DISPLAYED AND EFFECTIVE SPREADS BY MARKET

by

Marshall E. Blume
Michael A. Goldstein

27-92

RODNEY L. WHITE CENTER FOR FINANCIAL RESEARCH
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6367

Displayed and Effective Spreads by Market

Marshall E. Blume
and
Michael A. Goldstein

The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6367

December 23, 1992

*We thank Dhaneesh Kumbhani, Kashif Hussain and Anuj Malhotra for their excellent research assistance. We also thank Charles Black, Gene Finn, Craig MacKinlay, Ananth Madhavan, Bernard Madoff, Peter Madoff, Mark Roomans, and James Shapiro for their valuable comments. Goldstein gratefully acknowledges financial support from Geewax, Terker and Company and the Rodney L. White Center for Financial Research. A preliminary version of this paper was presented at the 1992 ESSEC-AFFI Meetings in Paris. The contents of this paper are the sole responsibility of the authors.

Abstract

This study explores the integration of the markets for NYSE-listed stocks. Although the NYSE bid or offer is part of the best displayed intermarket quote roughly ninety percent of the time, there is some evidence that non-NYSE markets do on occasion contribute to price discovery. Actual execution prices for NYSE-listed stocks sometimes fall within the best displayed intermarket quote. The average effective spread across all stocks is 13.5 cents, which is 76.2 percent of the best displayed intermarket spread. Often, the best displayed spread is almost double the average effective spread. For 100- and 200-share prints, the average effective spread on the NYSE is consistently less than on non-NYSE markets; but for prints of 1,000 to 3,000 shares, the reverse sometimes occurs.

Many common stocks that are listed on the New York Stock Exchange (NYSE) trade on other markets as well. A non-exhaustive list of these markets includes regional exchanges like the Midwest Stock Exchange, broker-dealers who are members of the National Association of Securities Dealers (NASD) like Bernard L. Madoff Investment Securities, Inc., and major international markets like the Tokyo Stock Exchange or the London over-the-counter market.

The 1970s and 1980s saw the development of several electronic systems linking the more important domestic markets for NYSE-listed stocks. Because of these linkages, participants in each market know the best displayed intermarket quote at any point in time. However, the institutional structure of these markets allows executions to take place on occasion at better prices than those displayed. This possibility implies that the effective quote—prices at which trades actually take place—is sometimes better than the best displayed intermarket quote, so that the best displayed intermarket quote is not always the real quote.

A study of effective spreads is of particular relevance today. Even since the seminal work of Demsetz (1968), numerous articles have presented models and estimates of the bid-ask spread and its components: to name a few, Tinic (1972), Garbade and Silver (1979), Amihud and Mendelson (1980), Ho and Stoll (1981), Copeland and Galai (1983), Roll (1984), Glosten and Milgrom (1985), Kyle (1985), Glosten (1987), Glosten and Harris (1988), and Stoll (1989). During the 1980s, the empirical studies of the bid-ask spread have used transaction prices to infer the spread since data on spreads themselves were not easily obtained.

Today, quotation data are readily available, and a recent paper by George, Kaul, and Nimalendran (1991) shows how to use quotation data in conjunction with transaction data to analyze the bid-ask spread. Implicit in this use of quotes is the assumption that the bid and ask prices of these reported or displayed quotes are the prices at which trades actually take place. A finding that the effective bid and ask prices systematically differ from the displayed prices could call for changes in the design and the interpretation of these types of empirical endeavors.

Measuring effective spreads is important to investors as well. From a trading perspective, an investor may prefer one market over another if some markets have smaller effective spreads; however, for small retail orders, it is usually the broker and not the customer who determines where an order is sent. Since brokers often receive payment for directing order flow to a particular market, brokers have an incentive to send orders to that market even when another market might on average provide better prices.[1] But, as the SEC or its staff has often pointed out, the best price is only one ingredient in determining the overall quality of execution, so that finding that an investor has not received the best price does not itself imply poor execution.[2]

The goal of this paper is twofold: first, to analyze the differences in the characteristics of quotes across markets and second, to measure and compare effective spreads for NYSE-listed stocks on the NYSE, the regional stock exchanges, and the NASD. The paper is organized as follows: The first section contains a brief description of the institutional structure for trading NYSE-listed stocks. The second section describes the data. The third section presents a comparison of the quotes across markets and some evidence on the degree to which the various markets contribute to price discovery. The fourth section examines properties of the displayed and effective spreads. The last section contains a brief conclusion.

1 Trading NYSE-Listed Securities

An analysis of displayed and effective spreads requires some familiarity with the institutional structure for trading NYSE-listed stocks and the systems that provide for a partial integration of the markets for NYSE-listed stocks. (A reader already familiar with these details can

[1] Paying for retail order flow is only one of many techniques that brokerage firms and market makers use to obtain order flow. For a detailed description of these practices, see NASD (1991).

[2] If the effective spreads were invariant to the place of execution, such inducements for order flow could not harm retail customers. Economic theory suggests that at least a portion of any payment for order flow would be passed back to retail customers through lower commissions. But if effective spreads differ across markets and if the ultimate investor does not receive sufficient additional benefits such as lower commissions, a fully informed retail customer might prefer one market to another.

skip to the next section with no loss of continuity.)

The primary domestic markets for trading NYSE-listed stocks are linked electronically through three major systems. The first is the consolidated tape system (CTS) that reports the trading activity in NYSE-listed stocks on the NYSE as well as the regional exchanges and the NASD. The second is the consolidated quotation system (CQS) that allows investors to compare in real time the quotations on most US markets for NYSE-listed stocks and to determine the market with the best bid and the best offer—in short, the best displayed intermarket quote.[3] The third is the Intermarket Trading System (ITS), which allows exchange members or a dealer on the NASD to route an order to another market for execution at the quote of that latter market.

As it ultimately emerged, ITS is not an automatic system, and each market maker must visually monitor the best displayed intermarket quote. If a market maker with a poorer quote than the best displayed intermarket quote receives a market order, the market maker can either exercise the order at the best displayed intermarket quote or transmit a "commitment to trade" to the market with the best displayed intermarket price.[4] The receiving market then has one or two minutes, depending upon the specific market, to accept the trade.[5] If there is no response within the required time, the commitment expires and the order is not filled. The original purpose of ITS was to facilitate execution of public orders at the best displayed intermarket quote, but as it has developed, ITS is also important to market makers themselves since it allows a market maker on one market to lay off positions to, or accumulate positions from, another market.

[3]The SEC called for both of these systems in 1972, three years before Congress put into law the national goal of establishing a National Market System (NMS). See SEC (1973).

[4]The SEC initially wanted an electronic switch to route orders to the markets with the best quotes, but ultimately agreed to this looser trading link. The ITS became operational in 1978 with a limited number of stocks but now includes virtually all NYSE-listed common stocks.

[5]Commitments sent to the NYSE expire after two minutes, while commitments to the regionals from the NYSE expire after one minute. There is, however, a presumption that the receiving market will accept all valid commitments. See SEC (1988).

Because of these integrated systems, the execution price of a market order for any NYSE-listed stock should never, at least in theory, be outside the best displayed intermarket quote when the size of the order is equal to or less than the depth of the quote. However, in this non-automated system, orders are sometimes executed at prices inferior to those of the best displayed intermarket quote. In 1981, the SEC estimated that such "trade-throughs" represented 0.56 percent of all trades.[6]

If the best displayed spread is greater than the minimum tick, typically one-eighth of a dollar, it is possible for an execution price for an NYSE-listed stock to occur within the best displayed spread. To illustrate with one example, assume that the current best displayed intermarket bid price is 20 and the current best displayed intermarket ask price is 20 1/4 and that a market order arrives on the floor of the NYSE to buy 100 shares. In the usual course of events, the specialist would first inquire of the crowd of traders around his post whether any trader wishes to sell 100 shares at 20 1/8. If someone accepts, the buyer has received a price within the best displayed intermarket quote; likewise, the seller has also traded within the best displayed intermarket quote. If not, the specialist might sell the stock at 20 1/8 from his own account. Alternatively, the specialist might "stop" the order, which means that the specialist guarantees that the order will be executed at no more than 20 1/4, in the hope that subsequently it will be executed at a better price, and in this case of a buy order, at a lower price.[7]

The procedures and methods for trading stocks sometimes differ according to the size of an order. Consider first the typically small orders of a retail customer. When a retail investor

[6]SEC (1982), as cited in Loss and Seligman (1989), p. 2566, fn. 243.

[7]A recent study by McInish and Wood (1992) finds that on occasion, a NYSE specialist will possess a public limit order with a price within the NYSE quote, but will not display it in the quote. If the display of this limit order would change the best displayed intermarket quote, the effective spread in this case is less than the best displayed spread. If a regional exchange is unaware of this non-published order, the effective spread on the regional may be greater than the effective spread on the NYSE and the best displayed intermarket quote will not reflect the true effective best intermarket quote. Orders routed through the ITS based on displayed quotes would therefore not be sent to the market with the best effective quotes.

places an order with a broker, the broker has a choice of submitting the order through one of several electronic systems. The NYSE has a system called SuperDot, which routes an order to the specialist's post for execution on the floor of the NYSE. Currently, SuperDot accepts market orders of up to 30,999 shares and limit orders of up to 99,999 shares. Unlike the NYSE, some of the regional stock exchanges provide for automatic execution of small orders. PACE at the Philadelphia Stock Exchange provides automatic and immediate execution of smaller market orders at the best displayed intermarket quote with no chance of execution within the quote. MAX at the Midwest Stock Exchange and Scorex at the Pacific Stock Exchange are automated systems that accept similar small orders and provide the possibility for execution within the best displayed intermarket quote when the best displayed spread exceeds one-eighth. In 1988, the Boston Stock Exchange introduced a similar automated execution system, called BEACON, which again also allows for execution within the best displayed intermarket quote in some circumstances.[8]

In the past several years, Bernard L. Madoff Investment Securities, Inc. has become an important player in the retail market and makes markets in several hundred of the largest equity issues. During 1990, this company, which is not a member of the NYSE, provided electronic execution of market orders for 3,000 shares or less at the best displayed intermarket quote. In September 1990, Madoff introduced a procedure for possible execution within the best displayed intermarket quote when the best displayed spread is greater than one-eighth.[9] Madoff reports its trades through Cincinnati and NASDAQ and uses these two markets to access ITS.

