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Dealer versus auction markets: A paired comparison of execution costs on NASDAQ and the NYSE

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Abstract

Execution costs, as measured by the quoted spread, the effective spread (which accounts for trades inside the quotes), the realized spread (which measures revenues of suppliers of immediacy), the Roll (1984) implied spread, and the post-trade variability, are twice as large for a sample of NASDAQ stocks as they are for a matched sample of NYSE stocks. The difference is not due to differences in adverse information, in market depth, or in the frequency of even-eighth quotes. Partial explanations are provided by differences in the treatment of limit orders and commissions in the two markets. We conclude that important explanations are the internalization and preferencing of order flow and the presence of alternative interdealer trading systems, factors that limit dealers' incentives to narrow spreads on NASDAQ.

Key words: NASDAQ; NYSE; Execution cost; Market structure; Bid–ask spreads
JEL classification: G12; G14; D23; L22

1. Introduction

In a dealer market, investors buy at a dealer's ask price and sell at a dealer's bid price. Important dealer markets for common stocks are the NASDAQ Stock

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Market and the London Stock Exchange. Most bond and foreign currency markets are also dealer markets. In an auction market, investors buy at the ask price established by a previously placed limit sell order of another investor and sell at the bid price established by a previously placed limit buy order of another investor. Continuous auction markets typically also involve the participation of a dealer, such as the New York Stock Exchange (NYSE) specialist, who enters bids and offers to maintain liquidity and continuous trading. Important auction markets for common stocks are the NYSE, the Paris Bourse, the Tokyo Stock Exchange, and other stock markets. Auction markets also exist for new issues such as those of government bonds.

Proponents of auction markets maintain that allowing investors to trade directly with each other reduces execution costs. Operationally, this direct trading is achieved by exposing public limit orders to incoming market orders. Proponents of dealer markets point to the flexibility of such markets in handling different types of securities and different types of customers and to the benefits of competing dealers. Dealer markets have no seats and entry is easy.

Despite the long-standing debate over the relative merits of auction and dealer markets, very few studies directly compare the efficiency of the two systems. Christie and Schultz (1994) and Christie, Harris, and Schultz (1994) infer from the absence of odd-eighth quotes in NASDAQ that NASDAQ spreads are large, since an absence of odd-eighth quotes implies a tick size of at least 25 cents, and they suggest that this finding is due to implicit collusion by dealers. But are spreads *too* large? One cannot tell since these studies do not directly compare the two systems. Their critics, Kleidon and Willig (1995) and Grossman et al. (1995), concede that spreads are large for NASDAQ, a justifiable economic result of the market structure. Again, one cannot tell from their work that spreads are *not too* large.

We compare execution costs for NASDAQ stocks with execution costs for comparable NYSE stocks. We define execution cost as the cost to a trader of selling or buying stocks. We do not have data on commissions, nor do we compare the quality of execution services rendered. An important feature of our analysis is that we select matched samples of NYSE and NASDAQ stocks on the basis of criteria that explain differences in risk and spreads. The sample comprises 175 pairs of companies for which we examine all transactions data for the entire year 1991, more than 5,400,000 transactions. A second important feature of this study is the wide range of execution cost measures that we employ. Prior studies have compared the two market types primarily on the basis of their quoted bid–ask spreads, but the quoted spread is not necessarily an accurate reflection of execution costs. In addition to the quoted spread, we compare execution costs on the basis of the effective spread, which accounts for the fact that trades may occur inside the posted quotes, the realized spread, which measures execution cost on the basis of the post-trade price reversal, the Roll

(1984) implied spread, calculated from the serial covariance of price changes, and the perfect foresight spread, which is an upper bound on the execution cost.

To determine whether execution costs are *too* high in one market, we begin by asking whether they differ across market structures. Surprisingly, the difference in execution costs between NASDAQ and the NYSE has not been clearly established. We find that quoted spreads and other execution cost measures are about twice as large on NASDAQ as on the NYSE. We investigate the sources of the difference and eliminate a number of potential explanations for the difference. We find that NASDAQ spreads have not always been high, and we investigate why they have increased. We conclude that certain structural developments in the NASDAQ market – internalization, preferencing, and the presence of interdealer trading systems – are the likely source of the higher execution costs.

The next section reviews previous research. We provide an overview of trading procedures on NASDAQ and the NYSE in Section 3. The selection of the paired stock sample and the transactions data are described in Section 4. In Section 5, we compare the quoted spread in NASDAQ to the quoted spread of comparable stocks on the NYSE. Section 6 compares the effective spreads and the frequency of trading inside the quotes. In Section 7, we compare the revenues realized by suppliers of immediacy in the two markets, and we consider whether differences in adverse information or market depth can explain differences in quoted and effective spreads. We compare two other measures of trading cost, the Roll (1984) implied spread and a measure we term the perfect foresight spread, in Section 8. In Section 9, we examine whether the samples are well matched, and we test whether other economic factors can explain the differences in execution costs in a cross-section regression framework. Section 10 investigates whether the difference in execution costs is related to the difference in the frequency of even-eighth quotes after adjusting for economic factors that determine execution costs and the use of evens. We examine institutional explanations for the spread differentials between the two market structures in Section 11. We first show that NASDAQ quoted spreads have increased over time and we investigate some explanations for this increase. We then consider certain institutional features of the NASDAQ dealer market and conclude that features such as preferencing limit the incentive to compete. We summarize our findings in Section 12.

2. Previous research

Several papers provide theoretical comparisons of dealer and auction markets. Ho and Stoll (1983) model quote setting in a competing dealer market from an inventory perspective and compare the result to a model with a single specialist. Madhavan (1992) develops a theoretical model to compare price formation in dealer and auction markets in a world with adverse information and strategic trading. Pagano and Roell (1992) compare dealer and auction markets in the presence of informed trading. Stoll (1992) analyzes general principles of market structure and related policy issues. Biais (1993) contrasts dealer and auction markets and concludes that dealer markets have less transparency and are informationally fragmented. Dutta and Madhavan (1994) provide a game-theoretic model of implicit collusion in dealer markets. Kandel and Marx (1995) provide a theoretical model of why NASDAQ bid–ask spreads are excessive based on the minimum tick size rule and NASDAQ excess spread policy. However, these papers contain little empirical evidence.

A host of papers have measured the cost of execution in a particular market, but without making a direct comparison across markets. Roll (1984) develops a method for estimating an effective spread and provides evidence for exchange-listed stocks. Stoll (1989) develops a model based on Roll to infer components of the spread and provides evidence for NASDAQ stocks. Berkowitz, Logue, and Noser (1988) provide evidence on execution costs on the NYSE. Chan and Lakonishok (1993) measure the price impact of trades by 37 large institutional money managers. Huang and Stoll (1994b) provide alternative measures of execution costs on the NYSE. Sofianos (1995) measures specialists' trading revenues on the NYSE. Hasbrouck (1993) develops a pricing error model, whose variance provides an estimate of market quality, and applies the model to NYSE data. Ho and Macris (1985) and Laux (1995) analyze the relation between spreads, volume, and the number of dealers in a dealer market. Hansch, Naik, and Viswanathan (1993) analyze competition among dealers in the London market. Reiss and Werner (1994) examine execution costs on the London Stock Exchange. Huang and Masulis (1995) and Wahal (1995) examine the competitive effects of dealer entry and exit in the foreign exchange market and the NASDAQ market respectively. Godek (1996) stresses the importance of preferencing as an explanation for the Christie and Schultz (1994) results. Kothare and Laux (1995) provide evidence of a sharp increase in NASDAQ spreads between 1988 to 1992, something which they associate with increased institutional trading.

Some recent studies compare the cost of trading listed stocks on an exchange with the cost of trading those same stocks in a competing market. Lee (1993), Petersen and Fialkowski (1994), Blume and Goldstein (1992), and Huang and Stoll (1995a) measure execution costs for NYSE stocks competitively traded on regional exchanges and NASDAQ. They find that execution costs are slightly higher in competing markets than on the NYSE. Studies of London trading in French and German listed stocks by Roell (1992), De Jong, Nijman, and Roell (1993), and Schmidt and Iversen (1993) find that spreads are greater on the London dealer market than on continental auction markets. Doran, Lehn, and Shastri (1995) analyze 19c-3 stocks traded on the NYSE and on NASDAQ for evidence that NASDAQ market makers implicitly collude.

Certain prior empirical studies compare execution costs in dealer markets for stocks principally traded in dealer markets with execution costs in auction markets for stock principally traded in auction markets. Hasbrouck and Schwartz (1986) and Marsh and Rock (1986), using data for 1985, conclude that trading costs are greater on NASDAQ than on the American Stock Exchange (ASE). Affleck-Graves et al. (1994) use a subset of the same 1985 data to compare the bid–ask spread on NASDAQ and on the NYSE and ASE for comparable companies. In contrast to other studies and to our results, they find that spreads are the same in dealer and auction markets. Keim (1989) includes cross-market comparisons of spreads in a paper on the turn-of-the-year effect. Christie and Huang (1994) find that trading costs fall for stocks that voluntarily switch from NASDAQ to the NYSE or the ASE. McInish and Wood (1994) compare volatility in NASDAQ and the NYSE. Booth et al. (1995) compare NASDAQ and the German stock market. Keim and Madhavan (1995) examine institutional trading costs in the NYSE and NASDAQ markets. Kleidon and Willig (1995) compare NASDAQ and NYSE spreads for unmatched samples in a regression framework that accounts for economic determinants of spreads. Despite this volume of research, the difference in execution costs between NASDAQ and the NYSE has not been clearly established. We provide a direct comparison of execution costs for NASDAQ stocks and matched NYSE stocks. We begin by summarizing the structural differences between the two markets.

3. The NYSE and NASDAQ market structures

Orders on the NYSE are submitted electronically over the Designated Order Turnaround (DOT) system or are handled by floor brokers who may 'work' the order. Market orders are executed against limit orders placed earlier on the limit order book or against the specialist's quote. The specialist disseminates a quote and a market depth on the basis of the orders on the book and his own position and preferences. As shown by McInish and Wood (1993), the disseminated quote may be wider than the inside quote because the specialist was not required until recently to disseminate the quotes of the best limit orders and because there may be undisclosed quotes from brokers in the 'crowd'. Rules of price and time priority apply, and the specialist may not trade ahead of a limit order at the same price.

The actual process of trading on the NYSE, while quite simple in its general outlines, is quite complex in practice. Although order routing is automated, execution is not, giving rise to some subtle complexities in the trading process. Each incoming market order is ultimately exposed to other orders. At this point, the specialist and traders in the crowd have the option to better the standing quote or to let the trade take place at the posted quote. If the quote is bettered, the transaction takes place inside the quotes, something that happens quite frequently. Trading inside the quotes also occurs if an incoming market order hits a hidden limit order quote inside the disseminated quote.

The NYSE specialist is connected electronically over the Intermarket Trading System (ITS) to the floors of the regional exchanges, and can send an order to a regional exchange for execution (and vice versa). Relatively few orders that reach the floor of the NYSE are routed to the regional exchanges. Most off-Board volume occurs when orders are routed directly from the broker to a regional exchange or the third market. This order flow is preferenced to certain market makers who promise to trade the orders at the best intermarket quotes.

On NASDAQ, bid–ask quotes of competing dealers are electronically disseminated to brokers' offices. The number of dealers in an active stock often exceeds 30 and can approach 60 for the most active issues. Each dealer in an active stock is obligated to trade 1,000 shares at the quote. Incoming market orders are executed against the inside dealer quote – the best bid and the best ask among all the dealers. Limit orders are not exposed to the rest of the market and are not executed against incoming market orders. Limit orders, like market orders, execute against the dealer's quote and must wait until the quote reaches the limit price. For example, a limit order to buy at 20 when the spread is 20 bid to 20.50 ask must wait until the dealer's ask reaches the limit price of 20. Recent NASDAQ rule changes introduce some competition from limit orders into the NASDAQ market. Dealers are no longer able to trade ahead of their own customer limit orders. Thus a dealer cannot buy at a bid price lower than a customer's limit order buy price. The customer's order has to be satisfied first. In 1995, the rule was broadened so that a dealer could not trade ahead of other customer orders left with him by a broker.

On NASDAQ, much of the customer order flow is internalized or is preferenced to specific dealers. A broker-dealer internalizes order flow by trading for its own account with the customer. Rules of best execution apply, which means that the trade takes place at the inside quote in the NASDAQ system. Preferenced order flow is sent by the broker to a particular market maker who guarantees execution at the best inside quote.

