

**DIFFERENCES IN EXECUTION PRICES  
AMONG THE NYSE, THE REGIONALS  
AND THE NASD**

by

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**4-92**

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Preliminary draft  
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September 1991

We wish to thank Martin Cher, Darren Klein, Anuj Malhotra and Todd Rosentover for their excellent research assistance. Michael Goldstein gratefully acknowledges financial support from Geewax, Terker & Company. The contents of this paper are the sole responsibility of the authors.

## **Abstract**

The purpose of this paper is to compare execution prices of NYSE-listed stocks on the NYSE and on non-NYSE markets. The first conclusion of this comparison is that most of the time the NYSE had the best quote. This result does not necessarily imply that execution prices on the NYSE are better than the regionals since an investor should always receive an execution price no worse than the best intermarket quote regardless of the particular market on which an order is executed. The second conclusion is that there is more price improvement on the NYSE than on other markets for NYSE-listed stocks. The third conclusion is that the average price improvement from trading on the NYSE varies according to the price of the stock and the size of the transaction. On a 100-share transaction of a 40-dollar stock, the price improvement on the NYSE is on average 1.5 cents greater than that on non-NYSE markets.

## **DIFFERENCES IN EXECUTION PRICES AMONG THE NYSE, THE REGIONALS AND THE NASD**

A common stock can be listed on the New York Stock Exchange (NYSE) and still be traded on other markets. A non-exhaustive list of such markets includes the regional exchanges like the Midwest Stock Exchange, broker-dealers who are members of the National Association of Securities Dealers (NASD) like Madoff Investment Securities, major international exchanges like the Tokyo Stock Exchange, and the London over-the-counter market. Some of these market places only trade the larger NYSE-listed issues.

The 1975 Amendments to the Securities and Exchange Act of 1934 called for the establishment of a National Market System (NMS) to link electronically the trading of all stock on all domestic markets, including NYSE-listed stocks. As envisioned at the time, a NMS would route electronically each order to that market displaying the best quote and would maintain an electronic Consolidated Limit Order Book (CLOB) to preserve strict price-time priority for all limit orders.

Thus, the execution price of any order in such a national system would always be at the best intermarket price, so that, at least in terms of execution price, an investor would be indifferent as to where an order was executed.<sup>1</sup> However, market places themselves would be free to compete in other ways, such as lower fees, more responsive trade reporting systems, and so on.<sup>2</sup> As it turned out, there has not been a full implementation of a NMS for NYSE-listed

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<sup>1</sup>An issue not addressed in the debate on a NMS in the 1970s was the degree of control that an investor would have in directing an order to a specific market. Could the investor direct the order to a specific market as long as that market matched the best intermarket price? Alternatively, would a computer rotate orders in some prespecified way among those market places tied with the best price?

<sup>2</sup>To have this type of competition, an investor would have to have some control over which market place to send an order. Cf. fn. 1.

stocks, although the industry has put into place some significant parts of such a system.<sup>3</sup> These parts include the Consolidated Tape System, the Consolidated Quote System, and the Intermarket Trading System (ITS), which provide substantial integration to the trading of NYSE-listed stocks. Nonetheless, there is no automatic routing of an order to the market displaying the best price, and, as discussed below, many trades actually do take place within the best displayed intermarket quote.<sup>4</sup>

The consequence of possibly receiving a better price than the best displayed intermarket quote is that some market places may provide better execution prices on average than other markets. The purpose of this paper is to compare the prices of NYSE-listed stocks that investors actually received on the NYSE itself, the regional stock exchanges, and NASD to determine whether there are any significant differences in the execution prices across these markets.

A study of differences in execution prices across markets is currently of particular relevance to public policy. The former Chairman of the SEC David S. Ruder under the auspices of the NASD chaired a committee to examine industry practices in soliciting order flow. The report of this committee documents many of the practices that the brokerage industry uses to attract order flow, including the outright payment for order flow. Payment for order flow may

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<sup>3</sup>Unlike NYSE-listed stocks, there is now a workable NMS-type system for NASDAQ-listed stocks. The NASD has developed a Small Order Execution System (SOES) for the automatic execution of market orders and limit orders up to 1000 shares for one class of stock and 500 shares for another class. In SOES, any order is automatically executed at the best published intermarket quote. All orders are executed against dealers' inventories, and there is no possibility of a cross of two public orders. Unless an investor or broker specifies to the contrary, orders are rotated among those dealers displaying the best intermarket prices.

<sup>4</sup>As described in footnote 3, small orders executed on SOES always receive the best displayed intermarket price. However, there is usually a telephone negotiation for the larger orders for NASDAQ-stocks, and the execution price for these orders may fall within the best intermarket quote.

be an important factor in explaining the recent decline in the NYSE's market share, particularly that of the small retail customer.

If the execution price of a trade were invariant to the place of execution, such inducements for order flow could not harm the ultimate investors. In the case of retail customers, one would expect at least a portion of any inducement or payment for order flow to be passed back to retail customers as a group through lower commissions leading to a better net price. But if execution prices become worse as these inducements for order flow increase, it is possible that the net price paid by an investor could become worse. This paper will not address the very difficult issue of measuring net price, but only the more limited issue of differences in execution prices among market places.

The paper itself begins with a short description of the institutional structure for trading NYSE-listed stocks. The next section shows that a substantial number of trades do occur at prices within the displayed quotes and that the probability of executing within the displayed quotes varies among markets. The following section measures the dollar differences in execution prices among exchanges. The paper ends with a brief conclusion.

