of its quote matches the best prices varies with the market value of the company's stock. This proportion increases as market value decreases for Boston (slightly), Cincinnati, Philadelphia (slightly), and Nasdaq. This proportion decreases on the Pacific Exchange.

D. Best Displayed Spreads

The best displayed spread is greater than one eighth 41.3 percent of the time on average for the 2023 stocks in the sample. Since the NYSE quote matches

Table II

Percentage of a Market's Dollar Volume that Occurs when Neither its Bid Price nor Ask Price Equals the Best Prices

The percentage is calculated for each New York Stock Exchange (NYSE)-listed stock for which the market reports a trade during the twelve months ending June 1995. Averages of these percentages are presented cross-classified by market and size categories as determined by the market value of the company's equity as of mid-year 1994. In addition, the rank order correlations between these percentages and size categories (with a rank of 5 for the top 50 to a rank of 1 for the smallest 1023) are shown for each market. Those correlations in boldface are significant at the one-percent level. Panel D of Table I gives the number of stocks for each market.[a]

	Percent of Volume						
	NYSE	Boston	Chicago	Cincinnati	Pacific	Philadelphia	Nasdaq
Averages over Stocks							
All Stocks	0.08	90.2	56.8	34.7	45.3	92.1	79.2
By Size							
Top 50	0.17	85.7	46.0	11.8	46.9	88.7	34.3
Next 200	0.13	89.4	56.5	24.7	54.8	90.9	47.7
Next 250	0.10	90.0	59.8	30.1	53.8	90.5	65.0
Next 500	0.09	90.8	57.6	48.5	46.1	92.5	83.3
Last 1023	0.06	90.4	56.2	53.5	34.0	92.7	89.2
Correlation with Size	**0.43**	**−0.11**	0.01	**−0.39**	**0.29**	**−0.18**	**−0.41**

[a] A two-way analysis of variance with an interaction term rejects the null hypothesis of no effects at the one-percent level with a test statistic of $F(34, 11181) = 893.49$. On the basis of a Type III test as outlined in SAS/STAT User's Guide (1990), the firm size effect, the market place effect, and the interaction effect are each significantly different from zero at the one-percent level.

or determines the best displayed quote most of the time, this result means that non-NYSE markets have many opportunities to jump inside the best displayed quote when they wish to post the very best bid or ask price. It also means that floor traders have numerous opportunities to become the contraparty to a market order after it arrives on the floor by offering a price within the best displayed spread.

A further analysis of the best displayed spread shows that the percentage of time that the best displayed spread exceeds one eighth decreases with the market value of a company (Table III). Also, as company size decreases, the percentage of time that the average stock has a spread of more than one eighth tends to increase at all price levels.

When the spread exceeds one eighth, trading practices on the NYSE suggest that a substantial proportion of trades will occur within the best displayed prices, and the prior results of Blume and Goldstein (1992) and Lee (1993) are consistent with this implication. These empirical pieces show that when the displayed spread is one quarter or more, over 50 percent of the trades on the NYSE occur within the best displayed quotes. A replication of these analyses for the more recent time period in this article comes to similar conclusions, and is not presented here.

Table III

Percentage of Trading Time that the Best Displayed Spread is Greater than One Eighth

This table notes the percentage of trading time that the best displayed spread is greater than one eighth for New York Stock Exchange (NYSE)-listed stocks for the twelve months ending June 1995, averaged across the relevant set of stocks as shown by the number in parentheses. The best displayed spread is the difference between the lowest ask price quoted across the NYSE, Boston, Chicago, Cincinnati, Pacific, and Philadelphia regional exchanges and the Nasdaq less the highest bid price found across these same markets. Stocks are grouped by their closing stock price and size category as determined by the market value of the company's equity as of mid-year 1994.[a]