Customers can negotiate with their broker-dealer on the execution price. A large institution might, for example, be able to negotiate a trade inside the disseminated NASDAQ quote. Consequently, price determination on NASDAQ, like that on the NYSE, involves some subtle complexities, which are not obvious to the outside observer.

4. Stock selection and data

We calculate execution cost measures for a sample of 175 NASDAQ firms and for a paired sample of 175 NYSE firms. We choose the largest NASDAQ stocks and match them to NYSE stocks on the two-digit industry code and characteristics identified by Fama and French (1992) as correlated with expected returns. These characteristics are share price, the market value of equity, the ratio of book to market value of equity, and leverage. Some of these variables are also correlated with factors that have been found to determine bid–ask spreads. We then use transactions data supplied by the Institute for the Study of Security Markets (ISSM) to calculate measures of execution costs for 1991.[1]

4.1. Stock selection

Using Center for Research in Security Prices (CRSP) data, we select CUSIP numbers of NASDAQ and NYSE firms that exist for the entire year 1991. We then obtain data on long-term debt, closing price, shares outstanding, and book value from the 1990 Compustat Annual database. We delete firms with a negative book value of equity, a stock price less than \$5, and a NASDAQ ticker symbol with a fifth letter identifier. (The fifth letter refers to an American Depository Receipt or stock with several classes.) We then calculate the market value of equity of all remaining NASDAQ firms and pick the top 300. After matching each NASDAQ firm with all NYSE firms that have the same two-digit SIC codes, we delete pairs if

$$\left|\frac{price^Q - price^N}{(price^Q + price^N)/2}\right| \geqslant 1\,,$$

where the superscripts Q and N refer to NASDAQ and the NYSE, respectively. The purpose of this screen is to eliminate candidate pairs for which price levels are extremely far apart. For each matched pair, we compute the following score:

$$\sum_{i=1}^{4}\left(\frac{x_i^Q - x_i^N}{(x_i^Q + x_i^N)/2}\right)^2,$$

where x_i is one of the four characteristics taken from the 1990 Compustat tape. Finally, for each NASDAQ firm, we pick an NYSE firm with the smallest score and delete pairs with duplicate NYSE firms.

[1]This procedure differs from that of McInish and Wood (1994) who use a linear programming procedure to form a NYSE portfolio and a NASDAQ portfolio of all stocks in each market. The portfolios are formed to minimize the differences in certain characteristics such as average firm size, average stock price, and so forth. The volatility of each portfolio is then calculated and compared. This procedure results in only one estimate for each market, making statistical tests difficult.

4.2. Transactions and quote data

We measure execution costs using 1991 transactions data supplied by ISSM. The transactions data include all bid and ask quotations, all transaction prices, and all volumes for NYSE and NASDAQ firms. All trades that are coded as regular sales and all quotations that are BBO (best bid or offer) eligible are retained. Certain quotes are not used for this purpose. For example, pre-opening quote indications or quotes that are not firm are eliminated. Our ISSM data tapes also exclude autoquotes of the regional exchanges. An autoquote provides no new information since it is simply calculated by adding (subtracting) $\frac{1}{8}$ to (from) the NYSE ask (bid) whenever the NYSE quote changes. We confine the sample to trades with positive prices and volumes and positive bid and ask quotes with nonnegative depths. To further minimize data errors, we apply the following filters:

1. Exclude quotes and prices when their decimal portions are not multiples of $\frac{1}{16}$.
2. Exclude bid–ask quotes if the spread is greater than \$4 or less than zero. (Zero spreads are possible on NASDAQ since some dealers are willing to buy at the price at which other dealers are willing to sell.)
3. Exclude trade price p_t when $(p_t - p_{t-1})/p_{t-1} > 0.10$.
4. Exclude ask quote a_t when $(a_t - a_{t-1})/a_{t-1} > 0.10$.
5. Exclude bid quote b_t when $(b_t - b_{t-1})/b_{t-1} > 0.10$.
6. Exclude the entire day's data when the first trade price and quotes at $t = 0$ satisfy $p_0 - ((a_0 + b_0)/2)/p_0 > 0.10$. This filter is used to eliminate data errors such as a price that is wrongly coded for the entire trading day, which will not be identified by third filter.

When trade prices in a market are compared to quotes, we follow Lee and Ready (1991) and use the most recent prior quote that is time-stamped at least five seconds earlier than the trade. This five-second rule is intended to compensate for the speedier reporting of quotes than of trades. Trades are probably reported more slowly on NASDAQ than on the NYSE. On NASDAQ, for example, dealers are required to report trades within 90 seconds. The greater delay in reporting increases the measurement error of our execution cost measures. To the extent that NASDAQ dealers are able to 'paint the tape' to their advantage as argued by Porter and Weaver (1995), NASDAQ execution cost measures may be biased downward. If a trade does not have a prior BBO-eligible quote on the same day, it is excluded from the analysis.

Table 1
Characteristics of matched firms

Distributional characteristics of matched NYSE and NASDAQ firms. All data for price (*Price*) in dollars, long-term debt (*Debt*) in millions of dollars, common shares outstanding (*Share*) in millions, book value of common equity (*Book*) in million dollars, and market value of common equity (*Market*) in millions of dollars are as of the end of 1990 and are from the Compustat Annual Database. The volatility (*Volatility*) measure is the variance of daily returns in 1991 from CRSP tapes and is multiplied by 100. The number of trades (*# Trades*) and trading volume (*Volume*) in round lots are averages of the monthly means from 1991 ISSM tapes. The statistic 25th %tile is the lower quartile and 75th %tile is the upper quartile.

Variable	Exchange	Mean	Minimum	Maximum	25th %tile	Median	75th %tile
Price	NYSE	21.603	5.750	84.750	12.750	19.875	27.250
	NASDAQ	22.604	5.625	75.250	14.125	19.750	28.750
Debt	NYSE	129.62	0.00	1,715.10	8.03	49.07	145.66
	NASDAQ	118.84	0.00	3,147.00	2.08	23.53	98.85
Share	NYSE	26.52	3.32	357.48	10.34	18.80	32.80
	NASDAQ	25.88	4.33	254.00	11.16	16.48	28.42
Book	NYSE	376.05	14.36	3,913.40	109.05	201.46	378.13
	NASDAQ	314.32	23.19	3,591.51	93.86	167.39	300.31
Market	NYSE	642.88	38.43	9,071.13	175.94	322.47	643.66
	NASDAQ	619.23	148.89	8,555.85	195.47	291.86	623.52
Volatility	NYSE	0.0548	0.0063	0.3752	0.0244	0.0374	0.0720
	NASDAQ	0.0863	0.0133	0.3534	0.0445	0.0709	0.1105
# Trades	NYSE	624	64	7,720	245	409	786
	NASDAQ	1,959	14	20,685	384	716	1,805
Volume	NYSE	12,624	251	161,201	3,235	7,147	14,660
	NASDAQ	36,815	73	409,622	7,156	14,879	32,736

Since we control for differences in stock price, execution costs are measured in dollar terms rather than as a percentage of stock price. An average value of each execution cost measure is calculated for each of the 12 months in 1991. In other words, the basic data set contains 175 pairs of companies for 12 months, or 2,100 stock-months. Later, to check on the robustness of our results, the sample is narrowed to a subset of 66 pairs of companies by eliminating pairs for which a NASDAQ company's beta exceeds its paired NYSE company's beta.

4.3. Sample characteristics

Summary data on the characteristics of our final sample of 175 NYSE and NASDAQ companies are contained in Table 1. The company ticker symbols of all the data pairs are listed in the Appendix. The first five variables provide end-of-1990 data on the characteristics used to match the stocks – stock price, long-term debt, book value of equity, and market value of equity – and on shares outstanding. (Shares outstanding were are to calculate market value of equity.) The mean NASDAQ stock price of $22.60 is slightly more than the NYSE mean of $21.60. The mean and median levels of debt, shares outstanding, book value of equity, and market value of equity are slightly smaller for NASDAQ than for the NYSE.

The last three variables provide information on other characteristics of our 1991 sample. Volatility, measured as the standard deviation of daily returns, is smaller for NYSE stocks than for NASDAQ stocks. The number of trades and the share volume is substantially larger for NASDAQ stocks than for NYSE stocks. In the NASDAQ dealer market each transaction involves a dealer whereas on the NYSE auction market many trades are directly between public customers (when a public market order trades with a public limit order). As a result, volume in dealer markets is not comparable to volume in auction markets.

5. The quoted spread

We first provide evidence on quoted spreads. Because the spread refers to a round-trip transaction, that is two trades, while we seek to measure execution costs per trade, we report half-spreads. The *quoted half-spread* is defined as

$$s_t/2 = (a_t - b_t)/2\,,$$

where s_t is the quoted bid–ask spread, a_t is the quoted ask price, and b_t is the quoted bid price. Microstructure literature has shown that the quoted spread reflects expected losses to informed traders (Glosten and Milgrom, 1985; Copeland and Galai, 1983), inventory costs (Stoll, 1978; Amihud and Mendelson, 1980; Ho and Stoll, 1981), order processing costs (Stoll, 1985), and monopoly or cartel power. Use of the quoted half-spread as a measure of execution costs assumes that transactions will occur at the quotes.

Average quoted half-spreads are given in Table 2 for the NYSE and NASDAQ samples. For each stock-month these are trade-weighted averages of all quotes appearing on the ISSM data set. The table reports the average over all stock-months. A statistically significant difference, based on the sample of 2,100 stock-months, is shown by an asterisk next to the NASDAQ value. Results are presented for all trade sizes and for trades classified by size. Trades with 1,000 or fewer shares are classified as small, trades with more than 1,000 shares but less than 10,000 shares are classified as medium, and trades with 10,000 or more shares are classified as large. The quotes associated with each trade size are the last quote at least five seconds prior to the trade. The table also provides information on and the proportion of trades at various price locations. The effective spread estimates are discussed in the next section.

Table 2
Number of trades, spreads, and frequency of trades inside the spread

The table presents the number of trades, the quoted half-spread defined as half the difference between the quoted ask price and the quoted bid price, and the effective half-spread defined as the absolute difference between the trade price and the quote midpoint existing at the time of the trade. The table also presents the proportion of trades at each price location. A small trade has 1,000 shares or less, a medium trade has greater than 1,000 but less than 10,000 shares, and a large trade has 10,000 or more shares. Results of t-tests of the differences between NASDAQ and NYSE spreads and trade proportions are reported under the NASDAQ panel.

				Proportion of trades						
Trade size	Number of trades	Quoted half-spread	Effective half-spread	< Bid	= Bid	Bid to mid	= Mid	Mid to ask	= Ask	Ask
NYSE										
Small	935,759	0.129	0.077	0.001	0.294	0.082	0.224	0.081	0.316	0.002
Medium	320,593	0.130	0.085	0.004	0.314	0.070	0.205	0.062	0.340	0.005
Large	51,861	0.132	0.085	0.004	0.326	0.070	0.247	0.051	0.299	0.004
All	1,308,213	0.129	0.079	0.002	0.298	0.080	0.222	0.077	0.320	0.002
NASDAQ										
Small	3,018,643	0.247*	0.199*	0.005*	0.396*	0.048*	0.120*	0.042*	0.385*	0.004*
Medium	915,084	0.240*	0.156*	0.007*	0.306*	0.103*	0.226*	0.077*	0.275*	0.006**
Large	180,948	0.223*	0.135*	0.021*	0.287*	0.126*	0.234*	0.091*	0.231*	0.009*
All	4,114,675	0.246*	0.187*	0.006*	0.369*	0.065*	0.150*	0.052*	0.354*	0.005*

Significant at the 5% (*) and 10% (**) levels.

The average quoted half-spread on NASDAQ is 24.6 cents, nearly double the average quoted half-spread of 12.9 cents on the NYSE. The statistically significant difference is not due to differences in stock characteristics since we have matched the stocks. (We check the adequacy of our matching procedure in Section 8.)

The quoted half-spreads by trade size are standing quotes just before execution of a trade of stated size. The results show that there is virtually no difference in either market in the quoted half-spread associated with different size trades. This suggests that trades are unanticipated so that quotes cannot be adjusted in advance, or alternatively that large trades are pre-negotiated in such a way as to avoid the need to adjust quotes.

The contrast between the two markets is quite striking. In each trade size category, the quoted spread on NASDAQ is nearly twice the quoted spread on the NYSE. The difference in all cases is statistically significant based on the sample of 2,100 stock-month pairs.