When institutions have smaller orders or program trades involving a large number of small orders, they frequently use a system like SuperDot—the same system used for small

[8]Domowitz (1992) and Domowitz and Wang (1992) contain detailed descriptions of these trading systems.

[9]Madoff advertises that the firm will enter a bid or offer within the best displayed intermarket quote for 300 shares for one minute. If the bid or offer is hit, Madoff executes the entire order at that price. Alternatively, if during that time, a trade takes place on another exchange within the best displayed intermarket quote, Madoff executes the entire order at that price. The effectiveness of this procedure has not yet been determined.

retail orders. For larger orders, where the order itself could cause a significant price change, institutions try to execute them so as to minimize their price impact. Rather than blindly sending a large market order over one of these electronic systems, an institution has a choice of execution strategies.[10] For example, an institution may use a broker in the "upstairs" market to find the other side of a trade, and the broker would then "cross" the matched trade on a registered exchange. If there are limit orders on an exchange at the same or better prices as the price of the cross, one side of the cross sometimes must be broken up to satisfy these limit orders, leaving the other side of the cross without a full execution. Whether the existence of limit orders does in fact break up a cross depends upon the specific rules of each exchange. For example, NYSE rules governing precedence by size of order facilitate the execution of large crossed trades without breaking them up to satisfy limit orders at the same price as the crossed trade, while smaller crossed orders are more likely to be broken up into smaller share sizes as they draw down the limit book.[11] Regardless of other rules, if there are limit orders at better prices than the price of the cross, these limit orders will be executed causing a breakup of the cross. Consequently, a broker in his capacity as an agent might prefer to cross matched orders on one exchange rather than on another if exchanges differ in the probability of breaking up a crossed order. To the extent that regional exchanges have fewer limit orders, traders may find these exchanges more attractive places to execute some of their crossed orders.

Quite apart from the possibility of larger effective spreads, these regional systems and Madoff are sometimes criticized in that they use the quote of the NYSE to set their trading prices and thus do not contribute to the price discovery process. If so, they are in effect free riders on the quotations developed through the trading process on the floor of the NYSE. Alternatively, these systems may provide competitive quotes and thus contribute to the

[10] For an analysis of these types of choices, see Grossman (1992) or Keim and Madhavan (1992).

[11] As of October 1992, the SEC has permitted "clean crosses" on the NYSE of 25,000 shares or more. The analysis in this paper utilizes 1990 data, a period before the implementation of this new rule.

process of price discovery. These issues are examined further in Section 3.

2 The Data

The 1990 Trades and Quotes Transaction File of the Institute for the Study of Security Markets (ISSM) is the main source of data for this study. The particular version of the file used in this study contains all of the quotes of the regional exchanges, enabling the reconstruction of the best displayed intermarket quote at any point in time. We apply various filters to these data to remove observations that may be subject to error.[12] To use this data, a researcher needs to make some adjustment to the time stamps of either the trades or quotes since, as suggested by Lee and Ready (1991), there are often differential delays in the reporting of transactions, which can alter the time sequence of reported trades from their true order as well as misalign reported trades with the sequence of quotes. Hasbrouck and Sosebee (1992) have confirmed this hypothesis with the TORQ data set.[13] The TORQ data set 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. This study utilizes the TORQ data to extend the analysis of Hasbrouck and Sosebee to the regional exchanges and the NASD. The same filters used on the ISSM data were also applied to the TORQ data set.

We only analyze those common stocks in the ISSM data that are listed as of the end of 1989 with a 1989 closing price of one dollar or more and for which the Center for Research in

[12]ISSM has flagged some of the quotes and trades that may be in error, and we have eliminated these data points. We also eliminate some other data. First, any best displayed intermarket quote with a bid or an ask price that is more than 50 percent away from the previous best bid or ask is eliminated. This check eliminates those quotes where a digit of the quote was obviously dropped. There are instances, for example, where one side of quote is \$3 when all the other quote and trade prices of a stock are between \$30 and \$33. The same filter is applied to trade prices. Second, any trade price more than \$5 away from the midpoint of the best displayed intermarket quote is eliminated. Third, to eliminate large errors in the overall spread, we dropped any quote with a spread greater than 20 percent of the stock price for stocks with a price over \$10 and greater than \$2 for stocks under \$10. This filter is based on data in Keim (1989). Fourth, we dropped any best displayed intermarket quote with a zero or negative spread. Whenever a quote was dropped, we eliminated from analysis any subsequent print of a transaction until we obtained a new and valid quote.

[13]See Hasbrouck (1992) for a description of the TORQ data set.

Security Prices (CRSP) has 1989 year-end data, a restriction which allows the construction of control variables based upon data from the year preceding the analyses of displayed and effective spreads. To help ensure that the minimum spread is one-eighth, we eliminate the data for any stock for any day on which the opening NYSE bid is less than one dollar. Finally, any trade or quote with a special code other than an opening or closing indication is excluded.[14]

The best displayed intermarket quote is calculated as follows: Record the opening quote from the NYSE and call this the best displayed intermarket quote. Subsequently, whenever there is a new regional or NYSE quote, determine whether the previous best displayed intermarket quote is still the best or whether one or both sides of the new quote are now part of the best displayed intermarket quote. In the event that quotes of two exchanges have either the same bid price or ask price, the better quote is the one with the greater depth and if the depth is the same, the older quote is considered to be the better quote.[15]

3 The Integration of the Marketplaces

The 1975 Amendments to the Securities Exchange Act called for a National Market System (NMS), which would fully integrate the trading of each security. This goal of a NMS has not been fulfilled, although there has been some integration of the various markets through the trade and quote reporting systems and ITS. The empirical evidence developed in this

[14]We also exclude Berkshire Hathaway and Capital Cities/ABC, both very high priced stocks with extremely large bid- ask spreads.

[15]There is a complication in analyzing the regional quotes. When regional specialists desire not to be part of the best displayed intermarket quote, they will automatically set their quotes to be inferior to the best displayed intermarket quotes. These quotes are termed "autoquotes." When there is a change in the best displayed intermarket quote, those regional exchanges using autoquotes will automatically update their quotes, but with a delay of several seconds. During this delay, it is possible that one side of the regional quote may appear to be part of the best displayed intermarket quote, but in fact it is not a valid quote and a regional specialist would generally not accept an ITS commitment at that quote. There is no explicit indication that a quote is an autoquote, but a NYSE spokeswoman has told us that the depth on both sides of an autoquote is almost always 100 shares. In calculating the best displayed intermarket quote, we have assumed that a regional exchange quote with a depth on both sides of 100 shares is not a valid quote and does not enter into the determination of the best displayed intermarket quote. Any regional quote with a depth on either side of greater than 100 shares is treated as a valid quote.

paper points to some integration of the markets in that the quotes on non-NYSE markets do sometimes narrow the spread. Specifically, the average best displayed intermarket spread is 17.7 cents, which is 90.6 percent of the average NYSE spread of 19.5 cents.[16] Nonetheless, the NYSE dominates the determination of the best displayed intermarket quote, being part of it roughly 90 percent of the time (Table 1).[17] The quote of the Midwest Stock Exchange is in general more often part of the best displayed intermarket quote than the other non-NYSE markets, followed by the Pacific Stock Exchange. The Cincinnati Stock Exchange is only an important player for the larger 50 stocks—consistent with the use of this exchange by Madoff in its market making activities for the larger NYSE stocks.

When the NYSE represents the bid side of the best displayed intermarket quote, the average depth ranges from 9,893 shares for the largest 50 companies to 6,534 for the companies not in the top 1000 (Table 2). When the non-NYSE markets represent the bid side of the best displayed intermarket quote, the depth of their bid is typically a third or less of the depth when the NYSE is part of the bid (Table 2). Although the depth is less when the non-NYSE markets represent the bid side of the best displayed intermarket quote, the best displayed spread in this circumstance is about 80 percent or so of the spread when the NYSE represents the bid side. The exception is Cincinnati, which often has a similar size spread as that of the NYSE (Table 3). The same general results apply to the ask side.

Thus, when regionals are part of the best displayed intermarket quote, they generally narrow the spread. One possibility for this narrowing may be that regional market markers wish to adjust their inventory and therefore temporarily place better quotes to attract order flow through ITS. After the adjustment of their inventory, the regional market makers withdraw their quotes and the best displayed intermarket quotes return to their prior level.

[16]These averages are calculated as follows: At each print on any market, we record the spreads of the best displayed intermarket quote and the NYSE quote and then average these spreads.

[17]In a related study, Hamilton (1991) examines the differences between the retail and dealer quotes for NASD-listed stocks.