Mid-Year 1994 Size Category	Mid-Year 1994 Closing Stock Price, P					
	$P \geq 80$	$40 \leq P < 80$	$20 \leq P < 40$	$10 \leq P < 20$	$5 \leq P < 10$	$1 \leq P < 5$
Top 50	44.9	17.1	10.2	none	none	none
	(5)	(35)	(10)			
Next 200	59.2	42.0	19.6	4.6	5.2	none
	(8)	(80)	(102)	(8)	(2)	
Next 250	86.3	53.2	37.5	15.5	3.9	none
	(2)	(49)	(147)	(47)	(5)	
Next 500	96.8	72.5	53.0	30.6	10.1	2.0
	(1)	(44)	(271)	(148)	(32)	(4)
Last 1023	none	65.1	68.6	46.8	29.6	26.6
		(9)	(180)	(463)	(269)	(102)

[a] A two-way analysis of variance with an interaction term rejects the null hypothesis of no effects at the one-percent level with a test statistic of $F(23, 1999) = 68.04$. On the basis of a Type III test as outlined in SAS/STAT User's Guide (1990), the firm size effect and the stock price are each significantly different from zero at the one-percent level. The hypothesis of no interaction is not rejected at the one-percent level. Within any price category, the rank order correlation between the percentage of trading time that the best displayed spread is greater than one eighth and the stock's size category (with a rank of 5 for the top 50 to a rank of 1 for the smallest 1023) is negative and significant at the one-percent level. The correlations themselves range from -0.31 to -0.79. Within any size category, the rank order correlation between the percentage of trading time when the best displayed spread is greater than one eighth and the stock's price category (with a rank of 6 for the highest price category to a rank of 1 for the lowest price category) is positive and significant at the one-percent level. The correlations themselves range from 0.56 to 0.77.

E. Attracting Order Flow

When the spread of the best displayed prices is one quarter or more, as it often is, a market maker can post a bid or offer within this spread for the purpose of attracting order flow. The success of posting a better bid or offer in attracting order flow is an empirical question.

Two measures of concurrent market share have been constructed to assess the ability of a better quote to attract order flow. To illustrate the general construction of these measures, consider those time periods when a specific market has posted a bid price which is superior to any other posted bid prices for a particular stock—in short, the very best bid price. Now, for those time periods when a market posts the very best bid price, record the total dollar volume of trading across all markets and the total dollar volume for that

specific market and include only the volume that occurs at the best bid price. Including only the volume at the best bid price focuses on seller-initiated trades—the types of trades that a better bid is designed to attract. The ratio of the market's volume to the total volume provides a concurrent measure of market share when that market posts the very best bid price, and an average of these ratios over all securities provide a summary measure of concurrent market share. Similar concurrent measures of market share are calculated for those time periods in which a market posts an inferior bid price, using the dollar volume that occurs at the best displayed bid.

These measures allow a comparison of the percentage dollar volume that a market receives when it posts the very best bid price with the percent that it receives when it posts an inferior bid price. If all trades went to the market with the very best bid, the market's concurrent volume percentage would be 100 when it posts the very best bid and zero percent when it posts an inferior bid.

To be included in these averages for a specific market, a stock must meet two criteria. First, there must be some intervals when that market had the very best bid and some intervals when it had an inferior bid. If a market had never posted the very best bid nor an inferior bid, a comparison of concurrent market share under these two scenarios would not be possible. Second, there must be some reported volume on any market both during the times in which the market had posted the very best bid and during the times in which the market had posted an inferior bid. This requirement is necessary to calculate concurrent market share.

A comparison of the number of companies with some reported trades and the number of these companies which met these more restrictive requirements discloses the impact of these requirements (Panel D of Table I and Panel D of Table IV). The greatest impact occurred on Nasdaq. Nasdaq reported trades in 2022 stocks, but only 796 met the requirements of this analysis. This large reduction is consistent with the use of Nasdaq for the reporting of trades that were executed by non-NYSE market makers while posting inferior bids or matched through systems like Posit. There was also a reduction of 711 stocks for Philadelphia and 516 stocks for Boston, but only a reduction of 123 for Chicago and 6 for the Pacific Exchange. These differences among these regional markets are consistent with the use by the Chicago and Pacific Exchanges of the percentage of time that their quotes match or determine the best displayed bid or ask prices in evaluating the performance of their specialists.