6. Trading inside the quotes and the effective spread

Bid and ask quotes are not necessarily the prices at which trades take place since it is possible to trade inside the quotes, especially if the spread is as wide as on NASDAQ. A possible explanation for large differences in quoted spreads is that they are simply the starting point for a negotiation, not the price at which trades take place. If trades can occur inside the spread, a better measure of execution costs is the effective spread, which is based on trade price. The *effective half-spread* compares the trade price to the quote midpoint:

$$z_t = |p_t - q_t|,$$

where z_t is the effective half-spread, p_t is the trade price at time t, and $q_t = (a_t + b_t)/2$ is the quote midpoint existing at time of trade. The effective spread is smaller than the quoted spread because it accounts for the fact that trades take place inside the quotes.

The quoted spread reflects disseminated quotes, whereas the effective spread reflects trades at implicit quotes not publicly disseminated. Implicit quotes inside the disseminated quote may exist on an exchange floor. For example, McInish and Wood (1993) show that the specialist frequently does not disseminate the quotes of limit orders. In addition, the specialist or other traders may hold orders at prices inside the disseminated quotes. Therefore, trades may occur at these implicit quotes.

If dealers and other suppliers of immediacy are willing to trade at the effective spread, they must cover their average costs, that is, order processing costs, inventory risk, and the adverse information cost. The effective spread is probably a better measure of these costs (and of any excess dealer revenues) than the quoted spread since it is based on the prices at which trades occur.

The results for effective half-spreads are also reported in Table 2. The average effective half-spread for all trade sizes is 7.9 cents on the NYSE, reflecting price improvement relative to the average NYSE quoted half-spread of 12.9 cents. In NASDAQ the effective half-spread for all trade sizes is 18.7 cents, reflecting price improvement relative to the quoted half-spread of 24.6 cents. Over all trades, the difference in effective spreads across the two markets is 10.8 cents per share, which is statistically and economically significant. The effective spread on NASDAQ is again more than twice the NYSE's effective spread. These results reflect the fact that a smaller fraction of trades take place inside the quotes on NASDAQ than on the NYSE. The last seven columns of Table 2 give the frequency of trading at various price locations. The proportion of all trades inside the quotes is 0.267 on NASDAQ and 0.379 on the NYSE.

Measuring execution costs on the basis of transaction prices does not eliminate the significant difference between the two market systems. Execution costs are still higher in NASDAQ. However, there are important differences by trade sizes in the two markets. The effective spread for small trades is 19.9 cents in NASDAQ and 7.7 cents in the NYSE, a substantial difference of 12.2 cents. On the other hand, the effective spread for large trades is 13.5 cents in NASDAQ and 8.5 cents in the NYSE, a less substantial difference of five cents. Effective spreads increase with trade size in the NYSE, consistent with Petersen and Fialkowski (1994), but they decrease with trade size in NASDAQ. This reflects the fact that institutions are able to negotiate transactions inside the quotes in NASDAQ whereas small NASDAQ trades are more likely to take place at the quotes. Trades inside the quotes on NASDAQ may also represent interdealer transactions. To the extent that such transactions are frequent, the effective spread will understate the execution cost to public investors. As implied by the effective spreads, the frequency of small trades inside the quotes is much greater on the NYSE (38.7% of the small trades) than on NASDAQ (21% of the small trades). By contrast, the frequency of large trades inside the quotes is much smaller on the NYSE (36.8% of the large trades) than on NASDAQ (45.1% of the large trades).

The 5 cent difference for large trades could, for example, be explained by the fact that NASDAQ trades are 'net', that is without commission, while on the NYSE a commission is normally charged by the broker. If that commission is 5 cents, which is reasonable, the effective spread ought to be 5 cents higher in NASDAQ to make up for the lack of a commission. However, commissions cannot easily explain the 12.2 cent difference in small trades, particularly since small traders usually pay a commission on NASDAQ.

7. Adverse selection and the realized spread

Dealers increase their spread to offset losses to informed traders, as Glosten and Milgrom (1985) and Copeland and Galai (1983) have shown. If one market structure is more effective than another in protecting against informed traders, its spread will not need to be as large. Most academic papers on the subject suggest that the NYSE market is better at protecting the specialist against adverse information than the NASDAQ market is in protecting dealers. Glosten (1989) argues that the specialist can offset losses to informed traders by excess profits on small trades. Benveniste, Marcus, and Wilhelm (1992) argue that the specialist can discipline brokers that represent informed trades. Rock (1991) argues that the specialist has the option of taking trades or letting them trade against the limit order book, a flexibility that limits the specialist's losses to informed traders.

On NASDAQ, dealers may have less information on the order flow since they cannot see the order flow of other dealers. They might also have less flexibility in shifting order flow to limit orders. This is especially true of orders received over the Small Order Execution System (SOES), a system over which executions take place automatically at the market inside quote. Dealers in major NASDAQ stocks must honor orders up to 1,000 shares. This makes the dealer subject to informed traders and to staleness in his own quotes. A dealer who is slow to change quotes is hit immediately by 'SOES bandits' who exploit short-run mispricing. If it is more difficult to protect against informed trading in NASDAQ, spreads will be wider than on the NYSE.

Because of the adverse information possessed by some traders, it is well known that prices move against the dealer after a trade, falling after a dealer purchase and rising after a dealer sale. Hasbrouck (1988) and Huang and Stoll (1994a), among others, find such effects on the NYSE. Consequently a dealer does not, on average, realize the effective spread because he realizes losses when he trades with an informed trader. He realizes the difference between the initial trade price and the subsequent price at which the trade is liquidated. If prices move against the dealer, he incurs losses.

7.1. Realized spreads

We adopt a simple procedure to decompose the effective spread in each market into an adverse information component and the component realized by the dealer (or other supplier of immediacy). We estimate the post-trade revenues earned by the dealer on the basis of actual post-trade prices. This measure is defined as the realized half-spread and is sometimes referred to as the price reversal since a dealer realizes earnings only if prices reverse. The excess of the effective spread over the realized spread is our estimate of the amount lost to informed traders.[2]

The average realized spread is an average across all suppliers of immediacy. On the NYSE, the average realized spread measures the average revenues earned by the specialist, floor traders, and limit orders. On NASDAQ, where only dealers directly provide immediacy, the average realized spread measures dealer revenues.

We define the *realized half-spread* for time horizon τ, δ_τ, as follows. For trades at the bid, we calculate

$$(\delta_\tau | b_t) = [(p_{t+\tau} - p_t) | (p_t = b_t)] ,$$

and for trades at the ask we calculate

$$(\delta_\tau | a_t) = -[(p_{t+\tau} - p_t) | (p_t = a_t)] ,$$

where t is the time of the trade and τ is the length of time after the trade at which the subsequent price is observed. We also report the price change subsequent to trades at other locations. Since the average price change over all transactions is close to zero, the realized half-spread is calculated conditional on transactions at the bid or ask side of the market. Since a larger fraction of NYSE trades take place inside the quotes, the comparison of realized spreads based on trades at the ask and at the bid overstates NYSE realized revenues relative to NASDAQ. For transactions at the bid, we expect positive price changes, and for transactions at the ask, we expect negative price changes. Trades on the ask side of the market are multiplied by -1 to yield the realized half spread. Our procedure assumes that trades at the bid are dealer purchases and trades at the ask are dealer sales. Sometimes dealers negotiate special prices that cause the dealer to buy at the ask or sell at the bid. We assume these cases are infrequent.

The time horizon, τ, must be chosen such that offsetting trades have an opportunity to be observed. If the period is too short, the subsequent price may reflect not a reversal but another trade in a series of trades pursuant to the same

[2]This procedure is not possible for Stoll (1989), who infers the components of the spread in NASDAQ stocks on the basis of a covariance model of price changes, or for Affleck-Graves et al. (1994), who estimate spread components using the Stoll model. The Stoll model could not determine whether a trade was at the bid or ask and could therefore not calculate directly the realized spread. Huang and Stoll (1995b) provide a more sophisticated approach to a complete decomposition of the spread that permits calculation of realized spreads at specific price locations. Jones and Lipson (1995) also investigate the adverse selection component in NASDAQ and in exchange markets.

order. If the period is too long, unnecessary variability will enter into the measure. Our analysis is performed for four alternative time horizons:

$\tau = 5$: Defined by the first trade between five and ten minutes after the initial trade at t. If no trade is observed in this time horizon, no realized spread is calculated.

$\tau = 5^+$: Defined by the first trade occurring at least five minutes after the initial trade at t. If no subsequent trade occurs on the same day, no realized spread is calculated.

$\tau = 30$: Defined by the first trade between 30 and 35 minutes after the initial trade at t. If no trade is observed in this time horizon, no realized spread is calculated.

$\tau = 30^+$: Defined by the first trade occurring at least 30 minutes after the initial trade at t. If no subsequent trade occurs on the same day, no realized spread is calculated.

Table 3 provides evidence of post-trade conditional price changes for horizons $\tau = 5$ and $\tau = 30$ for initial trades at the bid, the ask, and other price locations. Note that these are price changes. Trades on the ask side have not been multiplied by -1 as in the definition of the realized spread. The price changes for horizons $\tau = 5^+$ and $\tau = 30^+$ are not presented because they convey the same information. If trades are serially correlated so that purchases follow purchases and sales follow sales, price reversals would be less likely over the five-minute horizon than over the 30-minute horizon. In fact, the reversals calculated over the two horizons are virtually identical.

The realized half-spread is significantly larger on NASDAQ than on the NYSE. Consider the five-minute results: For all trades at the bid, the realized half-spread averages 15.3 cents on NASDAQ as compared with 2.7 cents on the NYSE; for all trades at the ask, the realized half-spread averages 13.6 cents on NASDAQ and 0.8 cents on the NYSE. Within each market, realized spreads are very similar for the different trade sizes. The results are essentially the same for the 30-minute horizon, and the differences across the two markets are highly significant.

7.2. *Adverse information component*

On the basis of the evidence in Table 3, we reject the theory that higher execution costs on NASDAQ are the result of an inability of dealers to cope with adverse information and SOES bandits. Revenues of NASDAQ dealers, net of adverse information, are significantly higher than the revenues of suppliers of immediacy on the NYSE, net of adverse information. The difference in realized spreads slightly exceeds the difference in effective spreads. If adverse information

Table 3
Five-minute and 30-minute price changes

The table presents five-minute and 30-minute price changes by trade size and price location. Price location is the location of the first price used to calculate the price change. A small trade has 1,000 shares or less, a medium trade has greater than 1,000 but less than 10,000 shares, and a large trade has 10,000 or more shares. Results of t-tests of the differences between NASDAQ and NYSE price changes are reported under the NASDAQ panels.

	Price location						
Trade size	< Bid	= Bid	Bid to mid	= Mid	Mid to ask	= Ask	> Ask
Five-minute price change on the NYSE							
Small	0.138	0.029	0.041	0.008	− 0.025	− 0.012	− 0.031
Medium	0.063	0.024	0.049	0.011	− 0.028	0.004	− 0.027
Large	0.098	0.027	0.042	0.017	0.006	0.009	0.038
All	0.105	0.027	0.041	0.009	− 0.023	− 0.008	− 0.024
Five-minute price change on NASDAQ							
Small	0.374*	0.149*	0.073*	0.008	− 0.057*	− 0.134*	− 0.379*
Medium	0.385*	0.149*	0.078*	0.002*	− 0.072*	− 0.122*	− 0.373*
Large	0.351*	0.169*	0.110*	0.011	− 0.074*	− 0.133*	− 0.335*
All	0.374*	0.153*	0.076*	0.004	− 0.065*	− 0.136*	− 0.375*
30-minute price change on the NYSE							
Small	0.142	0.039	0.055	0.018	− 0.023	− 0.006	− 0.021
Medium	0.071	0.029	0.069	0.023	− 0.023	0.012	− 0.017
Large	0.085	0.034	0.067	0.031	0.006	0.023	0.110
All	0.110	0.036	0.059	0.019	− 0.022	− 0.002	− 0.010
30-minute price change on NASDAQ							
Small	0.392*	0.161*	0.068*	0.014	− 0.038*	− 0.139*	− 0.403*
Medium	0.415*	0.147	0.076	0.013**	− 0.049*	− 0.107*	− 0.417*
Large	0.374*	0.172*	0.126*	0.022	− 0.066*	− 0.115*	− 0.339
All	0.398*	0.162*	0.075*	0.013	− 0.050*	− 0.138*	− 0.396*

Significant at the 5% (*) and 10% (**) levels.

were larger on NASDAQ than on the NYSE, the difference in realized spreads should narrow relative to the difference in effective spreads, but our results are inconsistent with this hypothesis. Another way to state the finding in Table 3 is that NASDAQ dealers retain a much large fraction of the effective spread than do NYSE suppliers of immediacy.