Another possibility is that a better quote plays a part in the price discovery process, and when a regional market places a better quote, other markets, particularly the NYSE, move to match it. The data support both of these hypotheses. If the NYSE bid is part of the best displayed intermarket quote and subsequently a non-NYSE market improves upon this bid, the NYSE will then match or improve the new bid 52.5 percent of the time, while the remaining 47.5 percent of the time the non-NYSE market will withdraw the bid and return the best displayed intermarket bid to the NYSE. The corresponding percentages on the ask side are 60.0 percent and 40.0 percent. This evidence means that non-NYSE markets do contribute to the process of price discovery, although most of the time it is the NYSE quote that determines the bid or the ask.

4 Effective Spreads

The first part of this section presents evidence that the best displayed intermarket quote is in excess of one-eighth a significant portion of the time—even for the stocks of larger companies. This finding is important to establishing that effective spreads can differ from displayed spreads. If the displayed spread were always one-eighth (the minimum spread for any stock with a price greater than one dollar), the effective spread would also be one-eighth.[18] Only when the displayed spread exceeds one-eighth can the effective spread be smaller than the displayed spread. The second part documents the percentage of trades that actually occur within the best displayed intermarket quote by market. The final part proposes two measures for the effective spread and applies these measures to estimate effective spreads.

[18]NYSE rules provide that any bid or ask in excess of one dollar must be stated in eighths; as a result, any trade price in excess of one dollar is also stated in eighths. There are some exceptions to this statement: A spokesperson from the NASD claims that trades of NYSE-listed stock reported through the NASD sometimes take place in increments of one-sixteenth, but the CTS adjusts the prices of such trades to eighths. In addition, the effective price for an upstairs cross can be set between the best displayed quote by executing the appropriate proportion of the order at the lower bid and the remaining portion at the higher ask. This same technique is used in "dividend recapture" programs as explained in Koski (1992)

4.1 Possibility of Execution within the Best Displayed Intermarket Quote

The proportion of the time that the spread of the best displayed intermarket quote exceeds one-eighth varies with the share price of the stock and the market value of the company's common stock. Of the top 50 companies in terms of the 1989 year-end market value of their outstanding stock, there were six companies with a 1989 year-end stock price that equaled or exceeded $100, and for these six stocks, the best displayed intermarket spread exceeded one-eighth 58 percent of the time that the NYSE was open (Table 4).[19] Even for those large companies with lower priced stocks, the spread is frequently greater than one-eighth: For example, the 14 stocks in the top 50 by 1989 year-end market value with a 1989 year-end price in the $25-$50 range had spreads in excess of one-eighth 27 percent of the time. The proportion of time that the spread is greater than one-eighth generally increases as firm size decreases. Of the smallest firms, those not making the top 1000, the spreads of the 16 firms with a price in the $25-$50 range were in excess of one-eighth 85 percent of the time.

These data show that the spread of the best displayed intermarket quote is in excess of one-eighth for a significant portion of time—even for the largest NYSE-listed common stocks. This finding is necessary if the effective spreads are to be less than the best displayed spreads.

4.2 Trading within the Best Displayed Spread

The initial step in calculating the proportion of prints whose prices fall within the best displayed intermarket quote is to pair each print with the quote applicable at the time of the print.[20] As noted above, this pairing requires that some time stamps be adjusted. Lee

[19]Thus, the analysis excludes the half hour following the close of the NYSE when the Pacific Stock Exchange is still open.

[20]In this paper, we shall use the correct term of print size rather than the more often used term "trade size" since the two terms are not synonymous. On the NYSE, the seller is responsible for reporting a trade as indicated in Hasbrouck and Sosebee (1992). If a seller's order is fully executed at one price, there will be one print even though there may have been more than one buyer as the contraparty. On other markets, such a trade might be reported as one print or two or more separate prints, depending upon the rules of the

and Ready (1991) recommend using the prior quote for classification of trades if the current quote has been in existence for less than five seconds, which is equivalent to subtracting five seconds from the print time of a trade. Hasbrouck and Sosebee (1992) used the TORQ data, which allows a more precise estimate of the reporting lags of transactions, to conclude that the adjustment for trades on the NYSE is generally more than five seconds.

Although Hasbrouck and Sosebee (1992) used the TORQ data set to analyze only trades on the NYSE, their approach can be used to estimate an adjustment factor for each exchange. Briefly, the TORQ data set contains two time stamps for each trade: The first is the time at which the trade is printed on the Consolidated Tape System, and the second is the time at which the buyer and seller have recorded their transaction for the clearing process. Although a trade may have taken place before either of these times, it is certainly true that the minimum of these two time stamps is closer to the actual time of the trade.

When the time that the buyer and seller have recorded for the clearing process precedes the print time, the difference is a minimum measure of the time delay in reporting the transaction.[21] Median delay times varied widely by exchange, ranging from three seconds on the Cincinnati Stock Exchange to thirty-four seconds on the Boston Stock Exchange (Table 5). To account for reporting delays, we subtract that exchange's median reporting lag from the time stamp of the print as reported on CTS.

To allow for differences that may be due to the size of the transaction, we classify our results by ten print-size categories ranging from 100 shares to over 20,000 shares. In addition, to allow for any effects due to the price level of a stock, we also divided our sample into five price categories based on the 1989 closing stock price.

Approximately 20 percent to 30 percent of the prints on the NYSE occur between the best

market.

[21] On some of the regionals, the reporting of larger trades to the clearing organization takes place after the close of trading, so that in these cases, the reporting time for clearing gives no information about the lag in reporting a trade to CTS.

displayed intermarket quote for stocks with a 1989 closing price over $50 (Table 6, Panel A).[22] For lower priced stocks, the percentage varies from 10 percent to 25 percent. The percentage of prints on the NYSE between the best displayed intermarket quote increases with increases in the price category for all print sizes.[23]

This analysis of the percentage of prints within the best displayed intermarket quote blends both trades that occur when the spread is equal to one-eighth and when the spread is greater than one-eighth, and gives the unconditional probability of trading within the spread. Also of interest is the probability of trading within the quote when an investor knows that the spread is greater than one-eighth. As expected, the percentage of prints on the NYSE within the best displayed intermarket quote when the spread exceeds one-eighth is greater than before (Table 6, Panel B). Now as many as 60 percent of NYSE prints occur within the best displayed intermarket quote.

Regardless of spread size, the percentage of prints within the best displayed intermarket quotes for the NYSE is generally greater than the corresponding percentages for the other markets (Table 7, Panel A). The difference is particularly pronounced for print sizes of 100 or 200 shares for stocks with 1989 year-end market prices in excess of $15. For example, the percentage of prints on the NYSE within the best displayed intermarket quote for print sizes of 100 shares and stocks with 1989-year end price of $100 or more is 33.2 percent, which is 16.0 percentage points greater than, or nearly twice, the corresponding percentage for the other markets. For print sizes of more than 1,000 shares, the differences are considerably less, and on occasion, the other markets have a greater percentage of trades within the best displayed intermarket quote. The number of prints in these comparisons varied from

[22]On rare occasions, a trade price can be outside of the bid and ask prices. This can occur when there are "trade-throughs," but it can also occur with the execution of crossed trades when the negotiated price is outside the bid and ask prices. In this case, existing limit orders with prices at the current quote or between the current quote and the better negotiated price receive this better price. Thus, our calculations also include trades where the price is slightly outside of the best displayed intermarket quote.

[23]The results in Table 6 are similar to results for 1989 data as reported in Blume and Goldstein (1991).

2,932,209 for NYSE prints of 100 shares to 22,969 for non-NYSE prints of more than 20,000 shares (Table 8, Panel A).

When one confines this analysis to trades where the spread of the best displayed intermarket quote is one-quarter or more, the differences between the NYSE and other markets change dramatically (Table 7, Panel B and Table 8, Panel B). As before, the NYSE has a considerably greater percentage of 100 and 200 share prints executed within the best displayed intermarket quote, but unlike the previous case, the other markets have a much larger percentage of the mid-size prints within the quote than the NYSE. This tendency is particularly pronounced for the lower priced stocks: For stocks with a 1989 year-end closing price of less than $15, the non-NYSE markets have a greater percentage within the spread for any print size category of 300 shares or more—a result that we shall subsequently examine in greater detail.

4.3 Measuring the Effective Spread

Having examined the differences between the unconditional and the conditional percentages of executing within the best displayed intermarket quote, let us turn to a direct estimate of the effective spread. This study utilizes two measures of the effective spread. As a prelude to presenting and analyzing these two measures, consider the transaction at time t, which is executed at the price P_t. Just before time t, P_t is a random variable and can be represented by

$$P_t = E(P_t \mid \theta_{t-}) + \eta_t \quad (1)$$

$$= P_t^* + \eta_t, \quad (2)$$

where θ_{t-} is the information set just before time t, η_t is a mean-zero random term, and P_t^* is an unbiased estimate of P_t.

For a sample of T transactions, one measure of the effective spread is

$$\Sigma_t (\eta_t)^2/T = \Sigma_t (P_t - P_t^*)^2/T, \tag{3}$$

while another measure is

$$2\,\Sigma_t \mid \eta_t \mid /T = 2\,\Sigma_t \mid P_t - P_t^* \mid /T. \tag{4}$$

The formula given by (3) is similar to an estimate of a conditional variance. The formula given by (4) is more akin to the usual definition of a spread as the difference between the bid and ask prices.[24]

To use either (3) or (4), one needs an estimate of P_t^*. Let us assume that one has an unbiased estimate of P_t^*, say $\hat{P}_t^*$, so that

$$\hat{P}_t^* = P_t^* + \epsilon_t, \tag{5}$$

where ϵ_t is a mean-zero disturbance uncorrelated with P_t^* and η_t.