### **I. Trading NYSE-Listed Securities**

Since the U.S. Congress called for a NMS in 1975, the security industry has put into place substantial electronic linkages among those US markets where NYSE-listed stocks are traded.<sup>5</sup> However, these linkages have not yet produced a national market where orders are electronically routed to the market with the best intermarket price.

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<sup>5</sup>Since the focus of this paper is on NYSE-listed stocks for which data are available, this paper will not describe the very significant changes in the trading of O-T-C stocks under NASDAQ.

In 1972, the SEC called for a consolidated tape to report prices and volume of trades on a real time basis and a consolidated quotation system to provide a single source for the current quotes from all US markets. The SEC viewed these two reporting systems as key elements in a NMS. Beginning in 1975, the consolidated tape was intended to give visibility to the trading activity in NYSE-listed stocks on the regional exchanges and on markets made by non-NYSE member firms who report their transactions through the NASD. Beginning in 1978, the consolidated quotation system allowed investors to compare on a real-time basis the quotations on most US markets for NYSE-listed stocks and to determine the market with the best bid and the market with the best offer--in short, the best intermarket quote.

The SEC initially wanted an electronic switch to route orders to the markets with the best quotes,<sup>6</sup> but ultimately agreed to a trading linkage called the Intermarket Trading System (ITS). The purpose of ITS was to allow a specialist on a registered exchange to route a customer's order to another market if that market had a better price. A specialist on one registered exchange can also use ITS to lay off or accumulate inventory for his own account. ITS became operational in 1978 with a limited number of stocks but now includes virtually all NYSE-listed common stocks.

As it ultimately emerged, ITS is not automatic. Each market maker must visually monitor the best intermarket quote. In the event that a market maker with a poorer quote than the best intermarket quote receives a market order, that market maker can either exercise the order at the best quote or transmit a "commitment to trade" to the market with the best intermarket price. The receiving market then has one or two minutes, depending upon the

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<sup>6</sup>"Policy Statement of the Securities and Exchange Commission on the Structure of a Central Market System," SEC, March 29, 1973.

specific market, to accept or reject the trade.<sup>7</sup> If there is no response within the required time, the commitment expires.

Because of these integrated systems, theoretically a trade for any NYSE-listed stock should never take place outside the best intermarket quote. However, it should come as no surprise that on occasion in this non-automated system there are orders that are executed at prices inferior to those of the best intermarket quote. In 1981, the SEC estimated that such "trade-throughs" represented 0.56 percent of all trades.<sup>8</sup>

On the other hand, the execution prices of trades in NYSE-listed stocks often are better than the best intermarket quote. This may occur because the institutional structure of the NYSE and the regional exchanges make it possible for an order to be executed at a better price than the quote if the spread for a stock is greater than the minimum tick, typically one-eighth of a dollar.<sup>9</sup> To illustrate, assume that the current bid is 20 and the current ask price is 20 1/4 and that a market order arrives on the floor of the NYSE to buy 100 shares at the market. 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 better price, as has the seller. If not, the specialist might buy the stock at 20 1/8 for 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

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<sup>7</sup>Commitments sent to the NYSE expire after two minutes, while commitments to the regionals from the NYSE expire after one minute. Cf. *The October 1987 Market Break*, U.S. Securities and Exchange Commission, February 1988, chapt. 7, p. 43.

<sup>8</sup>SEC, "A Report on the Operation of the Intermarket Trading System 1978-1981," (1982), as cited in Louis Loss and Joel Seligman, *Securities Regulation* (Boston: Little, Brown and Company, 1989), p. 2566, fn. 243.

<sup>9</sup>Additionally, there can be price improvement with a spread of 1/8 if two public orders cross. One side will have an improved price, possibly at the expense of a limit order on the other side.



subsequently it will be executed at a better or lower price. Thus, even in the case that the NYSE displayed quote is the best intermarket quote, there is always the possibility of obtaining a better execution price.

Both the SEC and Congress have praised this possibility of improving upon the displayed quotes as a desirable property in the trading of equities and have criticized market structures that do not have this property of possible price improvement. It should be noted that this possibility of price improvement is inconsistent with a NMS that automatically routes orders to the best bids and offers.

To aid in interpreting the following analyses, it is worth pausing to discuss the procedures for trading stocks as a function of the size of an order. Consider first small retail trades for which there are several electronic systems to facilitate their execution. A retail investor places an order with a broker, who then submits the order to 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 where there is sometimes the possibility of price improvement. Currently, SuperDot accepts market orders of up to 30,999 shares and limit orders of up to 99,999 shares. The brokerage firm pays no fee to the specialist for most market orders<sup>10</sup> or limit orders up to 2,099 shares executed within two minutes. The specialist fees for limit orders held over two minutes vary from specialist to specialist and from customer to customer.

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 market orders of up to 599 shares at the best intermarket quote. There is no chance for an improvement in price. MAX at the Midwest Stock Exchange and Scorex at the

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<sup>10</sup>The specialist may charge fees on some orders such as sell short orders.

Pacific Stock Exchange, very similar systems, accept orders of up to 1,099 shares and display these orders for 15 seconds to the floor and to the specialist for possible improvement in price. If not executed within 15 seconds, the order is executed against the best intermarket quote prevailing at the original time of submission. In 1988, the Boston Stock Exchange introduced an automated execution system, called BEACON, that incorporates a delay of 15 seconds in the same way as MAX and Scorex. Recently, the Midwest has introduced an algorithm for improvement of price of small market orders when the spread is greater than one eighth.