An estimate of the average loss to informed traders can be calculated explicitly by subtracting the average realized half-spread (Table 3) from the corresponding average effective spread (Table 2). The results for the five-minute and

Table 4
Adverse information component of the effective half-spread

The table presents adverse information components in cents calculated as the difference between the effective half-spread and the realized half-spread. The effective half-spread is defined as the absolute difference between the trade price and the quote midpoint existing at the time of the trade, and the realized half-spread is defined as the price change for initial trades at the bid and negative of the price change for initial trades at the ask. The adverse information components are calculated using five-minute and 30-minute realized half-spreads. A small trade has 1,000 shares or less, a medium trade has greater than 1,000 but less than 10,000 shares, and a large trade has 10,000 or more shares.

	Five-minute adverse information		30-minute adverse information	
Trade size	At bid	At ask	At bid	At ask
NYSE				
Small	4.8	6.5	3.8	7.1
Medium	6.1	8.9	5.6	9.7
Large	5.8	9.4	4.9	10.8
All	5.2	7.1	4.3	7.7
NASDAQ				
Small	5.0	6.5	3.8	6.0
Medium	0.7	3.4	0.9	4.9
Large	– 3.4	0.2	– 3.7	2.0
All	3.4	5.1	2.5	4.9

30-minute horizons, presented in Table 4, show that adverse information is not larger in NASDAQ than in the NYSE. We ascribe this result to several factors. First, we believe the adverse information component is of significance on the NYSE because public investors who place limit orders lose to informed traders more so than specialists and floor traders. Simpson (1994) finds that, on average, there is no reversal after limit order trades on the NYSE. NYSE specialists and floor traders, on the other hand, earn a reversal in excess of the average reversal measured over all suppliers of immediacy. Specialist revenues, as estimated in Sofianos (1995) and in Huang and Stoll (1994b), exceed our measure of the NYSE average realized spread (but they are always less than the effective spread on the NYSE). On NASDAQ, the realized spread measures the revenues of dealers alone, unaffected by limit orders. Revenues earned by NASDAQ dealers, as estimated by the realized spread for trades at the bid, are 15.3 cents, not only larger than the corresponding NYSE realized spread of 2.7 cents, but also in excess of the NYSE effective spread of 7.9 cents and the NYSE quoted spread of 12.9 cents. NASDAQ dealers retain a large fraction of the spread and appear to lose relatively little to informed traders. Dealer revenues on NASDAQ could be overstated if they sometimes buy at the ask and sell at the bid, but as there is little incentive for dealers to behave this way, we believe such behavior is unlikely.

Second, the adverse information component may be no larger on NASDAQ because NASDAQ dealers 'know their order flow'. Preferencing of order flow and the development of long run relationships may protect the NASDAQ dealer in a way we had not anticipated. By this interpretation, NASDAQ dealers know their institutional customers well, for the adverse information effect is particularly small in the case of large trades. On NASDAQ, the adverse information effect decreases with trade size. On the NYSE, it increases with trade size. Consider, for example, large NASDAQ trades at the bid. The realized half-spread for these trades, shown in Table 3, is 17.2 cents, which compares with an effective spread of 13.5 cents (Table 2). The implied adverse information component is − 3.7 cents. In other words, the adverse information is possessed by the dealer, not the customer. The realized spread for large NASDAQ trades at the ask is 11.5 cents, less than the effective spread of 13.5 cents, which shows that prices move against the dealer in this case, albeit not as much as in the case of small trades and not nearly as much as on the NYSE. Institutional investors on NASDAQ seem to be effective in negotiating transactions inside the spread, but such negotiation does not translate into lower realized spreads.

Research on NYSE block trades, such as Kraus and Stoll (1972) and Holthausen, Leftwich, and Mayers (1987), has detected an asymmetry between sales (at the bid) and purchases (at the ask). Sales of blocks at the bid are followed by a price increase, which is viewed as compensation to the provider of immediacy. In contrast, purchases of blocks at the ask are not followed by a price decrease, implying that sellers of blocks are not compensated for providing immediacy to buyers. We also observe this asymmetry in our data for the NYSE, where the average price change after large trades at the bid is 2.7 cents and the average price change after a large trade at the ask is 0.9 cents (not the negative price change necessary to compensate sellers of blocks). The asymmetry is not nearly as evident for large trades on NASDAQ, where a large trade at the bid is followed by a price change of 16.9 cents and a large trade at the ask is followed by a price change averaging − 13.3 cents. We suspect that this difference in the two markets may also reflect the role of limit orders on the NYSE and the fact that NASDAQ dealers 'know their order flow'.

We had expected the realized spread in NASDAQ to be a smaller fraction of the effective spread than on the NYSE based on the assumption that dealers in a decentralized market would find it difficult to protect themselves against informed traders. However, that does not appear to be the case. Our empirical results imply that adverse information is less severe in dealer markets than auction markets. Consequently, the larger quoted and effective spreads in NASDAQ cannot be ascribed to adverse information. Dealers on NASDAQ report that they negotiate large trades, and this negotiation seems to be effective in limiting adverse information effects.

7.3. Market depth and quote adjustment

Having ruled out asymmetric information as a credible candidate, the higher realized spreads on NASDAQ may be due to higher inventory holding costs, higher order processing costs, or higher excess profit. It is possible that NASDAQ realized spreads are larger because NASDAQ dealers provide greater depth and as a consequence take on greater inventory risk. On the NYSE, all trades are funneled through the specialist post. If a sequence of purchases or sales arrives, the specialist is able to adjust his quotes quickly before the next trade in the sequence is executed. On NASDAQ, it is possible for a large order to be executed simultaneously with several dealers in the stock. The possibility of simultaneous trading in dealer markets increases inventory risk relative to the sequential dealing in auction markets. Each dealer, knowing that other dealers are simultaneously purchasing shares, must raise his spread to compensate not only for his inventory accumulation but also for that of the other dealers. This is because his ability to undo his inventory depends on the inventory position of his competitors. Ho and Stoll (1983) and Laux (1995) model such behavior. NASDAQ dealers assert that they avoid this risk by asking large repeat customers to disclose whether other trading is taking place. Nevertheless, the total depth of the market when each of 30 dealers is willing to trade a minimum of 1,000 shares may be greater than on the NYSE.

Unfortunately, there is little direct evidence on the inventory risk of NASDAQ dealers. Chan, Christie, and Schultz (1995) suggest that the narrowing of NASDAQ spreads at day-end may reflect inventory control, and Hansch, Naik, and Viswanathan (1993) analyze inventory adjustment in the London dealer market. We examine indirect evidence in the form of the relative frequency of quote adjustment in the two markets. A market in which many trades can take place without quote adjustments would seem to be more liquid with greater depth than a market in which few trades can take place without quote adjustment. We examine the relative frequency of quote adjustment for 66 pairs of firms that are a subset of our sample of 175 pairs. Since the number of trades on the two markets are not directly comparable, we only consider quotes that immediately precede trades. Despite the more frequent trades on NASDAQ as shown in Table 1, the number of quote adjustments on the NYSE exceed those on NASDAQ for every one of the 66 pairs. In 1991, the mean number of quote adjustments is 4,711.17 for a sample of 66 NYSE stocks and 991.30 for the paired sample of 66 NASDAQ stocks, a difference that would occur by chance with a probability of less than 0.0001.

The lower frequency of quote changes in NASDAQ is consistent with greater depth and possibly with greater inventory risk for NASDAQ dealers, but we are doubtful that it reflects significantly higher inventory risk or explains very much of the difference in realized spreads. First, any reasonable incremental compensation for inventory risk on NASDAQ would be much smaller than the difference in spreads that is to be explained, since existing measures of the inventory component of the spread are small. Ho and Stoll (1981) provide some theoretical calibrations of the inventory cost, and Stoll (1989) and Huang and Stoll (1995b) empirically estimate the inventory component of the spread. Second, NASDAQ market makers are, for the most part, integrated firms with large portfolios for which inventory risk is less of a concern. Third, NASDAQ dealers have inter-dealer trading systems such as SelectNet and Instinet through which dealer positions can be adjusted. Fourth, the relative quote adjustment frequencies reflect institutional features such as the role of limit orders on the NYSE that are unrelated to inventory risk. Small limit orders on the NYSE that are placed inside the specialist's spread cause changes in the quotes as they are executed and may raise the frequency of quote adjustments on that market. In summary, we conclude that greater inventory risk in NASDAQ cannot reconcile the difference in execution costs.

8. Other execution cost measures

In this section, we look for further evidence on NYSE and NASDAQ execution costs by examining two additional measures. The first is the implied spread derived by Roll (1984). The second is the maximum revenue a supplier of immediacy with perfect foresight can realize.

8.1. The Roll implied spread

The presence of a bid–ask bounce induces negative serial covariance in price changes, as Roll (1984) has shown. Roll calculates an implied spread from the observed serial correlation of transaction price changes and assumptions about the transaction process generating those price changes. Roll assumes that the bid–ask quotes do not change in response to trades, something that would be implied if there is no informed trading and if quotes are not changed to help equilibrate dealer inventories (see Stoll, 1989; Huang and Stoll, 1995b). The *Roll* implied half-spread is $\sqrt{-cov}$, where cov is the serial covariance of successive price changes. Using daily data for NYSE and ASE stocks in the period 1963 to 1982, Roll calculates an implied spread of 0.298 percent, or about 8.9 cents on a \$30 stock. Roll interprets his result as a measure of the effective spread at which transactions actually occur. Like the reversal measure of execution costs, the Roll half-spread is a prospective measure in the sense that it depends on price changes after the trade.

The first step in estimating the Roll half-spread for our samples of NASDAQ and NYSE stocks is to calculate a serial covariance for all trades in a given stock in a given month. For each trade, we determine the trade price, p_t, the most recent prior price, p_{t-1}, and the next price, p_{t+1}. The three prices provide two price changes, and we use all such pairs of price changes to calculate a serial covariance, *cov*, for each stock in each month:

$$cov = \mathrm{E}[(p_{t+1} - p_t - \overline{\Delta p})(p_t - p_{t-1} - \overline{\Delta p})],$$

where $\overline{\Delta p}$ is the mean price change in the stock-month. Serial covariances for each of the three trade sizes are calculated on the basis of the pairs of price changes defined by the trade size at time t. Thus, we calculate one overall covariance and three covariances based on trade sizes for each stock-month. Next, the covariances are averaged over all stock-months, and the implied half-spread is calculated as $\sqrt{-\overline{cov}}$, where $\overline{cov}$ is the average covariance. By taking the square root of the average we avoid the downward bias, due to Jensen's inequality, present in the average of the square root of negative covariances, something described by Harris (1990).

The evidence for the Roll implied spread in the first column of Table 5 is consistent with the other spread evidence. On the NYSE, the Roll implied half-spread is 3.4 cents, which is less than the effective half-spread shown in Table 2. This reflects the fact that quotes on the NYSE are permanently changed in response to trades, consistent with the presence of adverse information. The results for NASDAQ are strikingly different. The Roll implied half-spread is 18.3 cents, which is virtually identical to the effective spread. This means that quotes are not adjusted systematically in response to trades and implies the absence of adverse information effects.

8.2. *The perfect foresight spread*

Another execution cost measure is the *perfect foresight half-spread*, which we calculate as the unconditional absolute price change after a trade:

$$|\Delta p_t| = |p_{t+\tau} - p_t|,$$

where τ is defined for the same time horizons as for the realized half-spreads. We term this 'the perfect foresight realized half-spread' because it is the revenue of a supplier of immediacy who has perfect foresight that makes it possible always to pick the profitable side of the trade. The measure can also be thought of as a measure of post-trade variability. Stocks that trade at greater deviations from their equilibrium price will have greater post-trade variability as they revert to their equilibrium level. Hasbrouck (1993) also assesses the quality of a market on the basis of its short-run variability.