The evidence shows that posting the very best bid does increase concurrent market share. For example, the concurrent market share of Boston when it posts an inferior bid averaged over 1072 stocks is 1.6 percent (Table IV). When it posts the very best bid, its market share climbs to 43.0 percent. Thus, moving from an inferior bid to the very best bid increases Boston's concurrent market share by 41.4 percentage points. Even the NYSE sees its market share increase from 61.1 percent to 84.7 percent when it moves from an inferior bid to the very best bid. The increase in concurrent market share from posting the

Table IV

Concurrent Dollar Volume Market Share for Trades that Occurred at the Best Bid Price

This table contains for New York Stock Exchange (NYSE)-listed stocks for the twelve months ending June 1995 the concurrent market share of dollar volume during those time periods when a market posts a bid price that is inferior to the best displayed bid and when that market posts the very best bid—a bid that is superior to the bids of all other markets. To be included in these calculations of concurrent market share for a specific market, a stock must meet these two conditions: First, while that market is posting the very best bid, there must have been at least one trade on some market during the twelve months ending June 1995. Second, while that market is posting an inferior bid, there must have been at least one trade on some market during the twelve months ending June 1995. Panel A contains averages across stocks of the percentage of the dollar volume attributable to a particular market during those intervals when that market posts an inferior bid to the total dollar volume of all markets during these same intervals. These averages are cross-classified by market and size categories as measured by the market value of the company's equity as of June 1994. Panel B contains similarly cross-classified averages of the percentage of the dollar volume attributable to a particular market during those intervals when that market posts the very best bid to the total dollar volume of all markets during these same intervals. Panel C contains the increase in the concurrent market share while posting the best bid in comparison to the concurrent market share while posting an inferior bid. Those increases in concurrent market share from posting an inferior bid to the best bid that are significant at the one-percent level are shown in boldface. Panels A, B, and C also contain for each market the rank order correlations between the market share percentages and size categories (with a rank of 5 for the top 50 to a rank of 1 for the smallest 1023). Those correlations in italics are significant at the one-percent level. Panel D gives the number of companies in each average.[a]

	NYSE	Boston	Chicago	Cincinnati	Pacific	Philadelphia	Nasdaq
Panel A. Concurrent Market Share when Posting an Inferior Bid							
Averages over Stocks							
All Stocks	61.1	1.6	4.1	1.4	2.9	1.2	8.4
By Size							
Top 50	78.9	1.6	2.4	3.2	2.2	1.5	4.9
Next 200	77.7	1.2	2.5	1.4	1.8	1.1	4.3
Next 250	74.7	1.3	3.0	1.1	2.1	1.0	5.2
Next 500	66.4	1.6	3.9	1.1	2.7	1.1	9.2
Last 1023	49.7	2.1	5.0	1.6	4.2	1.3	13.4
Correlation with Size	**0.50**	**−0.13**	**−0.28**	**0.28**	**−0.28**	**0.02**	**−0.44**
Panel B. Concurrent Market Share when Posting the Very Best Bid							
Averages over Stocks							
All Stocks	84.7	43.0	30.2	15.1	13.4	42.7	18.9
By Size							
Top 50	83.9	29.7	14.6	10.2	6.1	33.0	5.5
Next 200	87.9	35.1	18.8	10.9	8.3	33.6	6.2
Next 250	87.5	39.0	20.4	14.8	8.9	42.6	9.1
Next 500	85.9	45.5	26.4	20.6	12.7	41.9	20.8
Last 1023	82.6	49.4	39.3	20.5	20.5	48.1	35.2
Correlation with Size	**0.18**	**−0.20**	**−0.44**	**−0.16**	**−0.42**	**−0.13**	**−0.41**

very best bid relative to an inferior bid tends to be (a) greater for smaller stocks for a specific market and (b) greater for Boston and Philadelphia in comparison to the other markets at any company size. The results for ask prices, which are not presented, are similar.