Recently, Madoff has become an important player in the retail market and makes markets in several hundred of the largest equity issues. This company, not a member of the NYSE, provides electronic execution of market orders up to 3000 shares at the best intermarket quote even if the depth of the quote is less than 3000 shares. To allow for price improvement, Madoff now exposes up to 300 shares of any order to ITS for one minute when the spread is greater than one eighth.

To attract order flow, the exchanges themselves, specialists on the exchanges and Madoff sometime provide an inducement for providing order flow. At least one of the regional exchanges offers credits against its fees, and it is rumored that some regional specialists pay one or two cents a share for order flow. Madoff has made arrangements with certain brokerage houses to pay one cent or so per share in return for market orders; the firm does not pay for limit orders. Madoff has argued that, quite apart from this payment for order flow, retail brokers find the firm's fully automated electronic execution system more responsive to their needs than those of the registered exchanges. The consequence of these inducements is that a retail firm may have an incentive to send small retail orders to a particular market even though another market may provide more opportunities for price improvement.

Another criticism of these regional systems and Madoff's is that they use the quote of the NYSE to set their trading prices and thus do not contribute to the price discovery process. In effect, they are free riders on the quotations developed through the trading process on the floor of the NYSE. The empirical results below find that the best intermarket quote is generally that of the NYSE, giving some support to this criticism.

When institutions have smaller orders, they frequently use a system like SuperDot. Program trades involving a large number of small orders would also fall into this category.<sup>11</sup> For larger orders, where the order itself could cause a significant price impact, institutions try to execute an order in such a way as to minimize the price impact. Rather than blindly sending a large market order over one of these electronic systems, an institution will carefully examine different strategies to execute an order.

## II. Execution Prices and Quotes

The Institute for the Study of Security Markets compiles a Trades and Quotes Transaction File from the source data for the Consolidated Tape and the Consolidated Quote System. This study analyzes the 1989 data for NYSE-listed common stocks.<sup>12</sup> From these data, one can determine the best intermarket quote at any point in time and then compare these quotes to actual execution prices. Since these data do contain errors, it is necessary to filter the data, and the 15-second delays in the execution of small orders on the Boston, Midwest, and

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<sup>11</sup>The NYSE defines a program trade as the simultaneous placement of orders for fifteen or more stocks with a total value of one million dollars or more.

<sup>12</sup>The ISSM will soon be sending us the data for 1990, which will include all regional quotes. As explained in the Appendix, regional exchanges sometimes use an autoquote device which updates the regional quote in response to changes in the best intermarket quote. Generally, regional specialists use this device to make their quotes worse than the best intermarket quote. The 1989 data excluded these autoquotes, requiring the extensive adjustments that the Appendix describes.

Pacific Stock Exchanges require an adjustment to the data. The Appendix describes in detail the filters and adjustments that have been made to the data.

We first analyzed the intermarket quotes themselves and found that the NYSE quote is generally better than the best quote on any of the regionals or on NASDAQ (Tables 1 and 2). Overall, the NYSE had the best bid 86.94 percent of the time and the best offer 84.40 percent of time. The percentages were calculated by determining for each NYSE-listed common stock the number of seconds that the bid or offer was better than that of any other market and then aggregating these seconds for the market as a whole. The bid or offer can be better because the bid or ask price is superior to other markets or equal to those of other markets but with greater depth. In terms of the bid, the NYSE had a better bid price 53.94 percent of the time and an equal bid but greater depth 33.00 percent of the time. Similar percentages apply to the offer.

The effect of aggregating the seconds for each individual stock to the whole is to give equal weight to each stock regardless of dollar volume of the market value of the stock. A breakdown of these aggregated numbers into deciles by dollar volume or market value reveals little relation between these two measures of size and the percentage of time that the NYSE has the best bid or offer with the exception of the smallest deciles. For the smallest decile of either measure, there is a marked increase in the percentage of time that the NYSE has the best bid or offer and a very marked increase in the percentage of time that the NYSE has the best bid price or ask price.

Even though the quotes on the NYSE most of the time are better than those on the regionals or NASDAQ, a buyer or seller of stock on a regional exchange or on NASDAQ should still receive the best intermarket price. In effect, the non-NYSE markets are using the quotes of the NYSE to price their trades and most of the time are not contributing to the price discovery process at least through their quotes. Since their trades are reported through the Consolidated

Tape System, the trades themselves may provide information to other trades that makes its way into the quotes of the NYSE.

While these results are consistent with the conjecture that the quotes set by the NYSE specialists are the primary determinants of trading prices, they certainly do not prove it. After all, it may be that trades on the regional markets and on NASDAQ are more likely to take place within the best intermarket quote. The paper now turns to this possibility.