Table 5
Roll's implied half-spread and perfect foresight half-spreads

The table presents Roll's implied half-spread and perfect foresight half-spreads. Roll's implied half-spread (Roll) is calculated as the square root of the negative of the mean covariance. The perfect foresight half-spreads are calculated as the absolute price change, and time between the trades is used to classify the various measures. Absolute price change ignores time between trades, five-minute (30-minute) absolute price change considers trades that are five to ten (30 to 35) minutes apart, and five-minute+ (30-minute+) absolute price change considers trades that are at least five minutes (30 minutes) apart. A small trade has 1,000 shares or less, a medium trade has greater than 1,000 but less than 10,000 shares, and a large trade has 10,000 or more shares. Results of t-tests of the differences between NASDAQ and NYSE half-spreads are reported under the NASDAQ panel.

Trace size	Roll	Absolute price change	5-minute absolute price change	5-minute+ absolute price change	30-minute absolute price change	30-minute+ absolute price change
NYSE						
Small	0.031	0.067	0.091	0.088	0.136	0.122
Medium	0.041	0.066	0.090	0.089	0.141	0.126
Large	0.037	0.055	0.072	0.077	0.131	0.118
All	0.034	0.066	0.090	0.088	0.137	0.123
NASDAQ						
Small	0.190*	0.169*	0.204*	0.211*	0.253*	0.248*
Medium	0.158*	0.165*	0.188*	0.197*	0.231*	0.233*
Large	0.137*	0.168*	0.188*	0.197*	0.229*	0.229*
All	0.183*	0.169*	0.200*	0.208*	0.249*	0.244*

Significance at the 5% level (*).

Table 5 contains measures of the perfect foresight spread by trade size for different horizons, τ. The average absolute price change between trades is 6.6 cents on the NYSE and 16.9 cents on NASDAQ, a difference that corresponds to the difference in spreads between the two markets. In both markets the absolute price change between adjacent trades is less than the effective half-spread in all trade sizes except large NASDAQ trades. As the horizon lengthens to five minutes and 30 minutes, the absolute price change increases as one would expect, but the relation between the NYSE and NASDAQ remains the same: the post-trade variability is always greater in NASDAQ than in the NYSE. This is evidence of a greater bid–ask bounce, consistent with our other findings.

Table 6 provides evidence for the five- and 30-minute horizons by trade size and price location. On the NYSE, trades at the bid, the midpoint, and the ask are followed by absolute price changes of 8.9 cents, 8.8 cents, and 8.6 cents, respectively. On NASDAQ, trades at the bid, midpoint, and ask are followed by absolute price changes of 20.5 cents, 18.6 cents, and 20.3 cents, respectively. As

Table 6
Five-minute and 30-minute perfect foresight half-spreads

The table presents five-minute and 30-minute perfect foresight half-spreads by trade size and price location. Price location is the location of the first price used to calculate the price change. The five-minute (30-minute) perfect foresight half-spreads are calculated as the absolute price change between an initial trade and a subsequent trade that is five to ten (30 to 35) minutes later. A small trade has 1,000 shares or less, a medium trade has greater than 1,000 but less than 10,000 shares, and a large trade has 10,000 or more shares. Results of t-tests of the differences between NASDAQ and NYSE price changes are reported under the NASDAQ panels.

	Price location						
Trade size	< Bid	= Bid	Bid to mid	= Mid	Mid to ask	= Ask	> Ask
Five-minute perfect foresight half-spread on the NYSE							
Small	0.229	0.090	0.116	0.089	0.113	0.087	0.163
Medium	0.159	0.089	0.120	0.083	0.108	0.086	0.158
Large	0.153	0.074	0.100	0.066	0.088	0.071	0.138
All	0.191	0.089	0.115	0.088	0.111	0.086	0.155
Five-minute perfect foresight half-spread on NASDAQ							
Small	0.403*	0.207*	0.233*	0.194*	0.231*	0.206*	0.412*
Medium	0.396*	0.189*	0.209*	0.166*	0.214*	0.175*	0.384*
Large	0.360*	0.189*	0.217*	0.161*	0.202*	0.162*	0.343*
All	0.394*	0.205*	0.222*	0.186*	0.226*	0.203*	0.401*
30-minute perfect foresight half-spread on the NYSE							
Small	0.312	0.137	0.168	0.135	0.165	0.136	0.252
Medium	0.242	0.140	0.188	0.140	0.177	0.142	0.226
Large	0.314	0.137	0.188	0.131	0.182	0.131	0.312
All	0.262	0.137	0.168	0.135	0.162	0.136	0.236
30-minute perfect foresight half-spread on NASDAQ							
Small	0.459*	0.251*	0.281*	0.240*	0.272*	0.254*	0.467*
Medium	0.457*	0.234*	0.251*	0.210*	0.255*	0.223*	0.457*
Large	0.421**	0.232*	0.268*	0.202*	0.244*	0.210*	0.398
All	0.449*	0.248*	0.268*	0.230*	0.264*	0.250*	0.450*

Significant at the 5% (*) and 10% (**) levels.

noted earlier, the difference between the two markets is substantial. However, an interesting similarity is that the post-trade variability within each market is about the same for all trade locations. One would expect trades at the ask or the bid to be followed by significantly larger absolute price change than trades at the midpoint, but this is not the case. This result suggests that profits to knowledgeable market makers (in each market) are approximately equal for trades inside the spread and for trades at the spread.

9. Are the stock samples well matched?

Given the surprisingly large difference in execution costs of NASDAQ stocks and matched NYSE stocks, a natural question is whether the stocks are indeed comparable. Another possibility is that certain trading characteristics not included in the matching procedure, such as volume or return volatility, explain differences in execution costs. We employ a cross-section regression framework to investigate if the difference in execution costs can be explained by the variables used to match stocks or by two other economic variables, share volume and return volatility.

As a second check, we impose the requirement that each NASDAQ stock not be riskier than its paired NYSE stock, with risk measured by the stock's beta. Fama and French (1992) argue that price, book to market, and market value are superior to beta in predicting cross-sectional differences in expected return. That is the basis for our sample selection. By matching on beta as well, we hope to satisfy those critics who believe beta would have been a better measure. We then recalculate our results.

9.1. Cross-sectional regression results

As a check on our stock matching procedure, we regress several measures of execution cost differences on differences in the variables used to pair stocks – price, shares outstanding, long-term debt, and book equity. To the extent that we are unable to match stocks precisely on these variables, they may have explanatory power. In addition, we include two other variables that have been found to affect spreads – share volume and return variability.[3] The observations used to estimate each regression are the average of the monthly values for each stock pair difference.

Let y_i^* be the excess execution cost measure for stock pair i, defined as the NASDAQ execution cost minus the paired NYSE execution cost. We then estimate the following :

$$y_i^* = \alpha_0 + \alpha_1 p_i^* + \alpha_2 v_i^Q + \alpha_3 v_i^N + \alpha_4 \sigma_i^* + \alpha_5 D_i^* + \alpha_6 S_i^* + \alpha_7 B_i^* + e_i ,$$

where

y_i^* = NASDAQ execution cost measure minus paired NYSE execution cost measure; measures are the quoted spread, the effective spread, the perfect foresight spread, and four measures of the realized spread;

[3]See, for example, Stoll (1978). Stoll shows theoretically that total risk, not systematic risk, is the relevant measure of inventory risk for a supplier of immediacy with respect to an incremental trade. Empirically, he also finds that for Over-the-Counter stocks spread is related to total risk.

p_i^* = NASDAQ stock price minus paired NYSE stock price;
v_i^Q = NASDAQ share volume in round lots;
v_i^N = paired NYSE share volume in round lots;
σ_i^* = NASDAQ standard deviation of return minus paired NYSE standard deviation of return based on daily returns for 1991;
D_i^* = NASDAQ long-term debt minus paired NYSE long-term debt in millions of dollars;
S_i^* = NASDAQ shares outstanding minus paired NYSE shares outstanding in millions;
B_i^* = NASDAQ book value of common equity minus paired NYSE book value of common equity in millions of dollars.

Except for volume, all of the independent variables are the excess of the NASDAQ value over the paired NYSE value. Volume is a function of the market structure. In dealer markets volume is large because all trades go through a dealer who reports the trade when he buys and when he sells, whereas in auction markets the public investors can trade directly with each other. The effect of this difference is not clear, and we let the regression determine the relative importance of volume in the two markets.

The results for the seven regressions are contained in Table 7. Our original matching variables (long-term debt, shares outstanding, and book equity) are not significant, which shows that matching was precise on these variables (or that they bear no relation to execution costs). Price per share is statistically significant in five of the seven regressions. The price variable is not the variable used to match the firms initially (the end-of-1990 price) but the average price during 1991. It is not surprising therefore that this measure would have explanatory power. The price has the expected positive sign, showing that spread (and the other measures of execution cost) increase with stock price, and the coefficient is less than one as in other spread studies. NASDAQ volume has explanatory power and the expected negative sign. NYSE volume is not statistically significant. This may reflect the fact that for NYSE stocks volume provides little additional information relative to the matching variables, particularly shares outstanding. Finally, the difference in volatilities has a significant positive effect on the quoted spread, effective spread, and perfect foresight spread, albeit not on the realized spread measures.

The most striking feature of the regressions is the fact that all the constant terms are significantly positive. The constants are, in fact, of the same order of magnitude as the paired differences reported earlier. The constant in the quoted spread regression is 12.2 cents, which compares with a difference in the matched sample of 11.7 cents (from Table 2). The constant in the effective spread regression is 11.3 cents, which compares with a difference in the matched sample of 10.8 cents (from Table 2). The constant in the perfect foresight regression is 10.8 cents, which compares with a difference in the matched sample of 11.0 cents

Table 7
Cross-sectional regressions: Sample of 175 companies

The table presents results of regressing the difference between NASDAQ and NYSE execution cost measures on a constant, the difference in mean trade price (*DPrice*), the NASDAQ trading volume in round lots, the NYSE trading volume in round lots, the difference in daily return variance (*DVolatility*), the difference in long-term debt (*DDebt*), the difference in common shares outstanding (*DShare*), and the difference in book value of common equity (*DBook*). The execution cost measures are the quoted half-spread (*Quoted*) defined as half the difference between the quoted ask price and the quoted bid price, the effective half-spread (*Effective*) defined as the absolute difference between the trade price and the quote midpoint existing at the time of the trade, the perfect foresight half-spread (*Perfect Fore*) defined as the absolute price change, and realized half-spreads (*Rlz Bid 5*, *Rlz Ask 5*, *Rlz Bid 30*, *Rlz Ask 30*). *Rlz Bid 5* (*Rlz Ask 5*) is defined as the (negative of the) price change between an initial trade at the bid (ask) and a subsequent trade that is five to ten minutes later. *Rlz Bid 30* and *Rlz Ask 30* are analogously defined for subsequent trades that are 30 to 35 minutes later than the initial trades. The constant term is unadjusted but the *DPrice* coefficient is multiplied by 100, the *DVolatility* coefficient is divided by 100, and the remaining coefficients are multiplied by 1,000.