Substituting (5) into (3) yields

$$\Sigma_t(P_t - \hat{P}_t^*)^2/T = \Sigma_t(P_t - P_t^* - \epsilon_t)^2/T \tag{6}$$

$$= \Sigma_t(P_t - P_t^*)^2/T + \Sigma_t\epsilon_t^2/T + 2\Sigma_t[(P_t - P_t^*)\epsilon_t]/T. \tag{7}$$

The asymptotic expectation of (7) is

$$\mathrm{Var}\,(P_t - \hat{P}_t^*) = \mathrm{Var}\,(P_t - P_t^*) + \mathrm{Var}\,(\epsilon_t) + 2\,\mathrm{Cov}\,[(P_t - P_t^*), \epsilon_t]. \tag{8}$$

By assumption the covariance term is zero. If the variance of the measurement error ϵ_t is the same across all marketplaces, the difference between the estimate of $\mathrm{Var}\,(P_t - \hat{P}_t^*)$ for one marketplace and $\mathrm{Var}\,(P_t - \hat{P}_t^*)$ for another marketplace provides an unbiased estimate of the difference between the value of $\mathrm{Var}\,(P_t - P_t^*)$ for the two marketplaces.

[24]Variants of this measure have been used by Goldstein (1991) and Blume and Goldstein (1991).

The other measure of spread given by (4) is upward biased by a small amount under some assumptions that may apply in this paper. We first present a set of assumption under which (4) is unbiased and then relax one of these assumptions. The first assumption is that $|\epsilon_t|$ is always less than the difference $|P_t - P_t^*|$ when this difference is positive and that the conditional expectation of ϵ_t is zero. The second assumption is that $|\epsilon_t|$ is zero when $|P_t - P_t^*|$ is zero. The first assumption says that the error in estimating the expected transaction price is small relative to the size of the spread. The second assumption is probably not valid, and we shall subsequently relax it. Under these two assumptions, the following expression holds:

$$2\,E(|P_t - \hat{P}_t^*|) = 2\,E(|P_t - P_t^*|). \tag{9}$$

To prove this statement of unbiasedness, note that

$$\begin{aligned} E(|P_t - \hat{P}_t^*|) &= E(-\eta_t + \epsilon_t \,|\, \eta_t < 0) + E(|\epsilon_t| \,|\, \eta_t = 0) + E(\eta_t - \epsilon_t \,|\, \eta_t > 0) && (10)\\ &= E(-\eta_t \,|\, \eta_t < 0) + E(\eta_t | \,\eta_t > 0) && (11)\\ &= E(|\eta_t|) && (12)\\ &= E(|P_t - P_t^*|). && (13) \end{aligned}$$

The first line follows from the assumption that $|\epsilon_t|$ is small relative to the difference $|\eta_t|$, when $|\eta_t|$ is positive, so that the sign of η_t determines the sign of $(\eta_t - \epsilon_t)$. The second line follows from the assumptions that the conditional expectation of ϵ_t when $\eta_t > 0$ is zero and that $\epsilon_t = 0$ when $\eta_t = 0$.

In the event that $\epsilon_t \neq 0$ when $\eta_t = 0$, estimates of (4) would be biased by the amount $E(|\epsilon_t| \,|\eta_t = 0)$ times the probability that $\eta_t = 0$. Based upon some empirical analyses below, a reasonable value for $E(|\epsilon_t| \mid \eta_t = 0)$ is somewhat less than 0.5 cents. A necessary but not sufficient condition for η_t to have a value of zero is that the print price must be within the best displayed intermarket quote. Based upon the previous analyses, the proportion of trades with print prices within the best displayed intermarket quote is at most 25 to 35 percent. Thus, a reasonable upper bound for the bias in estimates of (4) is 0.25 cents.

The two key assumptions in estimating (3) are that $\hat{P}_t^*$ is an unbiased estimate of P_t^* and that ϵ_t is uncorrelated with $P_t - P_t^*$. Further, the estimate of (4) will have a negligible bias providing the magnitude of ϵ_t is small. Let us consider using the midpoint of the bid and ask prices, M_t, as an estimate of $\hat{P}_t^*$. A regression of P_t upon M_t can be used to test unbiasedness and obtain an estimate of the magnitude of ϵ_t. Run over all companies and all transactions (25,170,617 in number), the resulting regression is

$$\begin{aligned} P_t &= -0.00080 + 1.000098 M_t + \nu_t, \qquad (14) \\ &\quad (0.000023) \quad (0.0000004) \end{aligned}$$

with an R^2 of 0.992 and where the numbers in parentheses are standard errors. While the intercept is significantly different from zero at any usual level and the slope significantly different from one, the potential bias is negligible. For instance, the predicted P_t for a \$40 stock is \$40.003 —a bias of 0.3 cents. On the assumption that the magnitude of ϵ_t is of the same size as this bias, the bias in estimates of (4) would be negligible.

Lee and Ready (1991) argue that ϵ_t may be correlated with $(P_t - P_t^*)$ or $\mid P_t - P_t^* \mid$. They have observed on the floor of the NYSE that a specialist will sometimes execute a trade and then change the quote, but report the change in the quote first. To illustrate, assume a current bid of 20 and an ask of 20 1/4. A market buy order arrives and is executed at 20 1/4 and then the specialist revises the quote to a bid of 20 1/8 and an ask of 20 3/8. The correct midpoint to use is 20 1/8, but if the quote revision is reported first, the measured midpoint will be 20 1/4, violating the independence assumption.

The adjustment to the time stamps of prints described above will mitigate this type of dependency, but may not fully eliminate it. To assess the robustness of our results to this problem, we have made an even greater adjustment to the time stamps that of the median delay of reporting by market. Specifically, we have subtracted from the time stamp of each print the median delay plus three minutes and have recalculated the estimates of effective

spread with these much greater time adjustments. Using such a large adjustment to the reported times of the prints will increase the variance of the measurement error ϵ_t for the statistic in (3), but as long as the midpoint of this quote is an unbiased estimate of P_t^*, this older midpoint can still be used for $\hat{P}_t^*$ in (5). However, the increase in the magnitude of ϵ_t may cause a bias in (4). The tables presented in the text only contain estimates of the effective spread using (4) with the time stamps of the transactions adjusted by the median time delays from Table 5, while the Appendix tables contain results using various alternative methods to estimate the effective spread. The behavior of these alternative estimates confirms the robustness of the conclusions of this paper.

4.4 Estimates of the Effective Spread

Averaged over all transactions of all securities, the effective spread is 13.5 cents, which is 76.2 percent of the best displayed intermarket spread of 17.7 cents. When the spread of the best displayed intermarket quote exceeds one-eighth, the average effective spread is 15.0 cents, which is 56.0 percent of the best intermarket displayed spread and not much greater than the minimum spread of 12.5 cents.

However, these average values hide some variability in the size of the effective spreads across markets, size of print, and the price of the stock. For the NYSE, the average effective spread for all print sizes except those over 20,000 shares ranges from 12.3 cents to 15.8 cents for stocks with 1989 year-end price of under $100 and is around 20 cents for stocks of $100 or more (Table 9, Panel A).

When the spread of the best displayed intermarket quote exceeds one-eighth, the average effective spreads generally are greater than before, but not by very much (Table 9, Panel B). As an example, the average effective spread for a print size of 100 shares for a stock with a year-end price of between $25 and $50 is 12.8 cents for all prints in comparison to 13.0 cents when the best displayed intermarket quote exceeds one-eighth. To put these numbers into

perspective, there are 1,323,226 prints in total for this category, of which 554,154 prints take place when the best displayed intermarket quote exceeds one-eighth.

This small increase in effective spreads implies that a large percentage of trades take place within the quote when that quote exceeds one-eighth. By construction, the average effective spread must be at least one-eighth when the best displayed spread is one-eighth. (The reason that it can be greater than one-eighth is that there are a few occasions such as execution of limit orders in conjunction with crosses where the print price can be outside the range of the best displayed intermarket quote.) In contrast, when the best displayed spread exceeds one-eighth, the effective spread could theoretically be zero. For example, if the best displayed intermarket quote is a bid of 20 1/4 and an offer of 20 1/2, the effective spread would be zero if all trades took place at the midpoint of 20 3/8.

One reason for this small increase in effective spreads may be found in McInish and Wood (1992). They find that when the NYSE displayed spread exceeds one-eighth, specialists on the NYSE sometimes receive limit orders at better prices than the NYSE displayed quote, but choose not to display these better prices in the quote, so that the effective spread is not the displayed spread. In addition to these non-displayed limit orders, there can be discretionary orders held in the crowd or by the specialist acting as an agent for someone in the crowd that may be executed within the best displayed intermarket quote when a market order arrives.