If non-NYSE markets are attracting the small retail order through their automated systems, any comparison of price improvement should control for the size of a transaction in measuring the amount of price improvement among markets. Our analysis shows that across all size categories of transactions, execution prices of NYSE executed trades fall within the best intermarket quote more often than for non-NYSE trades (Table 3). For 100-share transactions, the NYSE executes 26.18 percent within the best intermarket quote, while non-NYSE markets execute only 12.02 percent. Similar relations apply to other size transactions.<sup>13</sup>

There have been some comparisons of NYSE transactions with the NYSE quote rather than the best intermarket quote.<sup>14</sup> For completeness, this study has replicated the previous comparison of NYSE and non-NYSE transactions using instead the NYSE quote (Table 4). As expected, the percentage of NYSE transactions within the NYSE quote increases as does the

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<sup>13</sup>The text uses the term "transactions" loosely to refer to the more technical term "print." A "print" is not the same as an order or even a transaction. On the NYSE, it is customary to record the set of opening transactions as one print, while the data suggests that the Midwest often records the opening transactions in many prints. One reason for this difference in practice is that the revenues from the sale of transaction data and quote data are allocated to market centers according to the number of prints. Since there is little difference in the price improvement as a function of print size, this possible difference between transaction size and print size among exchanges introduces little bias in this analysis.

<sup>14</sup>"Roundtable on Commission Dollar and Sale of Order Flow Practices," SEC, July 24, 1989, pp. 123-124.

percentage of non-NYSE transactions. In contrast to the analysis using the best intermarket quote, the percentage of trades within the NYSE quote now increases with the size of the transactions. This increase with size is consistent with a greater tendency for large orders to cross orders within the quote on the NYSE.<sup>15</sup>

The difference between the percentage of 100-share transactions executed within the quote on NYSE and non-NYSE is approximately 12 to 14 percent regardless of which quote standard is used. However, for intermediate-size transactions from approximately 500 shares to 3000 shares, there is almost a negligible difference between the NYSE and non-NYSE markets in the percentage executed within the NYSE quote in contrast to the much larger difference using the best intermarket quote. The behavior of these differences as a function of the quote standard indicate that when an intermediate-size trade takes place on a non-NYSE market, a non-NYSE quote is more likely to be the determinant of the best intermarket quote than normal.

To illustrate, at 10:41 on January 23, 1989, the NYSE quote for GE was a bid of \$45.50 with a depth of 150,000 shares and an ask of \$45.75 with a depth of 70,000 shares. This was the best intermarket quote. The Pacific quote in effect at that time was a bid of \$45.375 with a depth of 500 and an ask of \$45.75 with a depth of 500. One second later, the Pacific quote changed to a bid of \$45.375 with a depth of 1500 and an ask of \$45.625 with a depth of 2000 shares, making its ask the best intermarket ask. Meanwhile, the NYSE increased the depth of its bid and offer but did not change the prices themselves. There followed a trade of 200 shares on the Boston at \$45.50, 700 shares on the NYSE at \$45.625 and ultimately a trade of 2000

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<sup>15</sup>A regression analysis to be reported in a later draft of this paper finds the same positive relation between the percentage within the best intermarket quote and transaction size holding constant the natural log of both price and market value and the specialist in the stock.

shares on the Pacific at \$45.625. Thereupon, the specialist of the Pacific revised his quotes, so that his offer was no longer the best offer. What may have happened is that the specialist wanted to buy some stock for his own account, and when that purchase was made withdrew his better quote.<sup>16</sup>

### III. A Monetary Measure of Price Improvement

The previous section presented evidence that a transaction executed on the NYSE had a greater probability of being executed within the best intermarket quote than if it were executed on a non-NYSE market. The purpose of this section is to provide a dollar and cents measure of the price improvement of the NYSE in comparison to that possible on non-NYSE markets.

Price improvement as used in this paper means an execution at a better price than the best intermarket quote at the time of the transaction. This is a much narrower concept than that of Berkowitz, Logue, and Noser who are concerned with the execution of a large institutional order and its impact on subsequent bids and asks.<sup>17</sup>

A buyer who submits a market buy order should at least obtain the best intermarket ask price, providing there is sufficient depth. Any lesser price is an improvement. Likewise, a seller should obtain at the least the bid price. Any greater price is an improvement. On average, the best price that both buyers and sellers can achieve will be midway between the bid and the ask. Thus, this study will take the midpoint of the best intermarket quote as a benchmark from which

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<sup>16</sup>Alternatively, it could have been a limit order. However, this possibility is less likely since an investor would generally want to place a limit order on the most active market to enhance the probability of a favorable execution. In the case of GE, the NYSE is the dominant market.

<sup>17</sup>Berkowitz, Stephen A., Dennis E. Logue and Eugene A. Noser, Jr., "The Total Cost of Transactions on the NYSE," *Journal of Finance*, XLIII, 1 (March 1988), 97-112.

to measure price improvement and use the mean absolute deviation of the execution price from the midpoint of the best intermarket quote as the measure of price improvement for each market.<sup>18</sup> Since the units of the mean absolute deviation are dollars and cents, this measure can readily be interpreted as a direct measure of price improvement.

Finally, since the previous section suggested that there was a greater possibility of price improvement on the NYSE and this paper is concerned with the relative amount of price improvement, the relative price improvement measure analyzed in this paper will be the mean absolute deviation for the non-NYSE markets less the mean absolute deviation of the NYSE market. A positive value indicates a better execution price on the NYSE. We calculate this measure for the same transaction sizes as used before and by groups of stocks according to their stock price as of year-end 1988.

The results confirm that the NYSE generally provides greater price improvement than non-NYSE markets. Overall, execution on the NYSE improves price by 0.79 cents per share over execution on a non-NYSE market (Table 5). This relative price improvement is almost strictly increasing in price, growing from 0.16 cents per share for stocks priced from \$0-10 to 1.83 cents per share for stocks priced over \$60 but less than or equal to \$80, before dipping down to 1.37 cents per share for stocks from \$100-150. The table also presents summary statistics over all price categories, but these statistics are heavily influenced by stocks with 1988 year-end price in excess of \$150.00 and should be used with caution. Finally, t-statistics indicate a high level of significance for many of these measures of relative price improvement.