Table IV—*Continued*

	NYSE	Boston	Chicago	Cincinnati	Pacific	Philadelphia	Nasdaq
Panel C. Increase in Market Share from an Inferior Bid to the Very Best Bid							
Averages over Stocks							
All Stocks	**23.6**	**41.4**	**26.1**	**13.7**	**10.5**	**41.5**	**10.5**
By Size							
Top 50	**5.0**	**28.1**	**12.1**	**6.9**	**3.9**	**31.4**	0.6
Next 200	**10.2**	**33.9**	**16.3**	**9.5**	**6.5**	**32.5**	**1.9**
Next 250	**12.8**	**37.7**	**17.4**	**13.7**	**6.8**	**41.6**	**3.9**
Next 500	**19.5**	**43.9**	**22.4**	**19.5**	**10.0**	**40.8**	**11.6**
Last 1023	**32.9**	**47.3**	**34.3**	**18.9**	**16.4**	**46.8**	**21.8**
Correlation with Size	**−0.49**	**−0.19**	**−0.41**	**−0.21**	**−0.38**	**−0.13**	**−0.34**
Panel D. Stocks Included in this Analysis							
Number of Stocks							
All Stocks	1884	1072	1789	565	1234	1103	796
By Size							
Top 50	50	50	50	49	50	48	50
Next 200	200	180	200	176	200	166	177
Next 250	250	205	249	150	237	200	151
Next 500	491	294	485	135	368	284	168
Last 1023	893	343	805	55	379	405	250

[a] A two-way analysis of variance with an interaction term rejects the null hypothesis of no effects at the one-percent level for each of the Panels A, B, and C. For Panel A, $F(34, 8408) = 1491.83$; for Panel B, $F(34, 8408) = 415.56$; and for Panel C, $F(34, 8408) = 98.01$. On the basis of a Type III test as outlined in SAS/STAT User's Guide (1990), the firm size effect, the market place effect, and the interaction effect are each significantly different from zero at the one-percent level.

F. Price Discovery

The prices in the NYSE quote match the best displayed quote most of the time. Yet when a non-NYSE market does post the best bid or offer, it does attract additional order flow, indicating that the bids and offers of non-NYSE markets do have an economic effect.

There are two ways that a market can have the very best bid. The first, an active way, is to post a bid within the spread and thereby narrow the spread. The second, a passive way, is to find that other markets have worsened their bids to the extent that the remaining market now has the very best bid. Similarly, there are two ways to terminate having the very best bid. The first, an active way, is to post a worse bid. The second, a passive way, is to find that other markets have changed their bids to match or better the previously very best bid. It is also possible that a market may find that it has the very best bid at the end of the trading session.

How a market obtains and loses the very best bid may have different implications for the role of that market in discovering prices. As one example, a market maker who posts a better bid to adjust inventory and as soon as the inventory is adjusted withdraws the better bid undoubtedly has a different role

in price discovery from a market maker who posts a better bid that is then quickly matched by other markets. As a second example, a market maker whose bid becomes the very best bid through the worsening of the bids of other markets and who then quickly responds by worsening its own bid might be viewed as having had only a token bid with the same informational content as having posted no bid at all.

There are wide differences in the way in which the various markets become the very best bid. In 1990, the NYSE bid became the very best bid 1,842,403 times actively through an improvement in its quote, and 683,141 passively through the worsening of the bids of other markets, for a ratio of active to passive initiations of 2.70 (Table V).[16] The bids of Boston and Philadelphia are more likely to become the very best bid through active improvement than through the worsening of other bids. Chicago, Cincinnati, Pacific, and Nasdaq more often became the very best bid passively through the worsening of other bids than through active improvement.

How a market terminates having the very best bid varies with how it initially obtains the very best bid. With the exception of Boston and Nasdaq, a market that actively initiates having the very best bid is more likely to have its bid matched than to withdraw it. In contrast, a market whose bid becomes the best through the worsening of other quotes is more likely to worsen its quote than have it matched (although this difference is small for the NYSE). Moreover, a non-NYSE market whose bid becomes the very best bid passively through the worsening of other bids and who then actively withdraws its own bid will do so very quickly—over half the time in less than a minute.