Dependent variable		*Constant*	*DPrice*	*NASDAQ volume*	*NYSE volume*	*DVolatility*	*DDebt*	*DShare*	*DBook*	Adjusted R^2
Quoted	Coeff.	0.1222	0.3939	− 0.0010	0.0006	0.6579	− 0.0041	− 1.1660	0.0061	0.15
	P-value	0.0001	0.0011	0.0089	0.5809	0.0089	0.9478	0.3450	0.9471	
Effective	Coeff.	0.1130	0.2619	− 0.0007	0.0004	0.4427	− 0.0115	− 0.9230	0.0034	0.15
	P-value	0.0001	0.0015	0.0077	0.6153	0.0098	0.7864	0.2732	0.9573	
Perfect Fore	Coeff.	0.1086	0.2256	− 0.0005	0.0003	0.2201	− 0.0062	− 0.7560	− 0.0035	0.22
	P-value	0.0001	0.0001	0.0020	0.5981	0.0520	0.8271	0.1765	0.9327	
Rlz Bid 5	Coeff	0.1430	0.1216	− 0.0004	− 0.0006	0.1157	− 0.0026	0.3450	− 0.0482	0.10
	P-value	0.0001	0.0176	0.0225	0.1837	0.2761	0.9233	0.5117	0.2202	
Rlz Ask 5	Coeff.	0.1555	0.0694	− 0.0003	− 0.0010	0.0992	− 0.0221	− 0.7250	− 0.0163	0.03
	P-value	0.0001	0.4437	0.2800	0.2412	0.6032	0.6376	0.4371	0.8148	
Rlz Bid 30	Coeff.	0.1517	0.1514	− 0.0004	− 0.0005	− 0.0701	− 0.0162	− 0.5610	− 0.0201	0.11
	P-value	0.0001	0.0235	0.0412	0.3613	0.6162	0.6383	0.4116	0.6928	
Rlz Ask 30	Coeff.	0.1803	0.0862	− 0.0005	− 0.0011	0.0285	− 0.0269	− 0.8550	− 0.0621	0.03
	P-value	0.0001	0.4874	0.1698	0.3476	0.9131	0.6761	0.5032	0.5149	

Table 8

Cross-sectional regressions: sample of 66 companies

Panel A presents results of regressing the difference between NASDAQ and NYSE execution cost measures on a constant, the difference in mean trade price (*DPrice*), the NASDAQ trading volume in round lots, the NYSE trading volume in round lots, the difference in daily return variance (*DVolatility*), the difference in long-term debt (*DDebt*), the difference in common shares outstanding (*DShare*), and the difference in book value of common equity (*DBook*). The execution cost measures are the quoted half-spread (*Quoted*) defined as half the difference between the quoted ask price and the quoted bid price, the effective half-spread (*Effective*) defined as the absolute difference between the trade price and the quote midpoint existing at the time of the trade, the perfect foresight half-spread (*Perfect Fore*) defined as the absolute price change, and realized half-spreads (*Rlz Bid 5*, *Rlz Ask 5*, *Rlz Bid 30*, *Rlz Ask 30*). *Rlz Bid 5* (*Rlz Ask 5*) is defined as the (negative of the) price change between an initial trade at the bid (ask) and a subsequent trade that is five to ten minutes later. *Rlz Bid 30* and *Rlz Ask 30* are analogously defined for subsequent trades that are 30 to 35 minutes later than the initial trades. The constant term is unadjusted but the *DPrice* coefficient is multiplied by 100, the *DVolatility* coefficient is divided by 100, and the remaining coefficients are multiplied by 1,000. Panel B uses the same explanatory variables and makes the same adjustments to the coefficients as in panel A but the dependent variables are percentages of quotes that are both even bid and even ask (*Ev1*) and average of the percentage even bid and percentage even ask (*Ev2*).

Dependent variable		*Constant*	*DPrice*	*NASDAQ volume*	*NYSE volume*	*DVolatility*	*DDebt*	*DShare*	*DBook*	Adjusted R^2
Panel A: Execution cost regressions										
Quoted	Coeff.	0.2232	0.8748	– 0.0034	– 0.0003	2.0074	0.0133	– 1.4960	0.0565	0.35
	P-value	0.0001	0.0017	0.0384	0.9273	0.0001	0.9580	0.5973	0.7635	
Effective	Coeff.	0.1850	0.5885	– 0.0023	– 0.0005	1.3440	– 0.0021	– 1.2310	0.0601	0.37
	P-value	0.0001	0.0013	0.0346	0.8158	0.0001	0.9899	0.5082	0.6251	

Perfect Fore	Coeff.	0.1566	0.4157	– 0.0016	– 0.0004	0.7455	0.0169	– 1.2380	0.0498	0.39
	P-value	0.0001	0.0005	0.0200	0.7937	0.0006	0.8746	0.3049	0.5314	
Rlz Bid 5	Coeff.	0.1773	0.3219	– 0.0011	– 0.0014	0.4907	0.0150	0.1620	0.0212	0.33
	P-value	0.0001	0.0008	0.0482	0.2547	0.0044	0.8624	0.8673	0.7418	
Rlz Ask 5	Coeff.	0.2392	0.2828	– 0.0014	– 0.0034	0.6622	0.0855	– 2.3760	– 0.0439	0.13
	P-value	0.0001	0.2116	0.2837	0.2381	0.1175	0.6800	0.3096	0.7752	
Rlz Bid 30	Coeff.	0.1967	0.3607	– 0.0005	– 0.0030	0.1378	0.0279	– 2.0280	0.0376	0.17
	P-value	0.0001	0.0197	0.6100	0.1277	0.6240	0.8410	0.1975	0.7156	
Rlz Ask 30	Coeff.	0.2705	0.4735	– 0.0013	– 0.0044	0.8047	0.1080	– 3.2130	– 0.1200	0.09
	P-value	0.0001	0.1444	0.4927	0.2906	0.1820	0.7146	0.3361	0.5862	
Panel B: Even quote regressions										
Ev1	Coeff.	0.5691	0.4311	– 0.0061	– 0.0031	0.7870	0.1890	– 4.2590	0.1820	0.42
	P-value	0.0001	0.1094	0.0004	0.3723	0.1077	0.4539	0.1360	0.3326	
Ev2	Coeff.	0.3648	0.3145	– 0.0042	– 0.0018	0.5922	0.1270	– 2.8910	0.1080	0.43
	P-value	0.0001	0.0797	0.0003	0.4300	0.0696	0.4494	0.1282	0.3870	

(from Table 5). The constants in the realized spread regressions are larger than in the other regressions and larger than the mean difference in the matched sample. Consider, for example, the realized spread over a five-minute horizon for transactions initiated at the bid. The constant term in this regression is 14.3 cents, which compares with a difference in the matched sample of 12.6 cents. The large realized spread reflects the fact, discussed earlier, that NASDAQ dealers retain a larger fraction of the spread than NYSE immediacy suppliers. In short, the regression results imply that factors other than the characteristics of the stocks are responsible for differences in execution costs.

The cross-sectional regressions suggest that differences in attributes of the paired samples are not responsible for the difference in execution costs. If other economic variables or other specifications would explain the difference in execution costs, we have been unable to identify them.

9.2. Classifying on beta

We now take a more radical approach. Our initial pairings were based on measures of risk identified by Fama and French (1992) as superior to the beta coefficient. As a check on our findings, we now exclude pairs for which the NASDAQ stock is riskier as measured by its beta. The beta coefficient for each stock is estimated from daily data for 1991. This procedure reduces the number of matched pairs from 175 to 66.

We find that the differences in execution cost for the sample of 66 are close to those reported for the sample of 175, although there is a tendency for the NASDAQ cost to be even larger than before relative to the paired NYSE stock (detailed results may be obtained from the authors).

Cross-sectional regression results in Table 8, panel A, corresponding to those presented in Table 7 for the 175-pair sample, summarize the differences in execution costs for the sample of 66 companies. The constant in these regressions is larger than in the Table 7 regressions, implying that elimination of high-beta NASDAQ stocks increases NASDAQ execution costs relative to the NYSE. The NASDAQ/NYSE difference in execution costs is not due to a failure to account for differences in risk as measured by beta.

10. Odd eighths and even eighths

Christie and Schultz (1994) find that differences in the use of even eighths across their sample of NASDAQ stocks cannot be explained by economic factors, and they conclude that noneconomic factors, that is 'implicit collusion', explain the absence of odd eighths. We examine the use of even eighths for our sample of 66 paired NYSE/NASDAQ firms.

The empirical anomaly identified by Christie and Schultz is that NASDAQ quotes are exclusively in even eighths for a large number of NASDAQ stocks. This necessarily implies that the tick size in these stocks is no less than 25 cents and that spreads are at least 25 cents. The question is whether this is too large. They conclude that the frequency of even eighths is too large primarily on the basis of a within-NASDAQ cross-section regression that relates the frequency of even eighths to economic factors.

Their critics – Kleidon and Willig (1995) and Grossman et al. (1995) – interpret Christie and Schultz to say that the excessive use of even eighths is a measure of overt collusion. They argue that the use of even eighths is not excessive, and that it reflects economic factors. In particular, they argue that the use of even eighths is likely to be large when spreads are large, a point also made by Finn (1994). Spreads, they imply, are large for good reason, although they provide no evidence that spreads are not too large.

Our analysis focuses on whether the use of even eighths by dealers can help explain the NASDAQ/NYSE difference in execution cost. In particular, we ask if the frequency of even-eighth quotes is associated with the difference in spreads once the economic determinants of both variables have been accounted for.

We measure the frequency of even eighths in two ways. The first method, *Ev1*, calculates for each stock the proportion of bid–ask pairs for which both the bid and the ask are at even eighths. The second method, *Ev2* (the method in Christie and Schultz), calculates the proportion of bids and asks that are even. If all quote pairs contained an even ask and an odd bid, *Ev1* would yield 0.0 and *Ev2* would yield 0.5. The mean values of *Ev1* (*Ev2*) are 0.75 (0.84) on NASDAQ and 0.33 (0.57) for the NYSE. Similar to the observation made by Christie and Schultz, our sample also shows that the use of even eighths is much more frequent on NASDAQ than on the NYSE.

Since the frequency of even eighths may depend on the same economic factors that determine spreads, we first regress the paired difference in our even/odd measures against the paired differences in characteristics of the stock used to explain execution cost differences. The regression results are in Table 8, panel B. The dependent variables, *Ev1* and *Ev2*, are the differences in the proportion of quotes at even eighths by the first and second methods, respectively. The independent variables explain 42% and 43%, respectively, of the cross-sectional variation in the even-eighth measures. The most significant explanatory variable is NASDAQ share volume. The higher the NASDAQ volume, the lower is the frequency of even eighths by either measure. This contrasts with the results in Christie and Schultz, who find that NASDAQ volume is an insignificant explanatory variable in predicting stocks that are quoted in odd eighths.

Whether the frequency of even eighths can explain the NASDAQ/NYSE difference in spreads can be inferred from the correlation of the residuals of the *Ev1* and *Ev2* regressions with the residuals from the seven execution cost regressions in Table 8, panel A.[4] These correlations are given in the lower left triangular matrix in Table 9. The correlation of the raw dependent variables are given in the upper right-hand triangular matrix. The last two columns of the upper triangle show that the use of even eighths is highly positively correlated with quoted spreads and other raw measures of execution costs, as expected. In other words, even eighths are more common for stocks with high spreads, as one would expect.

But what about the correlation of the residuals after adjustment for economic determinants of spreads and the frequency of even eighths? The last four rows of the lower triangle show that there is no evidence of significant correlation of residuals from the 'evens' regressions and the residuals from the execution cost regressions. For example, the correlation of the residuals from the *Ev1* regression and the quoted spread regression is 0.0426, which is not significantly different from zero. In other words, once the economic determinants of spreads and of the use of evens are accounted for, no association between the frequency of even eighths and the level of spreads remains. The use of even eighths tells us nothing about the spreads that we cannot learn by looking at the spreads themselves. Spreads may be high in NASDAQ (as the constant in the Table 8 regressions implies), but more frequent use of even eighths is not an explanation of why they are high. The use of even eighths provides no incremental information about the difference in spreads. Therefore, we conclude that the frequency of even eighths cannot explain the difference between NASDAQ and NYSE spreads, once economic determinants of spreads are accounted for.

We test the sensitivity of our conclusions to alternative specifications of the variables. Calculating the return standard deviation from quote midpoints rather than closing prices reduces the R-squared in the regressions, but does not change our conclusions. Taking the natural logarithm of the volume variables improves the R-squares of the regressions, but introduces slight negative correlation between the residuals from the evens and spread regressions.

A look at the remaining correlations shows that excess NASDAQ execution cost measures are correlated before adjustment and after adjustment. This reflects the fact that the various execution cost measures estimate the same thing. Stocks with large excess quoted spreads also have large excess realized spreads, before and after adjustment. Only the use of even eighths is not correlated with the spread once adjusted by the cross-section regressions.

[4]An alternative procedure to our approach that yields equivalent inferences is to estimate multivariate regressions that include *Ev1* or *Ev2* as an explanatory variable.

Table 9
Correlation matrix

The table shows bivariate correlations between differenced variables. The differences are calculated as the NASDAQ variable minus the NYSE variable. The execution cost measures are the quoted half-spread (*Quoted*) defined as half the difference between the quoted ask price and the quoted bid price, the effective half-spread (*Effective*) defined as the absolute difference between the trade price and the quote midpoint existing at the time of the trade, the perfect foresight half-spread (*Perfect Fore*) defined as the absolute price change, and realized half-spreads (*Rlz Bid 5*, *Rlz Ask 5*, *Rlz Bid 30*, *Rlz Ask 30*). *Rlz Bid 5* (*Rlz Ask 5*) is defined as the (negative of the) price change between an initial trade at the bid (ask) and a subsequent trade that is five to ten minutes later. *Rlz Bid 30* and *Rlz Ask 30* are analogously defined for subsequent trades that are 30 to 35 minutes later than the initial trades. *Ev1* is the percentage of quotes that are both even bid and even ask and *Ev2* is the average of the percentage even bid and percentage even ask. The upper triangular matrix shows the bivariate correlations between the unadjusted variables and the lower triangular matrix shows the bivariate correlations between the adjusted variables. The adjustment is made by the regressions reported in Table 8. The numbers below the correlations are *p*-values.