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<sup>18</sup>This measure is similar to that proposed by André Perold, "The Implementation Shortfall: Paper versus Reality," *Journal of Portfolio Management* (Spring 1988), 4-9.



#### **IV. Conclusion**

The purpose of this paper was to compare execution prices of NYSE-listed stocks on the NYSE and on non-NYSE markets. The first conclusion of this comparison is that most of the time the NYSE had the best quote. This result does not necessarily imply that execution prices on the NYSE are better than the regionals since an investor should always receive an execution price no worse than the best intermarket quote regardless of the particular market on which an order is executed. The second conclusion is that there is more price improvement on the NYSE than on other markets for NYSE-listed stocks. The third conclusion is that the average price improvement from trading on the NYSE varies according to the price of the stock and the size of the transaction. On a 100-share transaction of a 40-dollar stock, the price improvement on the NYSE is on average 1.5 cents greater than that on non-NYSE markets.

## APPENDIX I

### **The Filters and Adjustments Applied to the ISSM Data**

The data analyzed in this paper comes from the 1989 Trades and Quotes Transactions Files supplied by the Institute for the Study of Security Markets. The source of the ISSM data is the same data as reported in the Consolidated Tape System and the Consolidated Quote System to outside vendors. These two systems contain the price and volume of every trade of securities listed or traded on a US registered exchange and every quote displayed on a US registered exchange as well as NASDAQ for the same securities. The displayed quotes contain the bid and ask prices and the number of shares available at each price, called the depth. This study only analyzed NYSE-listed common stocks and dropped all other securities.

In processing the original data, ISSM decided to delete those quotes on non-NYSE markets for which both the bid and ask prices are worse than the NYSE quote on the assumption that these quotes were autoquotes. An autoquote is a quote from a non-NYSE market that is changed automatically in response to changes in the NYSE quote and is often used in non-NYSE markets to make the displayed quote for that market non-competitive. Although these deleted autoquotes are by design not a determinant of the best intermarket quote, the omission of these autoquotes forced us to make some assumptions to ascertain the best intermarket quote. Were these autoquotes not deleted, these additional assumptions would not have been necessary. Shortly, ISSM will send us a 1990 version of their ISSM file that contains these autoquotes, and we shall then replicate the analysis contained in the body of the paper. In the meanwhile, we have made assumptions that bias some of our results towards the finding that the non-NYSE markets offer better quotes than the NYSE.

There are some significant data errors in these files which may trace their origins to the original data. Sometimes it appears that the transactions of two different securities are reported under the same ticker. To remove these, any transaction price which was more than 20 percent greater or less than the immediately preceding transaction price was deleted. This process started anew with the opening price each day, so that there was no comparison between the opening price and the prior closing price.<sup>19</sup> Further, any trade with a condition code other than "O" was dropped.

A filter was also used to discard unusual quote changes. If there was an unusual increase or decrease in the bid or ask price of a quote followed by another change of roughly the same absolute size, the intermediate quote was discarded. The definition of "unusual" depended upon the price level of the stock. The specific filters were:

For quotes under \$20, if a quote was posted which was more than \$0.50 from the then current best intermarket quote and the next quote listed on any exchange was more than \$0.50 different from the previous quote in either direction, the intermediate quote was discarded.

For quotes between \$20 and \$100 inclusive, if a quote was posted which was more than \$2 from the then current best intermarket quote and the next quote listed on any exchange was more than \$1.50 different from the previous quote in either direction, the intermediate quote was discarded.

For quotes over \$100, if a quote was posted which was more than \$5 from the then current best intermarket quote and the next quote listed on any exchange was more than \$4.125 different from the previous quote in the either direction, the intermediate quote was discarded.

According to an NYSE spokeswoman, it should be assumed that any non-NYSE bid or ask price with a depth of 100 shares on both sides is an autoquote and not a real quote to which

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<sup>19</sup>Additionally, all the transaction data for BRO and BRK were excluded from the analysis of the monetary measure of price improvement since their data had a large number of errors.

ITS commitments to trade orders would apply. Thus, the side of any non-NYSE quote with a depth of only 100 shares was deleted.

Institutional reporting practices suggested that some of the time stamps should be adjusted:

First, all time stamps later than 4:00 pm were changed to 3:59 pm for quote changes and to 4:00 pm for transactions, which is the official closing time of the NYSE, to correct for computer delays in the processing of quotes and transactions near the close of trading on the NYSE.

Second, as mentioned in the text, the automated execution system for small orders on the Boston, Midwest, and Pacific Stock Exchanges are exposed to the floor for approximately 15 seconds before execution, so that 15 seconds was subtracted from the time stamp of transactions on these exchanges. This adjustment is approximate since if an order is executed within the 15 seconds, this adjustment is greater than warranted.<sup>20</sup>

Third, a detailed examination of a sample of stocks indicated that there was a delay of up to 10 seconds between the change in an NYSE quote and the subsequent revision of non-NYSE quotes. Thus, any revision of a non-NYSE quote following a change in an NYSE quote within 10 seconds was assumed to have been posted simultaneously at the time of the NYSE quote.