Once having obtained the very best bid, the NYSE is likely to retain this status longer than the other markets. However the NYSE becomes the very best either actively or passively and however it terminates having the very best bid either actively or passively, it retains the very best bid from 16.0 to 19.7 minutes on average. In contrast, non-NYSE markets retain the very best bid from 0.2 to 10.7 minutes on average. The median summary statistics result in similar rankings. Cincinnati and Nasdaq tend to retain the position of having the very best bid for shorter time periods than other non-NYSE markets. A possible explanation of the faster reaction for these two markets is twofold. First, both of these markets are electronic ones allowing for a more rapid display of changes in market quotes than possible on more traditional markets. Second, Madoff reportedly uses these markets in its market making function and through its highly automated trading systems, has the capability of rapidly changing its quotes.

When the NYSE actively obtains the very best bid and retains this position until the end of trading, it retains this position, on average, for 247.1 minutes

[16] After actively posting the very best bid, a market can maintain this position of active initiator with further improvements in its bid. If the bid is \$20 and the ask is \$20¼, a market maker who posts a bid of \$20⅛ and an ask price of \$20¼ now has the very best bid. If other markets worsen their ask price to \$20⅜, the active initiator can now raise its bid to \$20¼ and its ask to \$20⅜ and maintain its position as having the very best bid.

Table V

Summary Statistics on Initiating and Terminating the Very Best Bid for NYSE-Listed Stocks for the Twelve Months Ending June 1995

The table presents summary statistics for every instance on how the bid price of a specific market place becomes the very best bid-actively by improving its bid or passively by other markets worsening their bids. It also shows how a market place once having the best bid terminates this position—actively by worsening the bid, passively by other markets matching the bid or the closing of trading on the New York Stock Exchange (NYSE). Also shown are the average and median time per instance of having the best bid cross-classified by the method of initiating the best bid and terminating this position.[a]

	NYSE	Boston	Chicago	Cincinnati	Pacific	Philadelphia	Nasdaq
Panel A. Number of Instances							
All Active Initiations	1,842,403	14,325	76,963	109,847	51,341	8,972	48,437
All Passive Initiations	683,141	12,748	244,621	165,906	224,870	8,736	223,731
Panel B. Ratio of Active to Passive Initiations							
	2.70	1.12	0.31	0.66	0.23	1.03	0.22
Panel C. Percentage Breakdown of Instances							
Active Initiation							
Active Termination	42.5	51.3	45.7	29.6	44.7	47.7	67.8
Passive Termination	46.8	46.8	51.4	70.4	53.8	49.9	31.8
End of Trading	10.7	1.8	2.9	0.0	1.4	2.5	0.3
Passive Initiation							
Active Termination	45.9	64.5	67.2	83.5	63.8	61.9	88.6
Passive Termination	44.4	34.5	31.3	16.4	34.9	36.7	11.2
End of Trading	9.7	1.0	1.5	0.1	1.3	1.4	0.2
Panel D. Average Time in Minutes per Instance							
Active Initiation							
Active Termination	18.6	8.2	10.7	1.1	8.4	9.1	3.8
Passive Termination	19.7	7.8	9.7	0.2	7.8	9.5	5.6
End of Trading	247.1	23.0	33.8	26.1	30.6	38.1	76.2
Passive Initiation							
Active Termination	16.0	2.7	3.1	0.4	3.6	3.6	0.9
Passive Termination	17.2	5.8	8.1	1.6	7.2	7.4	6.1
End of Trading	90.0	21.9	30.3	6.5	28.4	29.0	61.1

(4.1 hours) or, using the median as a summary measure, 378.3 minutes (6.3 hours). A close examination of the data discloses that these long time intervals shown by the summary statistics are due to smaller stocks. For the 1023 companies with the smallest market value, the average minutes that the NYSE will actively obtain the very best bid and retain that position until the end of trading are 295.9, while for the largest 50 companies, the average