	Quoted	*Effective*	*Perfect Fore*	*Rlz Bid 5*	*Rlz Ask 5*	*Rlz Bid 30*	*Rlz Ask 30*	*Ev1*	*Ev2*
Quoted		0.9926	0.9537	0.7843	0.8390	0.7030	0.7970	0.4003	0.4052
		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0009	0.0007
Effective	0.9879		0.9712	0.8175	0.8304	0.7158	0.7820	0.4267	0.4285
	0.0001		0.0001	0.0001	0.0001	0.0001	0.0001	0.0004	0.0003
Perfect. fore.	0.9309	0.9582		0.8765	0.8336	0.8145	0.7721	0.5002	0.4975
	0.0001	0.0001		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Rlz Bid 5	0.6758	0.7254	0.8187		0.6745	0.7834	0.5914	0.5108	0.5031
	0.0001	0.0001	0.0001		0.0001	0.0001	0.0001	0.0001	0.0001
Rlz Ask 5	0.7603	0.7656	0.7924	0.5890		0.8359	0.9754	0.3592	0.3402
	0.0001	0.0001	0.0001	0.0001		0.0001	0.0001	0.0033	0.0056
Rlz Bid 30	0.6018	0.6315	0.7625	0.7315	0.8261		0.8012	0.4330	0.4130
	0.0001	0.0001	0.0001	0.0001	0.0001		0.0001	0.0003	0.0006
Rlz Ask 30	0.7263	0.7226	0.7250	0.4952	0.9737	0.7782		0.3131	0.2908
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		0.0111	0.0188
Ev1	0.0426	0.0664	0.1473	0.2194	0.0985	0.2092	0.0826		0.9929
	0.7342	0.5961	0.2379	0.0768	0.4348	0.0944	0.5128		0.0001
Ev2	0.0306	0.0491	0.1226	0.1946	0.0627	0.1745	0.0417	0.9872	
	0.8073	0.6957	0.3266	0.1175	0.6199	0.1644	0.7418	0.0001	

11. Structural explanations

Our analysis has failed to uncover economic factors that could explain the large difference in spreads between NASDAQ and the NYSE. We turn now to other possible explanations related to unique institutional arrangements on NASDAQ. Dealer and auction markets differ in a number of important ways that could be the source of the large observed differences in execution costs. After considering intertemporal patterns in NASDAQ spreads, we examine three features: the role of limit orders, commission costs, and the degree of competition in the two structures. We also consider whether the rapid expansion of NASDAQ could explain the increase in spreads.

11.1. Have NASDAQ spreads always been high?

We have so far confined our analysis to 1991 data. However, if institutional features are responsible for the spread differential between the NYSE and NASDAQ, we may be able to identify these characteristics by examining intertemporal data. This is because structural changes tend to occur over time.

Affleck-Graves et al. (1994) find that quoted spreads are the same for a matched sample of NASDAQ and NYSE/ASE stocks in 1985. For 1985, they find a half-spread of about 15.3 cents on NASDAQ and about 16.2 cents on the two exchanges. (We have converted the percentage spreads in Affleck-Graves et al. to dollar spreads on the basis of the average stock price in their sample.) Our results are strikingly different. For 1991, we find a half-spread of 24.6 cents on NASDAQ and 12.9 cents on the NYSE (Table 2). One explanation for the difference is a difference in samples. We believe this to be an unlikely explanation since our sample is likely to contain larger, more actively traded NASDAQ firms than theirs.[5] Another possibility is that spreads have increased over time. Kothare and Laux (1995) examine NASDAQ spreads October of 1984, 1988, and 1992. They report that quoted spreads increased dramatically between 1984 and 1992.

We examine the time trend in the quoted spread for two sets of stocks over the period January 1983 to November 1993. For each month in this time period we select from the *NASDAQ Fact Book* the 50 NASDAQ volume leaders based on share trading volume and the 50 largest firms based on market value of equity. Daily closing inside bid–ask spreads are taken from the CRSP tape and

[5] We start with the 300 largest NASDAQ firms and match against NYSE firms. Affleck-Graves et al. start with 815 NASDAQ firms and match against NYSE and ASE stocks. Our final sample contains 175 firms while theirs contains 399 firms.

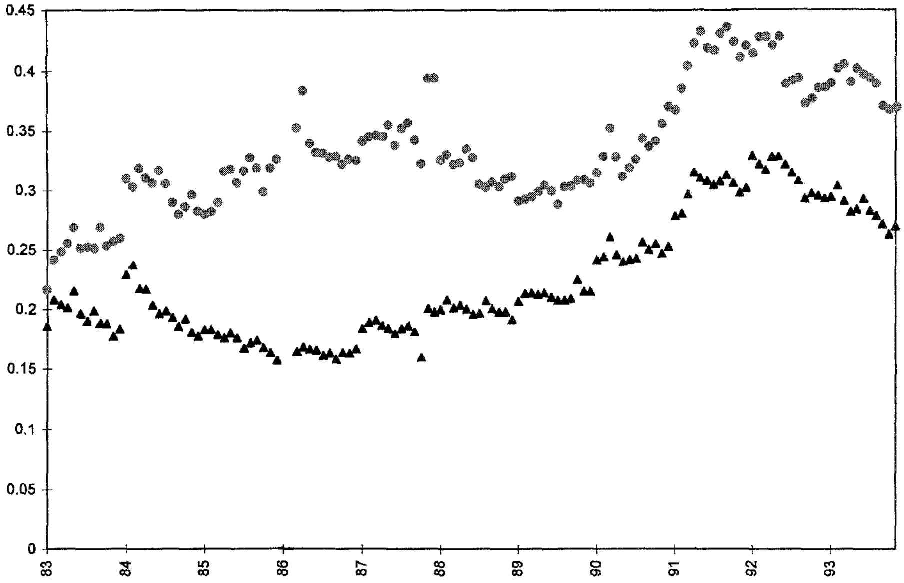

Fig. 1. NASDAQ quoted spreads.

averaged over the month. Because firms could not always be found on CRSP to match the NASDAQ ticker symbol, the final sample ranges from 18 firms to 44 firms for the trading volume group and from 14 to 42 firms for the market value group. Also, no data were available for January and February 1986.

The dollar quoted spread is plotted over time in Fig. 1 for each group of firms. An increase in spreads is evident, particularly in the period December 1989 to December 1991. In 1989, spreads averaged 21.2 cents for the high-volume group (containing 36 stocks in that year) and 30.0 cents for the high-value group (containing 28 stocks in that year). By 1992, spreads on the high-volume group (containing 44 stocks) had risen to an average of 31.2 cents, and spreads on the high-value group (containing 39 stocks) had risen to 40.1 cents. Since 1992, spreads have declined, something also noted by Grossman et al. (1995).

The time trend in Fig. 1 confirms the findings of Kothare and Laux (1995). There has been a clear increase in NASDAQ spreads during a period in which trading technologies have become ever more automated and more efficient. By contrast, Huang and Stoll (1994b) find a slight decline in various measures of NYSE execution costs in the period 1989 to 1991. Using accounting data (FOCUS reports) submitted to the Securities and Exchange Commission, Stoll (1995) confirms these time trends. Between 1988 and 1992, he finds that commissions plus execution costs increased on NASDAQ and decreased on the other exchanges.

We conclude from Fig. 1 and the evidence in Kothare and Laux (1995) that NASDAQ spreads have not always been high. The question is why did they increase? Kothare and Laux conclude that it is due to an increase in institutional trading. We reject that explanation on the basis of our evidence on the effective spread. The effective half-spread on large transactions is 13.5 cents, compared with a quoted half-spread of 24.6 cents on NASDAQ. It is unlikely that institutions would be responsible for an increase in the quoted half-spread to 24.6 cents if they are able to trade with dealers at 13.5 cents. Kothare and Laux also suggest that institutions might be better informed, thereby increasing the danger to dealers of adverse information, but we have rejected this explanation earlier in our analysis of adverse information.

In the period after the crash of 1987, the NASD instituted regulatory changes and imposed new affirmative obligations on NASDAQ dealers. Chief among these was the requirement to trade automatically up to 1,000 shares on a new automated Small Order Execution System (SOES). Over time, SOES 'bandits' increasingly used the SOES system to 'pick off' dealers that failed to adjust quotes promptly. The NASD (1994) has argued that a January 1, 1994 modification of SOES to limit the power of the SOES bandits reduced spreads; by implication, SOES caused the prior increase in spreads. While there is no doubt that SOES obligations imposed new costs on NASDAQ dealers, it is not evident that they are sufficient to explain the large difference in execution costs that we have observed. After all, NYSE specialists also have affirmative obligations. Moreover, SOES trades account for only a small fraction of NASDAQ volume. If SOES bandits imposed significant costs, one should observe lower realized dealer revenues on NASDAQ than on the NYSE, but as we have already noted, the realized spread is significantly larger on NASDAQ than on the NYSE.

11.2. Limit orders

An important structural difference between auction and dealer markets is in the handling of limit orders. On the NYSE, limit orders are exposed directly to incoming market orders and limit order prices are publicly disseminated. Limit orders narrow the quoted spread on the NYSE because they compete with the specialist. One would expect competition among dealers to have the same effect in NASDAQ, but that has not been the case. Limit orders do not compete directly with dealers in NASDAQ. In NASDAQ, where quotes are posted only by dealers, limit orders cannot narrow the spread.

Limit orders may have an additional narrowing effect because they become stale and are not adjusted as market conditions change. For example, a limit order to buy might be placed at 20 when the specialist was quoting 20 bid and

20.50 ask. Suppose new information caused the specialist to lower his quote to 19.825 bid and 20.25 ask. If the limit order did not change in response to the new information, it would be considered stale. The resulting spread would be 20 bid (limit order) and 20.25 ask (specialist). Staleness is related to the free trading option provided by limit orders to the rest of the market. If market conditions change but limit orders are not revised, the limit order is 'picked off'. For example, suppose new information now warrants a bid of 19 and an ask of 19.50. The limit buy order at 20 is very stale. It is immediately picked off at 20. There is no reversal since a lower equilibrium price exists. Consequently, stale limit orders also reduce the average NYSE realized spread. However, the lack of limit order competition on NASDAQ cannot explain the dramatic increase in spreads in the period 1988 to 1991, because the procedure by which limit orders trade did not change in this period. It is only a partial explanation of the difference in spreads in 1991.

11.3. Commissions

Dealer markets and auction markets differ in how they charge for the provision of trading services. Auction markets almost always charge a commission, even to institutional customers, whereas dealer markets often trade 'net', that is, without a commission, particularly when the customer is an institution. If no commission is charged on NASDAQ, revenues from the spread must be greater on NASDAQ than on the NYSE in order to make up the difference. As we noted earlier in our discussion of effective spreads, commissions might explain the difference in effective spreads on large trades, but they are unlikely to explain the difference in the case of small trades. Other execution cost measures such as the realized spread (even for large trades) differ by more than five cents, which weakens the commission explanation. Commissions are at best a partial explanation. Since the practice of trading 'net' has not changed over time, commissions cannot explain the dramatic increase in spreads.

11.4. Demand for trading on NASDAQ

The NASDAQ stock market began in 1971 by automating the 'pink sheets' that were used prior to that time to disseminate quotes in the Over-the-Counter (OTC) market. When firms became large enough, they graduated to the American or New York stock exchanges. NASDAQ did not view itself as a real competitor to the exchanges until the mid-1980s. After the crash of 1987, it began more aggressively to publicize itself, to seek to retain its firms, and to introduce affirmative obligations and other features heretofore reserved for the exchanges. NASDAQ volume grew dramatically in comparison to NYSE volume. Perhaps the price of NASDAQ's trading services increased simply because of demand pressures. While we cannot rule out this explanation for the increase in spreads, we are skeptical. Entry of dealers and competition among dealers should limit any increase in spreads above costs. Wahal (1995) shows there is significant entry by dealers and that entry affects spreads.