Fourth, five seconds was subtracted from the time stamp for each NYSE quote as suggested by Lee and Ready.<sup>21</sup>

Except for the delays in the reaction of one market to a quote change in another market, the determination of the best intermarket quote should be straightforward. However, the deletion of the autoquotes from ISSM files forced us to approximate the best intermarket quote. The problem is that a dealer or market maker for a non-NYSE market will post a valid quote

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<sup>20</sup>Also, this adjustment was made to all transactions on these Exchanges, and in a subsequent refinement for the 1990 data, this adjustment will only be applied to trade sizes that are likely to be executed through the automated systems. Nonetheless, in a preliminary version of this paper, we did not make this adjustment and the qualitative nature of the results were similar to those reported in the text.

<sup>21</sup>Charles M. C. Lee and Mark J. Ready, "Inferring Trade Direction for Intraday Data," *Journal of Finance*, XLVI, 2 (June 1991), 733-746.

and then at some subsequent time post an autoquote that makes the earlier quote stale.

Without knowledge of the time of this subsequent autoquote, it is necessary to make some assumption as the length of time over which a valid regional quote is effective. After examining the data carefully, we made the following assumption: At the time at which there were more than ten changes in the NYSE quotes since the last change in a non-NYSE quote, the non-NYSE quote was considered stale and dropped.

The results of these filters were carried forward in an array noting the current posted quotes for each exchange. To find the best bid and best ask, we initially set the best bid and best ask to the NYSE quotes. We then compared all other bids to these values to find the best bid. If an exchange had a bid higher than the current best bid, then the best bid was reset to that exchange's bid. However, if that exchange's bid is higher than the best ask (which at this time is set to the NYSE ask), then that exchange's bid is removed at this time and the next exchange is analyzed. After the best bid is calculated, the best ask is calculated using the same process. Only 0.137% of the data was omitted in this way.

Table 1

**Percentage of Time That NYSE Has Better, Equal or Poorer Quote than Regionals and NASD  
Breakdown by 1989 Dollar Volume Decile**

**A. BID**

Dollar <sup>a</sup> Volume Decile	No. of Companies	Better Bid (%)	Equal or Poorer Bid (%)	Breakdown of Better Bid		Breakdown of Equal or Poorer Bid	
				Better Bid Price (%)	Equal Bid But Greater Depth (%)	Equal Bid But Lesser or Equal Depth (%)	Poorer Bid Price (%)
High	6	82.14	17.86	34.29	47.85	5.09	12.77
2	12	77.70	22.30	27.34	50.36	6.39	15.90
3	19	80.28	19.72	30.86	49.43	5.42	14.30
4	24	79.45	20.55	30.11	49.34	4.20	16.35
5	29	80.16	19.84	34.40	45.76	4.50	15.35
6	38	80.72	19.28	37.40	43.31	3.08	16.21
7	53	81.87	18.13	36.92	44.94	3.59	14.54
8	81	82.10	17.90	38.18	43.93	3.69	14.21
9	141	83.46	16.54	44.36	39.10	3.77	12.77
Low	945	88.96	11.04	59.99	28.97	4.20	6.84
Total <sup>b</sup>	1540	86.94	13.06	53.94	33.00	4.08	8.98

**B. OFFER**

Dollar <sup>a</sup> Volume Decile	No. of Companies	Better Offer (%)	Equal or Poorer Offer (%)	Breakdown of Better Offer		Breakdown of Equal or Poorer Offer	
				Better Ask Price (%)	Equal Ask But Greater Depth (%)	Equal Ask But Lesser or Equal Depth (%)	Poorer Ask Price (%)
High	6	78.27	21.73	28.18	50.09	4.89	16.84
2	12	74.60	25.40	20.88	53.73	6.34	19.05
3	19	76.42	23.58	24.05	52.37	4.92	18.66
4	24	79.55	20.45	28.99	50.55	3.77	16.68
5	29	76.25	23.75	28.62	47.63	4.76	19.00
6	38	76.61	23.39	31.58	45.02	3.85	19.54
7	53	77.62	22.38	31.19	46.42	4.73	17.65
8	81	78.49	21.51	33.17	45.32	4.52	16.99
9	141	78.17	21.83	38.07	40.10	5.06	16.77
Low	945	87.04	12.96	58.55	28.49	4.90	8.06
Total <sup>b</sup>	1540	84.40	15.60	51.32	33.08	4.80	10.80

<sup>a</sup>Based upon 1988 volume.

<sup>b</sup>The total includes 192 companies for which 1988 values were not available.

**Table 2**

**Percentage of Time That NYSE Has Better, Equal or Poorer Quote than Regionals and NASD  
Breakdown by 1989 Market Value Decile**

**A. BID**

Market <sup>a</sup> Value Decile	No. of Companies	Total Better Bid (%)	Total Poorer Bid (%)	Breakdown of Better Bid		Breakdown of Equal or Poorer Bid	
				Better Bid Price (%)	Equal Bid But Greater Depth (%)	Equal Bid But Lesser or Equal Depth (%)	Poorer Bid Price (%)
High	4	86.17	13.83	24.51	61.66	3.03	10.80
2	11	75.86	24.14	27.43	48.43	8.90	15.24
3	15	77.30	22.70	32.47	44.83	6.25	16.45
4	22	78.86	21.14	39.18	39.69	3.81	17.33
5	35	82.45	17.55	40.54	41.91	3.37	14.17
6	47	79.99	20.01	35.94	44.05	3.79	16.21
7	65	81.52	18.48	41.12	40.41	3.45	15.02
8	105	83.57	16.43	44.55	39.02	3.43	13.00
9	177	84.26	15.74	44.62	39.64	3.78	11.96
Low	872	89.20	10.80	60.12	29.09	4.28	6.51
Total <sup>b</sup>	1540	86.94	13.06	53.94	33.00	4.08	8.98