Table V—*Continued*

	NYSE	Boston	Chicago	Cincinnati	Pacific	Philadelphia	Nasdaq
Panel E. Median Time in Minutes per Instance							
Active Initiation							
Active Termination	4.9	2.7	3.2	0.7	2.4	3.2	0.5
Passive Termination	3.6	2.2	2.4	0.1	1.9	2.6	0.6
End of Trading	378.3	5.2	8.2	2.0	8.2	8.4	25.4
Passive Initiation							
Active Termination	4.4	0.7	0.5	0.1	0.7	0.9	0.1
Passive Termination	4.0	1.6	2.0	0.4	2.0	1.9	0.9
End of Trading	44.8	6.5	9.8	1.7	9.2	8.3	9.5

[a] There are numerous tests that might be made upon the data in this table, but because of the large number of data points, almost every interesting test would lead to rejection of the usual null hypotheses at high levels of significance. Consider the hypothesis that an active or passive initiation is equally likely. For the NYSE, the expected number of active initiations is 1,262,772 with a standard error of 795. The actual number of active initiations is 1,842,403—over 700 standard errors from the expected value. Only for Philadelphia is the hypothesis not rejected at the one percent level. Similarly, one can reject at the one percent level for every market the hypothesis that conditional on an active initiation, there is an equal probability of an active or passive termination. The same rejection of active and passive termination applies to passive initiations.

minutes are 11.9. More generally, as the market size of a company decreases, this time interval increases.

These results indicate that non-NYSE markets do contribute to price discovery, particularly when they actively improve upon the previously displayed quotes. This conclusion is consistent with the empirical finding of Hasbrouck (1994), who finds that non-NYSE quotes explain 7.3 percent of the variance in the best displayed quotes. The results for ask prices, which are not presented, are similar.

IV. Conclusion

In 1975, Congress set the goal of integrating the trading of major securities across markets. With this goal in mind, the SEC caused the development of several electronic systems to integrate the trading of NYSE-listed stocks. The evidence in this article suggests that these systems have not succeeded in integrating fully the markets that trade NYSE-listed securities. Two fundamental barriers to such an integration of the markets are that the displayed quotes do not reveal all of the trading interest on the NYSE itself, and possibly non-NYSE markets as well, and that markets obtain order flow for reasons other than posting the best prices.

The best displayed spread is frequently one quarter or more, even though trades often take place within such spreads. The quote of the NYSE matches or determines the best displayed bid and offer most of the time. Non-NYSE

markets obtain a substantial proportion of their total trading volume when both sides of their quotes are inferior to the best displayed bid or offer. Nonetheless, when a market posts the very best bid or offer across all markets, that market does receive increased order flow. An important question that this article does not address is whether the attraction of order flow to a particular market for reasons other than posting a bid or offer equal to or better than other markets retards, if at all, the price discovery process.

An extreme approach to integrate the markets further is to establish a consolidated limited order book, a proposal considered in the mid-1970s. In such a system, limit orders with strict price and time priority over all markets would determine the best bid and ask prices, and market orders could only be executed against these limit orders. In this way, the entity displaying the best bid or ask prices would be the contraparty to any trade at those prices.[17]

But this extreme solution would entail fundamental change. Since all trading could and would be done by computer, the trading floors of the various markets for NYSE-listed stocks would have no function and would disappear. In analyzing the merits of this solution, it is important to note that full integration through a consolidated limit order book would eliminate the competition among markets that now exists. As mentioned above, maintaining such competition is one of the goals of the national market system—a goal that is arguably inconsistent with full integration. But quite apart from the Congressional mandate for a national market system, no one to date has established that a computerized market in which all trading is accomplished through one system dominates the trading processes for NYSE-listed stocks that have developed over the last two centuries.

In conclusion, as long as the current trading protocols in which traders on the floor of the NYSE and other markets have discretion as to how they reveal their trading interests and execute their orders and markets can attract order flow through means other than displaying the best bid and offer, the bid and offers displayed on CQS will not fully describe the true trading interest in any security. Thus, the electronic systems linking the markets that trade NYSE-listed stocks provide only a partial integration of the markets for NYSE-listed stocks. But, in repetition and as a word of caution, there has been little theoretical or empirical work to show that an overriding goal of public policy should be a complete integration of the markets for the trading of NYSE-listed stocks.

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