11.5. Competition, preferencing, and implicit collusion

Analysts of dealer markets have often concluded that competing dealers will narrow the spread relative to the spread of the monopolistic specialist on the NYSE. However, the specialist is not a monopolist; he faces competition from limit orders, from other traders on the floor, and from other markets. On the other hand, competition among NASDAQ dealers could be restrained by strategic behavior and by a variety of institutional arrangements. Ho and Stoll (1983) show that dealers will use second-best pricing. They will not quote their best price; rather, they will try to quote a price just slightly better than their next competitor. In practice, because the minimum tick size makes it impossible to improve over a competitor's quotes just slightly, the effect of this strategic behavior may be to match the price of other dealers and compete on other dimensions where pricing is more continuous.

Competition is also limited by the practice of internalizing and preferencing customer order flow. Internalization occurs when a broker-dealer trades as a dealer with its own retail customers. Preferencing arrangements exist between dealers and retail firms that are not dealers. Retail firms will preference their customer orders to a particular dealer in return for various services or cash payments known as payment for order flow. In both cases, the dealer promises to execute orders at the best quote of any dealer (the inside quote). If a larger fraction of the retail order flow is internalized or preferenced, which we believe to be the case, there is little incentive for any dealer to narrow the spread. A dealer that narrows the spread does not increase his share of the order flow because the order flow is already internalized or preferenced to specific dealers. Since quotes are publicly disseminated, any such dealer is quickly identified and subjected to the ire of the other dealers who have the order flow and who must pay the better price. We believe that preferencing has increased over time consistent with the increase in spreads depicted in Fig. 1, although we do not have direct evidence on this.

Further influencing competitive incentives on NASDAQ is the presence of alternative quote dissemination and trading systems such as SelectNet and Instinet, a point made by Finn (1994). SelectNet is a service of NASDAQ through which dealers may quote prices different from their public NASDAQ quotes. If they are anxious to sell, they can lower their ask in SelectNet without lowering their ask price in the NASDAQ system. SelectNet was introduced in 1990, the time of the increase in NASDAQ quotes. Instinet is a proprietary trading system independent of NASDAQ that is used by institutions and dealers. Dealers who wish to even out their inventories can trade on these alternative systems rather than offering attractive quotes on NASDAQ. These alternative systems lessen the incentive of dealers to post narrow quotes over NASDAQ. On the other hand, these systems, particularly Instinet, compete with NASDAQ and have the potential to reduce execution costs for investors who have access to them.

Internalization, preferencing, and the existence of alternative dealer quote dissemination systems are likely sources of the wider spreads observed on NASDAQ. These structural arrangements primarily affect retail customers. Institutions are not subject to preferencing to the same degree because they can more easily shop for brokers. They are also able to negotiate trades inside the quotes, and they have access to some alternative quote systems such as Instinet (but not SelectNet). Order flow in NYSE stocks is also preferenced to regional exchanges or NASDAQ dealers such as Madoff Investments, but a large fraction of NYSE order flow still goes to the floor where there is competition from floor traders and, most importantly, from limit orders. Preferencing reduces the incentive to narrow spreads, but there may be other forms of competition that we do not observe. For example, NASDAQ dealers could compete to attract order flow from brokers by offering various services or by paying for order flow. Payment for order flow could allow a retail broker to reduce charges for services rendered to customers.

Christie and Schultz (1994) suggest that implicit collusion exists among NASDAQ market makers. They argue that nothing else can explain the tendency of market makers to trade only on even eighths. Their critics have interpreted this suggestion as a claim that market makers have established a cartel with explicit coordination. More likely, the actions of market makers are explained by preferencing, internalization, and SelectNet, features that simply limit the incentives to compete. It is not so much that market makers implicitly collude as that the system provides no incentive for competition, at least in quotes. Our results are consistent with Christie and Schultz interpreted in this way. We find that NASDAQ spreads are excessive in the sense that they exceed spreads of NYSE stocks by more than we can account for by economic factors.

12. Summary

The cost of executing transactions is higher on NASDAQ than on the NYSE by every measure we calculate. Our empirical findings are based on all transactions during 1991 for a paired sample of 175 stocks. We examine the quoted spread, the effective spread, the realized spread, the Roll implied spread, and the perfect foresight spread. In our matched sample, the quoted spread averages 49.2 cents on NASDAQ and 25.8 cents on the NYSE. The proportional differences for the other measures are at least as great as the difference in the quoted spread. We examine a number of possible explanations for the dramatic differences in execution costs in the two markets:

1. Different stocks. Viewed as whole, the NASDAQ market contains smaller, less actively traded stocks than the NYSE, and transaction costs are expected to be greater for such stocks. We control for these differences by choosing a sample of the largest NASDAQ stocks matched to comparable NYSE companies on industry, stock price, company size, leverage, trading volume, and risk characteristics. Our results are not due to differences in these stock characteristics.

2. Trading inside the quotes. Quoted spreads can be a misleading measure of execution cost since many trades are executed inside the quotes. Therefore, we also compare effective spreads, which are based on trade prices. Effective spreads are significantly larger on NASDAQ than on the NYSE. The frequency of trading inside the quotes is less in NASDAQ for small and medium-sized trades, but greater for large trades. Even for large trades, though, the effective spread is significantly greater on NASDAQ than on the NYSE.

3. Adverse information. NASDAQ market-makers operate in a decentralized market in which it may be difficult to identify the presence of informed traders, whereas the NYSE specialist operates in a centralized market and is usually assumed to be better able to detect the presence of traders with special information. However, our evidence on realized spreads shows that NASDAQ dealers do not suffer from adverse information more so than do NYSE suppliers of immediacy. NASDAQ market makers, in fact, realize a larger fraction of the effective spread than do NYSE suppliers of immediacy. Adverse information thus cannot explain the differences in execution costs.

4. Market depth and inventory costs. The fact that quotes are adjusted less frequently on NASDAQ than on the NYSE suggests that depth and inventory costs are greater on NASDAQ. However, inventory costs are typically small, and institutional considerations preclude differences in depth as an explanation for differences in execution costs.

5. Even eighths. We find that the relative frequency with which stocks are quoted in even eighths is not associated with high spreads once the economic determinants of the variables are considered. The lack of correlation is also observed for other measures of execution cost. The difference in the use of even eighths in the two markets is thus not a source of differences in spreads.

6. Changes in NASDAQ. We confirm the findings of others that NASDAQ spreads increased dramatically in the years 1989 to 1991. An increase in institutional trading and an increase in affirmative obligations, including the requirement to trade automatically 1,000 shares on SOES, have been proposed as explanations for the increase in spreads. We conclude that these changes cannot explain the increase in spreads, nor can they explain the difference in execution costs in 1991 since the NYSE also has considerable institutional trading and affirmative obligations.

7. Limit orders. Limit orders narrow the inside spread on the NYSE because they compete with the specialist. Limit orders cannot compete (until recently) with dealer quotes, and competition among dealers in NASDAQ does not have an equivalent effect. The inability of limit orders to compete with dealers provides a partial explanation for the wider spreads in NASDAQ.

8. Commissions. On NASDAQ, trading is 'net' (without a commission) for institutional customers, while all investors pay commissions on the NYSE. For trades in excess of 10,000 shares, reasonable institutional commissions can explain the difference in the effective spreads (5 cents per share). However, commissions cannot explain differences in execution costs for small investors or for other large trade execution cost measures. Moreover, since the practice of trading 'net' has not changed over time, commissions cannot explain the dramatic increase in NASDAQ spreads in 1989 to 1991.

9. Internalization and preferencing. Internalization occurs when a dealer trades with its own retail customers. Preferencing occurs when order flows are routed to chosen dealers who may not have the best quote but who promise to trade at the inside quote. When a large fraction of the order flow is internalized or preferenced, there is little incentive for any dealer to compete by narrowing the spread because the dealer would not attract much additional order flow. Preferencing also exists on the NYSE, but not to the same degree.

10. Interdealer trading systems. NASDAQ dealers are able to post quotes over an interdealer system (SelectNet) that are different from quotes posted in the public NASDAQ market. The presence of such an alternative system gives dealers a way to adjust inventories and lessens their incentive to offer good quotes in the public market (NASDAQ).

In summary, spreads are too large on NASDAQ because there is little incentive to narrow them. Institutions can negotiate trades inside the spread, but even accounting for that fact, their costs of trading appear to exceed the costs on the NYSE in comparable stocks. Individuals have little negotiating power and face substantially higher execution costs on NASDAQ than on the NYSE. NASDAQ rule changes to give limit orders greater standing will increase the bargaining power of individual investors and help reduce NASDAQ trading costs. Modifications in preferencing rules and other features of the NASDAQ market so as to increase incentives for dealers to compete would undoubtedly reduce measured execution costs. Finally, many of the inefficiencies of the present system are likely to be self-correcting. As we write this, competitors are no doubt plotting how to take advantage of the high spreads on NASDAQ.

Appendix

Table 10
Ticker symbols of 175 matched NASDAQ and NYSE firms

NASDAQ	NYSE	NASDAQ	NYSE	NASDAQ	NYSE	NASDAQ	NYSE	NASDAQ	NYSE
AAPL	CPQ	BSET	LEG	HCCC	AJG	NEBS	EBF	SNPX	DBD
ABIO	MX	CBSS	CYN	HENG	GQ	NGNA	DP	SOCI	FOA
ACAD	SK	CDIC	UVV	HHRD	AW	NOBE	MES	SODA	FLO
ADBE	BID	CHRS	MGR	INEL	MI	NSCO	GRB	SONO	AVY
ADCT	NPK	CLRK	SUP	INGR	CNR	NWNG	PNY	SOTR	ASO
ADDR	ACI	CNTX	HTD	INTC	KYO	OCAS	HSB	SQNT	SRA
ADIA	CDN	COUS	NHP	IRIC	CRX	OCTL	MAG	SRCO	POP
ADVO	LGN	CPER	TIN	KDON	DCI	ORCL	CA	SREG	MNI
AGII	TRH	CSFN	NCC	KEYC	CBC	ORCO	DAN	STRZ	SNV
AGNC	RLC	CTAS	LES	KLAC	WHT	PAYX	CRG	SUBN	UPC
ALDC	ROL	CTEX	CQ	KMAG	BEZ	PCAR	SNS	SUNW	TAN
ALEX	OSG	CYTO	LRI	LANC	WST	PCLB	MST	SVAN	UFC
AMAT	BGG	DBRN	CLE	LLTC	DS	PLTZ	ABP	SYMC	UCO
AMGN	CLX	DEPS	DSL	LNCE	TR	PNTA	SPW	TBCC	ATM
AMSY	ABM	DIGI	LSI	LOTS	OMC	PROT	AVE	TDAT	SBL
AMTR	SBK	DLCH	HRD	LTEK	LAW	PSNC	CTG	TEJS	CV
ANAT	UNM	DMIC	SFA	MANT	DCA	PTCM	CSN	TKOS	V
ANDW	VSH	DOLR	GOT	MCCS	WAG	PVIR	CZM	TLAB	CTS
APBI	SW	DRYR	GVF	MCIC	CWP	QCHM	WOL	TLXN	GGG
APCC	AYD	DYTC	SXI	MDSN	LG	QFCI	WMK	TROW	BEN
APOG	JWP	EGGS	WYL	MEDC	HRC	QNTM	CS	TTRA	MB
ARBR	DXK	ENGY	ION	MEYR	VEN	ROAD	GMT	ULAB	GRG
ARMR	MYL	FAST	SBP	MGMA	IEI	ROUS	CDX	UNIT	JP
ASAI	ABF	FHPC	LFT	MIKL	CHE	RPOW	FOE	USBC	BBI
ASTA	SGI	FISV	FCB	MLHR	LZB	RYAN	TBY	VALU	RJF
BETZ	ACV	FLER	MDP	MNES	LUX	SAFC	LNC	WECO	NJR
BKLY	LC	FULL	HC	MODI	HDI	SANF	RUS	WERN	CAO
BKSO	HIB	GBND	WAL	MOLX	NSI	SCIS	IMD	WETT	MCK
BMET	ACN	GCCO	DY	MORR	PFR	SCRP	CTL	WMTT	PCH
BNTA	HTN	GENZ	STH	MRBK	FVB	SEIC	BQR	WPGI	REY
BOAT	KEY	GIBG	WCS	MRIS	FSR	SGAT	BC	WSGC	ITN
BOBE	LUB	GOAL	TSK	MSFT	AUD	SHLM	NCH	WTHG	ALS
BORL	TSS	GWCC	SJI	MSII	OCC	SIAL	ASN	XLNX	CY
BRAN	REN	GWTI	NGA	NAFC	RYK	SLTI	OCR	XOMA	BCL
BRNO	SFD	HARG	PSG	NDCO	GNR	SNDT	CDI	YELL	CNF

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