Although the effective spread on the NYSE is generally larger when the best displayed intermarket spread exceeds one-eighth, it is not always larger. For stocks with a 1989 year-end price of less than $15 and a print size of 100 shares, the average effective spread for all trades is 12.3 cents in comparison to 11.6 cents when the best displayed intermarket quote exceeds one-eighth. In order for the effective spread to be less than 12.5 cents when the best displayed spread exceeds one-eighth, there has to be a greater than 50-percent chance of execution within the spread, and indeed the percentage of prints within the best displayed

intermarket quote is 58.1 percent for this category (Table 6). The average effective spreads for 100- and 200-share prints of NYSE-listed stocks on non- NYSE markets are greater than the average effective spreads on the NYSE (Table 10). For stocks with 1989 year-end prices of $50 or more, the average effective spread on non-NYSE markets ranges from 2.7 to 3.2 cents more than on the NYSE for all prints of 100 and 200 shares and from 4.5 to 6.8 cents more for these two print sizes when the best displayed intermarket quote exceeds one-eighth.

For print sizes of 300 or more, the amount by which the average effective spreads on the non-NYSE markets exceed those on the NYSE becomes smaller and, for some categories of prints, the non-NYSE markets have lower average effective spreads than those of the NYSE. These lower effective spreads on non-NYSE markets are most pronounced for the lower priced stocks, which tend to be the smaller NYSE-listed stocks, and for mid-size prints of 300 to 3,000 shares, depending upon the particular price category. As an example, in the 2,100-3,000 print size for stocks with 1989 year-end prices of less than $15, the average effective spread on non-NYSE markets is 0.8 cents less than on the NYSE and 5.0 cents less for this print size when the best displayed intermarket quote exceeds one-eighth.

To shed some additional light on the differences in average effective spreads between the NYSE and other markets, we present in greater detail the average effective spreads for stocks with 1989 year-end prices less than $15 when the best displayed intermarket quote is one-quarter or more, cross-classified by market place and print size. (Table 11).[25] The average effective spread for 100- and 200-share prints when the best displayed intermarket quote exceeds one-eighth is respectively 11.6 and 11.8 cents on the NYSE and is less than that of any market for those print sizes except for 200-share prints on the Pacific Stock Exchange. For larger print sizes, the average effective spread on a non-NYSE market is often less than that of the NYSE, particularly in the case of the Pacific Stock Exchange. On the Pacific, the average effective spread for prints of 300 to 20,000 shares ranges from 4.5 cents to 7.6 cents,

[25] Lee (1992) has also examined execution quality across exchanges but using different statistical tools.

implying a high probability of an execution within the best displayed intermarket spread. With the exception of the NASD, all of the regionals have lower effective spreads than the NYSE for prints of 600 to 5,000 shares. For stocks with 1989 year-end prices of $15 or more, there is a similar but less pronounced relation between the NYSE and the regionals.

At this point, we do not know the reason for the apparently much lower average effective spreads on the non-NYSE markets for some of the mid-size prints when the best displayed intermarket spread exceeds one-eighth. One explanation is that the upstairs market finds that there is a smaller probability of having a crossed order broken up on the regionals and thus use the regionals to work crossed institutional orders, particularly when the spread of the best displayed intermarket quote is one-quarter or more, but this explanation seems implausible for orders as small as 300 shares. Another explanation according to a Pacific spokesperson is that the Pacific Stock Exchange has a "double uptick" rule that limits how fast a specialist on that exchange can adjust trade prices. Some of the other non-NYSE markets have similar rules. Whatever the reason, most trades on the Pacific are executed when the spread of the best displayed intermarket quote is one-eighth: 77.2 percent of all Pacific prints occur when the best displayed intermarket spread equals one-eighth.

In ending this section, it is important to put into perspective this tendency for the non-NYSE markets to have smaller effective spreads for mid-size prints and particularly for lower priced stocks when the best displayed intermarket quote exceeds one-eighth. First, if it is correct that this tendency is intertwined with the execution of crossed orders, a market order submitted to a regional would not have the same probability of being executed within the spread. Second, the NYSE still has the dominant market share, so that the majority of orders do not receive this greater probability of being executed within the spread. As an example, the NYSE in 1990 captured 68.4 percent of all prints of the lowest priced stocks when the best displayed intermarket spread exceeds one-eighth.

5 Conclusion

This paper began with a description of the institutional structure for trading NYSE-listed stocks on the NYSE and other markets. When the displayed spread exceeds one-eighth, this institutional structure permits trades within the spread; if trades take place within the displayed spreads, the effective spreads can be smaller than these displayed spreads.

The first analysis finds that the NYSE quote is part of the best displayed intermarket quote roughly ninety percent of the time and thus plays the dominant role is setting this intermarket quote. A comparison of NYSE quotes and non-NYSE quotes shows that when a non-NYSE market is part of the best displayed intermarket quote, the resulting intermarket quote has on average a tighter spread but less depth. The non-NYSE markets do on occasion contribute to price discovery: When a non-NYSE market is part of the best displayed intermarket quote, the NYSE matches the better price in somewhat more than 50 percent of the cases.

The paper also analyzes the effective spread as a function of the price of the stock, the size of the print, and the market reporting the print. Across all categories of stock prices, the average effective spreads on the NYSE are less than the average effective spreads on non-NYSE markets for prints of 100 or 200 shares, equal to or greater for moderate size prints of 300 to 3,000 or so shares, and again smaller for prints in excess of 3,000 or so shares.

The average spread of the best displayed intermarket quote is 17.7 cents, which is 90.6 percent of the average displayed NYSE spread of 19.5 cents. In turn, the average effective spread is 13.5 cents, which is 76.2 percent of the spread of the best displayed intermarket quote. Thus, researchers should be cautious in using displayed quotes as indicators of the prices at which trades actually take place.

References

1. Amihud, Y., and H. Mendelson. 1980. "Dealership Markets: Market-Making with Inventory," *Journal of Financial Economics,* 8, 31-53.

2. Blume, M. E., and M. A. Goldstein. 1991. "Differences in Execution Prices among the NYSE, the Regionals and the NASD." *Rodney L. White Center for Financial Research* Working Paper 4-92.

3. Copeland, T., and D. Galai. 1983. "Information Effects on the Bid-Ask Spread." *Journal of Finance,* 38, 1457–1469.

4. Demsetz, H. 1968, "The Cost of Transacting," *Quarterly Journal of Economics,* 82, 33–53.

5. Domowitz, I. 1992. "A Taxonomy of Automated Trade Execution Systems." *Northwestern University.*

6. Domowitz, I., and J. Wang. 1992. "Auctions as Algorithms: Computerized Trade Execution and Price Discovery." *Northwestern University.*

7. Garbade, K., and W. Silver. 1979. "Dually-Traded Securities: A Study of Dominant and Satellite Markets." *Review of Economics and Statistics,* 61, 1979, 455–460.

8. George, T. J., G. Kaul, and M. Nimalendran. 1991. "Estimation of the Bid-Ask Spread and Its Components: A New Approach." *The Review of Financial Studies,* 4, 623–656.

9. Glosten, L. R. 1987. "Components of the Bid-Ask Spread and the Statistical Properties of Transaction Prices." *Journal of Finance,* 42, 1293–1308.

10. Glosten, L. R., and L. E. Harris. 1988. "Estimating the Components of the Bid-Ask Spread." *Journal of Financial Economics,* 21, 123–142.

11. Glosten, L. R., and P. R. Milgrom. 1985. "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders." *Journal of Financial Economics,* 14, 71- -100.

12. Goldstein, M. A. 1991. "Why Small Investors Love New York: An Execution Analysis of Primary and Secondary Exchanges." *University of Pennsylvania.*

13. Grossman, S. J. 1992. "The Informational Role of Upstairs and Downstairs Trading." *The Journal of Business,* 65, 4, 509–528.

14. Hamilton, J. L. 1991. "The Dealer and Market Concepts of Bid-Ask Spread: A Comparison for NASDAQ Stocks." *Journal of Financial Research,* 129–139.

15. Hasbrouck, J. 1992. "Using the TORQ Database." *New York Stock Exchange.*

16. Hasbrouck, J., and D. Sosebee. 1992. "Orders, Trades, Reports and Quotes at the New York Stock Exchange." *New York Stock Exchange.*

17. Ho, T., and H. R. Stoll. 1981. "Optimal Dealer Pricing under Transactions and Return Uncertainty." *Journal of Financial Economics,* 9, 47–73.

18. Keim, D. B. 1989. "Trading Returns, Bid-Ask Spreads and Estimated Security Returns: The Case of Common Stocks at Calendar Turning Points." *Journal of Financial Economics* 25, 1, 75–97.

19. Keim, D. B., and A. Madhavan. 1992. "The Upstairs Market for Large-Block Transactions: Analyses and Measurements of Price Effects." *Rodney L. White Center for Financial Research* Working Paper 21–92.

20. Koski, J. L. 1992. "Nonstandard Settlement Trading on Ex- Dividend Days." *University of Washington.*

21. Kyle, A. S. 1985. "Continuous Auctions and Insider Trading." *Econometrica,* 53, 1315–1335.

22. Lee, C. M. C. 1992. "Purchase of Order Flows and Favorable Executions: An Intermarket Comparison." *University of Michigan.*

23. Lee, C. M. C., and M. J. Ready. 1991. "Inferring Trade Direction from Intraday Data." *Journal of Finance* 46, 2, 733–746.

24. Loss, L., and J. Seligman. 1989. *Securities Regulation.* Little, Brown and Company, Boston.

25. McInish, T. H., and R. A. Wood. 1992. "Hidden Limit Orders on the NYSE." *Memphis State University*

26. National Association of Securities Dealers, Inc. 1991. "Inducements for Order Flow."

27. Roll, R. 1984. "A Simple Measure of the Bid-Ask Spread." *Journal of Finance,* 39, 1127–1139.

28. Securities and Exchange Commission. 1973. "Policy Statement of the Securities and Exchange Commission on the Structure of a Central Market System." (dated March 29).