**B. OFFER**

Market <sup>a</sup> Value Decile	No. of Companies	Total Better Offer (%)	Total Poorer Offer (%)	Breakdown of Better Offer		Breakdown of Equal or Poorer Offer	
				Better Ask Price (%)	Equal Ask But Greater Depth (%)	Equal Ask But Lesser or Equal Depth (%)	Poorer Ask Price (%)
High	4	80.56	19.44	17.16	63.39	2.91	16.53
2	11	73.06	26.94	23.34	49.73	7.77	19.16
3	15	72.15	27.85	24.11	48.05	5.92	21.93
4	22	75.60	24.40	34.05	41.54	3.85	20.55
5	35	77.56	22.44	32.90	44.66	4.22	18.22
6	47	77.45	22.55	31.58	45.87	4.13	18.42
7	65	76.66	23.34	34.23	42.42	4.42	18.92
8	105	78.08	21.92	37.73	40.36	4.74	17.17
9	177	80.81	19.19	40.39	40.42	4.66	14.53
Low	872	87.50	12.50	59.06	28.44	4.97	7.53
Total <sup>b</sup>	1540	84.40	15.60	51.32	33.08	4.80	10.80

<sup>a</sup>Based upon 1988 year market value.

<sup>b</sup>The total includes 187 companies for which 1988 year end market values were not available.

**Table 3**

**Comparison of Transactions Prices to the Best Intermarket Quote  
Cross Classified by Size of Transaction and Exchange  
1989**

Transaction Size in Shares	Market	Percentage Breakdown				
		Below the Bid	At the Bid	Between the Bid and Ask	At the Ask	Above the Ask
100	NYSE	1.80	37.79	26.18	32.45	1.78
	Non-NYSE	2.48	46.15	12.02	37.12	2.23
200	NYSE	1.73	36.30	26.35	33.68	1.93
	Non-NYSE	2.43	43.47	12.21	39.40	2.49
201-500	NYSE	1.84	35.20	26.87	33.97	2.12
	Non-NYSE	2.42	41.34	13.52	40.12	2.60
501-1000	NYSE	2.00	34.32	27.62	33.73	2.34
	Non-NYSE	2.41	39.55	14.90	40.58	2.56
1001-2000	NYSE	2.16	34.20	27.97	33.10	2.56
	Non-NYSE	2.42	39.55	15.56	40.03	2.44
2001-3000	NYSE	2.31	33.27	28.64	33.00	2.78
	Non-NYSE	2.46	38.50	15.87	40.56	2.61
3001-5000	NYSE	2.30	31.97	29.90	33.00	2.83
	Non-NYSE	2.59	38.28	16.70	39.74	2.70
5001-10,000	NYSE	2.56	31.20	30.69	32.42	3.12
	Non-NYSE	2.81	38.30	17.81	38.15	2.93
10,001-20,000	NYSE	3.17	31.41	31.23	31.16	3.03
	Non-NYSE	3.23	36.75	18.87	38.08	3.07
Over 20,000	NYSE	5.12	33.56	28.40	28.67	4.26
	Non-NYSE	5.41	35.03	18.35	36.97	4.25



Table 3a

**Comparison of Transactions Prices to the Best Intermarket Quote  
Cross Classified by Size of Transaction and Exchange  
Where Intermarket Quote is Greater than 1/8**

Transaction Size in Shares	Market	Percentage Breakdown				
		Below the Bid	At the Bid	Between the Bid and Ask	At the Ask	Above the Ask
100	NYSE	2.15	23.39	45.00	26.93	2.53
	Non-NYSE	3.55	38.19	19.60	35.11	3.55
200	NYSE	2.19	22.94	44.41	27.71	2.75
	Non-NYSE	3.33	35.50	20.58	36.94	3.65
201-500	NYSE	2.39	22.56	44.62	27.34	3.09
	Non-NYSE	3.25	33.56	22.13	37.37	3.69
501-1000	NYSE	2.68	22.29	44.68	26.82	3.53
	Non-NYSE	2.92	32.12	23.97	37.56	3.43
1001-2000	NYSE	3.05	22.16	43.85	26.95	3.99
	Non-NYSE	2.68	31.59	24.70	37.86	3.17
2001-3000	NYSE	3.21	21.70	43.99	26.75	4.35
	Non-NYSE	2.77	30.10	25.94	37.68	3.52
3001-5000	NYSE	3.25	21.14	43.88	27.19	4.54
	Non-NYSE	2.86	29.53	25.36	38.59	3.66
5001-10,000	NYSE	3.41	21.69	42.82	27.28	4.80
	Non-NYSE	3.06	28.64	26.89	37.34	4.07
10,001-20,000	NYSE	3.89	22.49	41.43	27.26	4.93
	Non-NYSE	3.27	26.58	31.04	34.95	4.17
Over 20,000	NYSE	5.62	23.82	37.62	27.13	5.81
	Non-NYSE	5.16	24.90	32.56	32.31	5.06