29. Securities and Exchange Commission. 1982. "A Report on the Operation of the Intermarket Trading System 1978-1981."

30. Securities and Exchange Commission. 1988. "The October 1987 Market Break."

31. Stoll, H. R. 1989. "Inferring the Components of the Bid- Ask Spread: Theory and Empirical Tests." *Journal of Finance,* 44, 115–134.

32. Tinic, S. 1972. "The Economies of Liquidity Services." *Quarterly Journal of Economics,* 86, 79–93.

Table 1

Percentage of Time that Each Exchange Has the Best Displayed Intermarket Quote

NYSE-Listed Common Stocks, 1990

The proportion of time that each exchange has the best displayed intermarket bid or ask was calculated by dividing the cumulative number of seconds that each exchange had the best displayed intermarket bid or the best displayed intermarket ask by the total number of seconds analyzed for all stocks in that market value category. The time period covered includes all of 1990 during the time that the NYSE was open for trading. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. Market value categories were assigned based on data at the close of year-end 1989 as reported by CRSP.

Companies Ranked by Market Value	Percentage of Time						
	NYSE	Boston	Cincinnati	Midwest	Pacific	Philadelphia	NASD
A. Bid Quotes							
Top 50	88.97	0.47	4.15	3.31	2.06	0.26	0.78
Next 200	91.43	0.56	1.10	3.27	2.90	0.38	0.36
Next 250	91.82	0.52	0.26	3.44	3.23	0.39	0.36
Next 500	91.72	0.47	0.10	3.86	2.89	0.37	0.60
Remainder	92.37	0.24	0.03	4.27	2.29	0.29	0.50
B. Ask Quotes							
Top 50	88.33	0.56	3.61	3.83	2.18	0.41	1.08
Next 200	89.73	0.87	1.18	4.12	3.19	0.54	0.35
Next 250	90.23	0.62	0.33	4.31	3.62	0.57	0.32
Next 500	91.31	0.53	0.11	3.95	3.14	0.45	0.52
Remainder	92.26	0.33	0.01	4.04	2.47	0.28	0.61

Table 2

Comparison of the Depth When the NYSE Has the Best Displayed Intermarket Bid or Ask to the Depth When a Non-NYSE Market Has the Best Displayed Intermarket Bid or Ask

NYSE-Listed Common Stocks, 1990

For each best displayed intermarket bid, the depth quoted with that bid was assigned to the exchange which submitted that bid and that depth. The average depth quoted when the bid was part of the best intermarket displayed quote was then calculated for each exchange weighted by the number of seconds that the depth was quoted. (The same was done for the ask.) The time period covered includes all of 1990 during the time that the NYSE was open for trading. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. Market value categories were assigned based on data at the close of year-end 1989 as reported by CRSP.

Companies Ranked by Market Value	Average NYSE Depth (Sh.)	Depth as a Percentage of NYSE Depth					
		Boston	Cincinnati	Midwest	Pacific	Philadelphia	NASD
A. Bid Quotes[1]							
Top 50	9,893	21.1	27.7	23.5	11.9	27.2	8.9
Next 200	7,663	23.6	13.1	27.0	15.1	23.2	9.9
Next 250	8,233	28.6	11.5	28.2	16.0	22.9	10.1
Next 500	8,222	32.1	12.6	29.1	18.4	25.6	17.6
Remainder	6,534	34.8	25.4	32.0	22.5	29.1	28.5
B. Ask Quotes[2]							
Top 50	11,423	16.7	23.2	20.6	9.6	17.7	7.9
Next 200	8,056	21.9	12.1	23.3	13.7	27.7	9.1
Next 250	8,226	25.2	11.6	26.4	15.6	24.2	9.3
Next 500	8,121	28.2	15.7	28.7	17.4	26.3	14.6
Remainder	5,865	34.4	20.4	34.2	22.8	29.1	31.4

[1]Average Depth when the NYSE bid is part of the best displayed intermarket quote.

[2]Average Depth when the NYSE ask is part of the best displayed intermarket quote.

Table 3

Comparison of the Best Displayed Spread When the NYSE Has the Best Displayed Intermarket Bid or Ask to the Best Displayed Spread When a Non-NYSE Market Has the Best Displayed Bid or Ask

NYSE-Listed Common Stocks, 1990

For each best displayed intermarket bid, the associated best displayed intermarket spread of which that bid was a part was assigned to the exchange which submitted that bid. The average best displayed intermarket spread when the bid was part of the best intermaket displayed quote was then calculated for each exchange weighted by the number of seconds that the depth was quoted. (The same was done for the ask.) The time period covered includes all of 1990 during the time that the NYSE was open for trading. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges. Market value categories were assigned based on data at the close of year-end 1989 as reported by CRSP.

Companies Ranked by Market Value	Average NYSE Spread (cents)	Spread as a Percentage of NYSE Spread					
		Boston	Cincinnati	Midwest	Pacific	Philadelphia	NASD
A. Bid Quotes							
Top 50	17.8	82.6	100.3	85.2	81.1	80.7	87.1
Next 200	20.4	78.6	90.9	84.1	81.8	79.4	87.0
Next 250	21.8	78.3	95.2	83.6	83.1	77.7	87.3
Next 500	22.6	80.7	103.1	83.9	86.1	79.2	86.6
Remainder	20.5	83.4	81.5	85.4	88.9	82.1	71.5
B. Ask Quotes							
Top 50	17.8	82.9	99.7	85.7	81.8	82.3	86.4
Next 200	20.5	80.3	90.6	84.5	83.3	80.3	86.6
Next 250	21.8	77.3	96.6	84.8	84.8	81.5	88.1
Next 500	22.6	78.7	104.4	85.1	86.6	80.7	83.0
Remainder	20.5	80.2	87.6	84.9	89.3	81.8	81.6

Table 4

Proportion of Time that the Best Displayed Spread Is Greater than One-Eighth Cross-Classified by 1989 Market Value and 1989 Closing Share Price

NYSE-Listed Common Stocks, 1990

The proportion of time that the best displayed spread is greater than one-eighth was calculated by dividing the cumulative number of seconds that the spread was greater than one-eighth by the total number of seconds analyzed for all stocks in that price and market value category. The time period covered includes all of 1990 during the time that the NYSE was open for trading. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. Price, market value, and dollar volume categories were assigned based on data at the close of year-end 1989 as reported by CRSP. (The numbers in parentheses indicate the number of stocks per price and market value category.)

1989 Market Value Category	Proportion of Total 1989 Market Value	Proportion of Total 1989 Dollar Volume	1989 Closing Stock Price, P				
			$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
Top 50	0.41	0.31	0.58 (6)	0.39 (29)	0.27 (14)	0.13 (1)	none
Next 200	0.35	0.41	0.80 (7)	0.61 (61)	0.46 (115)	0.22 (17)	none
Next 250	0.15	0.17	0.99 (1)	0.77 (32)	0.61 (148)	0.34 (50)	0.17 (19)
Next 500	0.08	0.09	0.96 (2)	0.87 (16)	0.74 (149)	0.59 (183)	0.29 (150)
Remainder	0.01	0.02	none	none	0.85 (16)	0.76 (84)	0.43 (324)

Table 5

Distribution of Minimum Reporting Lags in Trades by Marketplace in Seconds

NYSE-Listed Common Stocks, 1990

The minimum reporting trade lag was determined using the TORQ data set provided by the NYSE. This data set covers 144 stocks from November 1990 through January 1991. The minimum reporting lag is calculated as the difference between the time that the buyer and the seller have recorded their transaction for the clearing process and the time the transaction was printed on the Consolidated Tape System, when the time recorded by the buyer and seller precedes the transaction print time. The 25 and 75 percent fractiles are reported to give an indication of the distribution of the lags.

Marketplace	25% Fractile	Median	75% Fractile
NYSE	9	16	27
Boston	19	34	49
Cincinnati	0	3	4
Midwest	7	16	24
Pacific	3	5	10
Philadelphia	14	29	44
NASD	15	31	48

Table 6

Percentage of Prints on the NYSE with Prices between the Best Displayed Intermarket Quote Cross-Classified by Print Size and 1989 Closing Share Price

NYSE-Listed Common Stocks, 1990

The percentage of prints is the number of prints within the best displayed intermarket bid and the best displayed intermarket ask divided by the total number of prints analyzed on that exchange for all stocks in that price and print size category when the time stamp of the print is reduced by the median reporting delay by exchange. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD.