**Table 4**

**Comparison of Transactions Prices to the NYSE Quote  
Cross Classified by Size of Transaction and Exchange  
1989**

Transaction Size in Shares	Market	Percentage Breakdown				
		Below the Bid	At the Bid	Between the Bid and Ask	At the Ask	Above the Ask
100	NYSE	0.89	35.94	33.39	29.04	0.74
	Non-NYSE	0.92	43.87	21.70	32.72	0.79
200	NYSE	0.82	34.48	33.76	30.19	0.74
	Non-NYSE	0.91	39.50	26.73	32.11	0.76
201-500	NYSE	0.84	33.34	34.72	30.34	0.77
	Non-NYSE	0.84	35.85	32.75	29.79	0.76
501-1000	NYSE	0.85	32.24	36.30	29.84	0.77
	Non-NYSE	0.96	33.96	35.11	29.17	0.80
1001-2000	NYSE	0.87	31.92	37.47	28.95	0.79
	Non-NYSE	1.01	34.02	36.06	28.08	0.84
2001-3000	NYSE	0.94	30.88	38.81	28.55	0.83
	Non-NYSE	1.17	33.36	35.14	29.46	0.88
3001-5000	NYSE	0.88	29.25	40.99	28.14	0.76
	Non-NYSE	1.36	34.54	31.58	31.34	1.18
5001-10,000	NYSE	0.93	28.05	42.92	27.23	0.87
	Non-NYSE	1.60	36.01	29.03	32.28	1.08
10,001-20,000	NYSE	1.06	27.92	44.99	25.33	0.70
	Non-NYSE	1.95	35.45	27.80	33.48	1.31
Over 20,000	NYSE	2.09	30.53	42.47	23.56	1.36
	Non-NYSE	3.60	34.48	27.14	32.74	2.04

Table 5

NYSE Price Improvement In Comparison to Other Markets<sup>a</sup>

## A. Relative Price Improvement in Cents

Transaction Size in Shares	Price Categories in Dollars											All Prices
	0 up to 10	10 up to 15	15 up to 20	20 up to 30	30 up to 40	40 up to 50	50 up to 60	60 up to 80	80 up to 100	100 up to 150	Above 150	
100	0.46	0.57	0.63	1.07	1.51	1.49	2.31	2.74	2.26	2.02	8.22	1.30
200	0.31	0.46	0.52	0.89	1.25	1.24	1.99	2.30	1.83	1.90	6.57	1.00
201-500	0.14	0.25	0.29	0.59	0.82	0.88	1.42	1.47	1.29	1.52	2.64	0.61
501-1000	-0.01	0.09	0.06	0.22	0.42	0.51	1.01	0.90	0.74	0.52	2.35	0.22
1001-2000	-0.19	0.02	-0.10	0.03	0.24	0.35	0.56	0.62	0.84	0.52	0.95	0.00
2001-3000	-0.31	-0.04	0.03	0.17	0.37	0.43	0.57	0.63	0.93	-0.16	13.40	0.08
3001-5000	-0.30	0.20	0.62	0.61	0.86	0.75	1.38	0.85	1.24	1.36	5.74	0.47
5001-10,000	-0.28	0.14	1.19	1.01	1.29	1.21	1.20	1.13	1.78	1.61	4.75	0.84
10,001-20,000	-0.36	0.54	0.63	0.91	1.00	0.98	1.52	1.07	1.20	3.04	-2.89	0.85
Over 20,000	-0.06	0.26	0.59	0.34	0.24	0.29	1.74	-0.02	1.04	1.03	-28.70	0.39
All Sizes	0.16	0.34	0.41	0.70	1.01	1.07	1.63	1.83	1.56	1.37	6.03	0.79

<sup>a</sup>See text for definition of Price Improvement.

**Table 5 (Continued)**

**B. t-statistics**

Transaction Size in Shares	Price Categories											All Prices
	0 up to 10	10 up to 15	15 up to 20	20 up to 30	30 up to 40	40 up to 50	50 up to 60	60 up to 80	80 up to 100	100 up to 150	Above 150	
100	36.44	35.39	48.39	106.39	114.49	100.89	110.81	65.29	80.99	40.33	4.65	220.13
200	23.40	24.87	32.50	72.09	72.01	60.74	71.87	41.20	45.85	25.98	5.76	143.27
201-500	13.35	16.06	21.54	56.22	57.85	40.49	58.37	35.18	35.48	20.14	2.96	105.69
501-1000	-0.74	5.76	3.42	14.97	23.21	24.28	32.33	17.27	16.42	6.23	1.23	32.36
1001-2000	-12.38	0.69	-3.60	1.39	7.79	11.09	9.79	8.51	12.05	3.00	0.40	0.13
2001-3000	-12.30	-0.85	0.54	3.89	6.45	8.13	7.36	3.70	10.02	-0.92	2.02	4.06
3001-5000	-10.87	2.73	9.07	11.60	10.01	14.03	7.87	6.92	9.22	6.10	1.79	17.59
5001-10,000	-7.00	2.03	11.29	15.07	15.07	8.82	12.47	4.78	6.81	6.05	1.25	24.15
10,001-20,000	-5.69	3.09	5.16	9.64	8.55	9.71	2.99	4.45	3.79	3.94	-0.27	13.56
Over 20,000	-0.69	1.69	4.41	2.90	1.81	2.36	2.27	-0.06	1.93	1.33	-1.99	5.18
All Sizes	32.90	44.68	60.76	130.42	142.61	122.01	124.72	83.09	93.63	39.69	6.93	266.25