Print Size (# shares)	1989 Closing Stock Price, P				
	$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
A. NYSE – All Spreads					
100	33.2	27.9	24.5	21.5	13.8
200	32.1	27.6	23.6	20.4	12.9
300 to 500	29.8	26.1	22.8	19.4	12.2
600 to 1,000	26.3	23.8	21.0	17.6	10.6
1,100 to 2,000	24.6	22.2	20.3	16.9	9.8
2,100 to 3,000	23.3	21.5	20.3	17.3	9.9
3,100 to 5,000	22.9	20.9	20.0	17.4	10.7
5,100 to 10,000	22.7	20.2	19.9	17.4	11.0
10,100 to 20,000	24.1	20.2	20.2	17.6	11.7
Over 20,000	21.1	18.5	17.7	16.2	10.9
B. NYSE – When Best Displayed Spread Exceeds One-Eighth					
100	51.6	60.1	58.5	59.2	58.1
200	49.9	56.9	55.2	56.5	57.5
300 to 500	45.4	53.5	52.7	53.3	55.7
600 to 1,000	40.5	49.9	49.6	49.9	52.9
1,100 to 2,000	38.5	47.8	48.5	48.5	50.4
2,100 to 3,000	37.0	47.1	48.6	48.7	50.3
3,100 to 5,000	36.9	46.5	49.2	49.7	50.9
5,100 to 10,000	37.9	44.9	49.1	50.2	51.2
10,100 to 20,000	39.9	43.6	49.2	50.5	51.2
Over 20,000	34.6	37.4	42.5	46.4	49.1

Table 7

Difference in the Percentage of Prints with Prices between the Best Displayed Intermarket Quote between the NYSE and Other Markets Cross-Classified by Print Size and 1989 Closing Share Price

NYSE-Listed Common Stocks, 1990

The percentage of prints is the number of prints within the best displayed intermarket bid and the best displayed intermarket ask divided by the total number of prints analyzed on that exchange for all stocks in that price and print size category when the time stamp of the print is reduced by the median reporting delay by exchange. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. Other markets include the Boston, Cincinnati, Midwest, Pacific and Philadelphia exchanges as well as the NASD.

Print Size (# shares)	1989 Closing Stock Price, P				
	$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
A. NYSE Less Other Markets – All Spreads					
100	16.0	14.4	12.3	9.9	5.2
200	14.6	13.1	10.7	8.3	4.0
300 to 500	9.2	8.1	6.6	3.7	0.8
600 to 1,000	5.9	5.9	5.0	2.8	0.4
1,100 to 2,000	2.3	2.8	2.4	0.8	−0.1
2,100 to 3,000	−7.7	0.8	2.2	0.3	0.3
3,100 to 5,000	3.5	1.6	2.9	0.7	1.1
5,100 to 10,000	0.3	3.1	3.2	0.5	2.0
10,100 to 20,000	2.5	2.0	1.8	−1.8	1.2
Over 20,000	0.0	0.4	−2.6	−2.6	−1.7
B. NYSE Less Other Markets – When Best Displayed Spread Exceeds One-Eighth					
100	23.7	28.1	22.9	20.0	15.9
200	20.7	21.9	17.2	14.4	10.3
300 to 500	8.5	9.6	6.2	1.6	−2.6
600 to 1,000	3.3	4.6	1.4	−2.7	−7.1
1,100 to 2,000	−0.7	−0.6	−3.8	−7.9	−13.5
2,100 to 3,000	−10.6	−2.0	−4.6	−10.8	−17.5
3,100 to 5,000	4.1	3.0	1.5	−7.4	−15.5
5,100 to 10,000	1.5	6.5	6.2	−2.2	−10.0
10,100 to 20,000	3.6	4.0	5.0	−3.4	−8.0
Over 20,000	−0.1	−2.3	−3.5	−3.5	−2.8

Table 8

Number of Prints for the NYSE and Other Markets
NYSE-Listed Common Stocks, 1990

The number of prints are the total number of prints that occurred in that print size category. Other markets include the Boston, Cincinnati, Midwest, Pacific, and Philadelphia regional exchanges as well as the NASD.

Print Size (# shares)	Number of Prints (NYSE)	Number of Prints (Non-NYSE Markets)
A. All Spreads		
100	2,932,209	2,591,756
200	2,170,205	1,474,651
300 to 500	3,650,491	2,040,794
600 to 1,000	2,858,414	1,094,617
1,100 to 2,000	1,832,200	375,125
2,100 to 3,000	839,644	119,960
3,100 to 5,000	979,307	99,746
5,100 to 10,000	685,956	60,266
10,100 to 20,000	280,135	26,730
Over 20,000	188,230	22,969
B. When Displayed Spread Exceeds One-Eighth		
100	1,196,332	913,809
200	889,175	487,972
300 to 500	1,500,588	673,904
600 to 1,000	1,139,393	325,229
1,100 to 2,000	729,253	110,495
2,100 to 3,000	335,888	36,037
3,100 to 5,000	385,618	31,745
5,100 to 10,000	267,020	20,882
10,100 to 20,000	110,018	10,291
Over 20,000	73,378	9,299

Table 9

Average Effective Spreads for the NYSE
Cross-Classified by Selected Print Size and 1989 Closing Share Price
NYSE-Listed Common Stocks, 1990

The average effective spread is twice the mean absolute deviation of the transaction price from the midpoint of the best displayed intermarket quote, calculated across all stocks in that price category for all prints in that print size category when the time stamp of the print is reduced by the median reporting delay by exchange. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD.

Print Size (# shares)	1989 Closing Stock Price, P				
	$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
A. NYSE – All Spreads					
100	18.0¢	12.9¢	12.8¢	12.6¢	12.3¢
200	17.9	13.4	13.3	12.8	12.4
300 to 500	19.0	13.9	13.6	13.2	12.5
600 to 1,000	19.9	14.4	14.0	13.5	12.7
1,100 to 2,000	20.0	14.7	14.1	13.7	12.8
2,100 to 3,000	19.8	14.7	14.1	13.7	12.9
3,100 to 5,000	19.6	14.8	14.0	13.6	12.9
5,100 to 10,000	19.2	15.1	14.1	13.6	12.9
10,100 to 20,000	19.2	15.8	14.3	13.8	13.1
Over 20,000	25.0	19.8	16.9	15.4	13.8
B. NYSE – When Best Displayed Spread Exceeds One-Eighth					
100	20.9¢	12.9¢	13.0¢	12.5¢	11.6¢
200	20.6	14.1	13.9	13.2	11.8
300 to 500	22.1	15.0	14.6	14.1	12.3
600 to 1,000	23.4	15.8	15.4	14.9	13.0
1,100 to 2,000	23.6	16.3	15.7	15.3	13.8
2,100 to 3,000	23.4	16.4	15.6	15.3	13.8
3,100 to 5,000	23.1	16.4	15.3	14.8	13.8
5,100 to 10,000	22.5	16.9	15.3	14.7	13.7
10,100 to 20,000	21.8	17.7	15.5	14.7	13.7
Over 20,000	28.8	22.0	19.0	17.0	15.0

Table 10

Difference in the Average Effective Spreads between the NYSE and Other Markets Cross-Classified by Selected Print Size and 1989 Closing Share Price

NYSE-Listed Common Stocks, 1990

The average effective spread is twice the mean absolute deviation of the transaction price from the midpoint of the best displayed intermarket quote, calculated across all stocks in that price category for all prints in that print size category when the time stamp of the print is reduced by the median reporting delay by exchange. The differences calculated are the average effective spread for non-NYSE markets in that price and print size category less the appropriate average effective spread for the same price and print size category for the NYSE. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. The average effective spread for other markets is the transaction weighted average of the Boston, Cincinnati, Midwest, Pacific, and Philadelphia regional exchanges and the NASD.

Print Size (# shares)	1989 Closing Stock Price, P				
	$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
A. Other Markets Less NYSE – All Spreads					
100	3.2¢	3.2¢	2.1¢	1.5¢	0.9¢
200	2.7	2.3	1.4	1.0	0.6
300 to 500	−0.4	0.9	0.4	−0.0	−0.1
600 to 1,000	−1.1	0.3	−0.2	−0.5	−0.3
1,100 to 2,000	−1.4	−0.2	−0.6	−0.8	−0.6
2,100 to 3,000	−2.1	−0.0	−0.6	−1.0	−0.8
3,100 to 5,000	0.7	0.8	0.3	−0.6	−0.7
5,100 to 10,000	1.5	1.1	1.0	0.1	−0.6
10,100 to 20,000	1.0	1.0	0.9	−0.1	−0.4
Over 20,000	−4.3	−2.2	−0.2	−0.0	0.0
B. Other Markets Less NYSE – When Best Displayed Spread Exceeds One-Eighth					
100	5.0¢	6.8¢	5.4¢	4.6¢	4.0¢
200	4.5	5.1	3.9	3.1	2.5
300 to 500	0.4	1.9	1.1	−0.3	−0.8
600 to 1,000	−0.4	0.7	−0.2	−1.5	−2.1
1,100 to 2,000	−1.5	−0.6	−1.5	−2.7	−3.9
2,100 to 3,000	−3.8	−0.6	−1.6	−3.3	−5.0
3,100 to 5,000	1.8	0.9	0.1	−2.2	−4.4
5,100 to 10,000	2.2	1.6	1.8	−0.3	−3.3
10,100 to 20,000	0.8	0.9	1.6	−1.1	−2.1
Over 20,000	−3.9	−1.5	−0.5	−0.9	−1.0

Table 11

Average Effective Spreads by Market When the Best Displayed Spread is Greater than One-Eighth for Stocks with a 1989 Closing Price Between $1 and $15

NYSE-Listed Common Stocks, 1990

The average effective spread is twice the mean absolute deviation of the transaction price from the midpoint of the best displayed intermarket quote, calculated across all stocks with a 1989 closing price between $1 and $15 for all prints in that print size category when the time stamp of the print is reduced by the median reporting delay by exchange. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD.

Print Size (# Shares)	NYSE	Boston	Cincinnati	Midwest	Pacific	Philadelphia	NASD
A. Average Effective Spread							
100	11.6¢	13.0¢	19.4¢	16.3¢	12.6¢	20.0¢	17.6¢
200	11.8	12.5	13.6	14.7	10.8	18.9	17.5
300 to 500	12.3	11.9	11.6	13.4	6.6	17.1	16.8
600 to 1,000	13.0	11.0	10.0	12.7	6.5	12.4	16.0
1,100 to 2,000	13.8	10.1	10.4	10.9	5.2	10.8	15.6
2,100 to 3,000	13.8	10.0	6.9	9.0	4.6	9.0	14.0
3,100 to 5,000	13.8	9.6	10.6	8.4	5.0	11.7	14.8
5,100 to 10,000	13.7	12.8	15.0	9.6	4.5	11.8	13.3
10,100 to 20,000	13.7	12.8	15.6	10.4	7.6	12.8	13.0
Over 20,000	15.0	16.5	7.8	11.5	14.1	15.9	15.6
Overall	12.7	11.9	12.2	13.8	7.8	16.8	16.6
B. Number of Prints							
100	79,370	5,237	133	18,196	9,534	3,574	6,788
200	60,623	4,221	134	13,719	8,136	2,717	5,662
300 to 500	114,417	7,182	560	22,516	24,498	4,752	9,307
600 to 1,000	91,464	5,754	264	15,140	14,602	2,538	6,900
1,100 to 2,000	50,589	1,647	97	5,334	4,971	803	2,918
2,100 to 3,000	20,936	478	25	1,595	1,373	174	982
3,100 to 5,000	24,832	343	26	1,247	927	199	829
5,100 to 10,000	17,740	211	30	541	350	135	566
10,100 to 20,000	8,008	49	12	250	74	47	292
Over 20,000	6,380	34	8	290	43	44	376
Overall	474,359	25,156	1,289	78,828	64,508	14,983	34,620

Appendix 1

Difference in the Average Effective Spreads between the NYSE and Other Markets Using the Lagged Mean Absolute Measure Cross-Classified by Selected Print Size and 1989 Closing Share Price

NYSE-Listed Common Stocks, 1990

The average effective spread is twice the mean absolute deviation of the transaction price from the midpoint of the best displayed intermarket quote across all stocks in that price category for all prints in that print size category when the time stamp of the print is reduced by the median reporting delay by exchange plus three minutes. The differences calculated are the average effective spread for non-NYSE markets in that price and print size category less the appropriate average effective spread for the same price and print size category for the NYSE. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. The average effective spread for other markets is the transaction weighted average of the Boston, Cincinnati, Midwest, Pacific, and Philadelphia regional exchanges and the NASD.

Print Size (# shares)	1989 Closing Stock Price, P				
	$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
A. Other Markets Less NYSE – All Spreads					
100	1.4¢	3.2¢	2.2¢	1.7¢	1.2¢
200	0.2	1.8	1.5	1.3	0.9
300 to 500	−3.4	0.6	0.8	0.6	0.5
600 to 1,000	−7.4	−2.1	−0.6	−0.3	−0.0
1,100 to 2,000	−8.4	−3.1	−1.6	−1.1	−0.7
2,100 to 3,000	−4.7	−2.4	−2.0	−1.6	−1.1
3,100 to 5,000	−5.7	−3.4	−1.9	−1.8	−1.3
5,100 to 10,000	−5.2	−4.8	−2.1	−1.6	−1.4
10,100 to 20,000	−3.5	−4.4	−2.3	−2.2	−1.5
Over 20,000	−8.2	−7.0	−2.8	−2.1	−0.9
B. Other Markets Less NYSE – When Best Displayed Spread Exceeds One-Eighth					
100	2.0¢	4.9¢	4.6¢	4.8¢	4.9¢
200	0.6	3.0	3.2	3.7	4.1
300 to 500	−3.1	1.6	2.3	2.3	2.9
600 to 1,000	−7.5	−1.9	0.2	0.6	0.8
1,100 to 2,000	−9.4	−3.4	−1.3	−1.0	−1.4
2,100 to 3,000	−6.7	−3.4	−2.2	−2.5	−2.7
3,100 to 5,000	−6.4	−4.7	−2.3	−2.7	−3.3
5,100 to 10,000	−5.8	−6.3	−2.9	−3.1	−3.7
10,100 to 20,000	−4.3	−6.1	−3.9	−4.5	−4.4
Over 20,000	−10.1	−8.5	−4.7	−4.5	−3.3

Appendix 2

Difference in the Average Effective Spreads between the NYSE and Other Markets Using Mean-Squared Measure Cross-Classified by Selected Print Size and 1989 Closing Share Price

NYSE-Listed Common Stocks, 1990

The average effective spread is the mean-squared deviation of the transaction price from the midpoint of the best displayed intermarket quote across all stocks in that price category for all prints in that print size category when the time stamp of the print is reduced by the median reporting delay by exchange. The differences calculated are the average effective spread for non-NYSE markets in that price and print size category less the appropriate average effective spread for the same price and print size category for the NYSE. The differences are reported in squared dollars multiplied by 200. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. The average effective spread for other markets is the transaction weighted average of the Boston, Cincinnati, Midwest, Pacific, and Philadelphia regional exchanges and the NASD.

Print Size (# shares)	1989 Closing Stock Price, P				
	$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
A. Other Markets Less NYSE – All Spreads					
100	0.8	0.6	0.4	0.3	0.2
200	1.0	0.5	0.3	0.2	0.1
300 to 500	−0.4	0.2	0.1	0.1	0.0
600 to 1,000	−0.7	0.1	0.0	−0.1	−0.0
1,100 to 2000	−0.8	−0.0	−0.1	−0.1	−0.1
2,100 to 3,000	0.6	0.2	−0.0	−0.1	−0.1
3,100 to 5,000	0.4	0.4	0.2	0.0	−0.1
5,100 to 10,000	0.3	0.3	0.4	0.1	−0.1
10,000 to 20,000	0.1	0.4	0.5	0.0	−0.0
Over 20,000	−4.3	−0.9	0.2	0.1	0.1
B. Other Markets Less NYSE – When Best Displayed Spread Exceeds One-Eighth					
100	1.2	1.3	1.1	0.9	0.7
200	1.8	1.0	0.8	0.7	0.4
300 to 500	−0.2	0.5	0.3	0.1	0.1
600 to 1,000	−0.7	0.2	0.1	−0.2	−0.2
1,100 to 2,000	−0.9	−0.1	−0.2	−0.3	−0.5
2,100 to 3,000	0.8	0.0	−0.1	−0.4	−0.7
3,100 to 5,000	0.9	0.4	0.2	−0.1	−0.7
5,100 to 10,000	0.6	0.3	0.6	0.1	−0.6
10,100 to 20,000	−0.5	0.1	0.5	−0.3	−0.3
Over 20,000	−5.2	−0.5	0.2	−0.6	−0.4

Appendix 3

Difference in the Average Effective Spreads between the NYSE and Other Markets Using the Lagged Mean-Squared Measure Cross-Classified by Selected Print Size and 1989 Closing Share Price

NYSE-Listed Common Stocks, 1990

The average effective spread is the mean-squared deviation of the transaction price from the midpoint of the best displayed intermarket quote across all stocks in that price category for all prints in that print size category when the time stamp of the print is reduced by the median reporting delay by exchange plus three minutes. The differences calculated are the average effective spread for non-NYSE markets in that price and print size category less the appropriate average effective spread for the same price and print size category for the NYSE. The differences are reported in squared dollars multiplied by 200. Price categories were assigned based on data at the close of year-end 1989 as reported by CRSP. The best displayed spread was calculated based on an expanded version of the ISSM 1990 Trades and Quotes Transaction file which included all quotes from the regional exchanges and the NASD. The average effective spread for other markets is the transaction weighted average of the Boston, Cincinnati, Midwest, Pacific, and Philadelphia regional exchanges and the NASD.

Print Size (# shares)	1989 Closing Stock Price, P				
	$P \geq 100$	$50 \leq P < 100$	$25 \leq P < 50$	$15 \leq P < 25$	$1 < P < 15$
A. Other Markets Less NYSE – All Spreads					
100	0.1	1.0	0.6	0.4	0.3
200	−0.8	0.5	0.4	0.3	0.2
300 to 500	−3.8	0.0	0.1	0.1	0.1
600 to 1,000	−6.4	−1.1	−0.3	−0.2	−0.0
1,100 to 2,000	−7.7	−1.1	−0.8	−0.6	−0.2
2,100 to 3,000	−5.5	−1.1	−0.8	−0.6	−0.3
3,100 to 5,000	−4.8	−1.6	−0.7	−0.6	−0.4
5,100 to 10,000	−1.2	−1.9	−0.7	−0.5	−0.4
10,100 to 20,000	−2.1	−1.5	−0.7	−0.7	−0.4
Over 20,000	−6.6	−2.6	−0.7	−0.6	−0.2
B. Other Markets Less NYSE – When Displayed Spread Exceeds One-Eighth					
100	0.3	1.4	1.2	1.0	1.1
200	−0.8	0.8	0.8	0.8	0.9
300 to 500	−4.8	0.2	0.5	0.5	0.6
600 to 1,000	−7.8	−1.3	−0.2	−0.1	0.1
1,100 to 2,000	−10.1	−2.0	−0.8	−0.5	−0.4
2,100 to 3,000	−8.2	−2.0	−0.9	−0.9	−0.8
3,100 to 5,000	−6.4	−2.4	−1.0	−1.0	−0.9
5,100 to 10,000	−0.8	−2.7	−1.2	−0.9	−1.3
10,100 to 20,000	−3.1	−2.4	−1.4	−1.5	−1.1
Over 20,000	−9.0	−3.2	−1.3	−1.8	−1.2