

The Impact of Limit Order Handling on the NYSE and Nasdaq Transaction Costs⁺

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The NYSE and Nasdaq stock markets treat limit orders differently before Nasdaq adopted the order handling rule (OHR) in 1997. Most of the studies before OHR, which compare the trading costs between these two markets, do not explicitly take this fact into consideration. As a consequence, the case for possible collusion among the Nasdaq dealers, as suggested by Christie and Schultz (1994), is likely to be overstated. We compare average trading costs on Nasdaq to those on the NYSE only when the specialists trade on their own account. We do not find strong evidence that trading costs on these two markets are significantly different for smaller firms or lower price stocks. In addition, after controlling for economic variables that are likely to affect spread sizes, the differences in spreads between these two markets are no longer significant.

Introduction

Optimal security market design is an important issue for both academics and practitioners. The questions “What constitutes an optimal market design?” and “Which of the existing stock markets is more efficient?” long have been important topics. The desirable characteristics of an ideal market design should include an efficient price discovery process without excessive costs of trade execution and price volatility. There has been great interest in comparing the trading costs between the New York Stock Exchange (NYSE) and Nasdaq markets, and debates have arisen over the size of spreads on Nasdaq. Before Nasdaq adopted the Security Exchange Commission’s (SEC) mandated order handling rule (OHR),¹ most studies find that

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¹ Partially due to academic research findings, the OHR was introduced by the SEC in 1997. These rules are to create a fair and competitive market. Under the new OHR, market makers

average trading costs on the Nasdaq stock market are larger than those on the NYSE stock market.² The debate is why the trading costs are higher on Nasdaq than on the NYSE.³

Much of the interest in this issue is spurred by Christie and Schultz (1994) and Christie, Harris, and Schultz (1994). They show the pattern of quotes for actively traded large firms on the Nasdaq market and find that odd-eighth quotes are virtually nonexistent for most of these firms, even though the minimum tick on Nasdaq is one-eighth of a dollar or less. This implies a spread of at least a quarter dollar for most of Nasdaq quotes. They conclude that the market makers on Nasdaq implicitly collude to maintain wider spreads.

Barclay (1997) shows that spreads become smaller when the stocks for which Nasdaq market makers avoid odd-eighth quotes move from the Nasdaq to the NYSE or Amex stock markets. Barclay supports the conclusion that the avoidance of odd-eighth quotes is used as a coordination device among the Nasdaq market makers to increase bid-ask spreads to above-competitive levels because even-eighth quotes are rounded prices and hence the natural focal points. Bessembinder and Kaufman (1997) compare average trade execution costs during 1994 for stocks listed on the NYSE and Nasdaq markets. They conclude that the average execution costs are greater for trades on the Nasdaq-listed firms compared to matched NYSE-listed firms and the differences in trading costs cannot be attributed to economic factors, such as firm size, return volatility, share price, or trading volume, which will likely affect the trading costs.

Besides the tacit collusion hypothesis asserted by Christie and Schultz for wider spreads on Nasdaq market, numerous other explanations have been proposed. Some argue that due to structural differences between the NYSE and Nasdaq markets, the trading costs are expected to be higher and the spreads are expected to be wider on the Nasdaq market. Huang and Stoll (1996) and Godek (1996) stress the practice of internalization and preferencing of order flow as important factors that limit dealers' incentives to narrow spreads. Internalization means that Nasdaq broker-dealers have no obligation to forward orders to the dealers who post the best quotes. Instead, they can execute the orders against their own account as long as they match the best inside quotes. Preferencing occurs when the retail firms redirect or preference the

reflect in their quote the price of any orders they placed in the private trading systems for institutional investors and broker-dealers, if the price was better than their own public quotation.

² An incomplete list of empirical research on cost comparisons between NYSE and Nasdaq markets before the OHR includes Barclay (1997), Bessembinder (1997), Bessembinder and Kaufman (1997), Chan and Lakonishok (1997), Christie and Huang (1994), Christie and Schultz (1994), and Huang and Stoll (1996).

³ See Barclay (1997) pp. 37-41 and Huang and Stoll (1996) pp. 351-353 for discussions of various proposed explanations for the higher spreads on Nasdaq.

orders to dealers who do not post the best current quotes but have agreed to match the best quotes when receiving the orders. Because of internalization and preferencing, the dealers with the better inside quotes do not necessarily get more order flow and the profits from their existing order flow are reduced. Thus, preferencing limits the incentives for competition among dealers.

Ho and Macris (1985) argue that Nasdaq, being a multiple dealer market, should have greater market depth and wider spreads because the collective ability of dealers to carry inventory to absorb order imbalances is higher on a multiple dealer market, while any single dealer has limited ability to adjust his or her inventory position because he or she faces competition from other dealers who may have smaller inventory positions. Greater market depth comes at a cost. The dealers together bear higher fixed costs and inventory costs; thus, the spreads become wider as the number of dealers increases. Vijh (1990) tests this relationship between market depth and spreads using data from the Chicago Board Options Exchange (CBOE), a multiple dealer market, and the NYSE, a specialist market. He confirms this trade-off between market depth and bid-ask spreads.

Another important structural difference that is largely ignored in empirical testing before OHR is that different procedures are used in handling limit orders between these two markets. As Demsetz (1997) observes, different methods are used by the NYSE and Nasdaq to accommodate limit orders received from investors before OHR. This could be responsible for at least part of the excess spreads on the Nasdaq market. On the NYSE, the best price can be set by either the limit orders from investors or the specialists' quotes. Limit orders have priority over specialists' quotes and can improve the best inside quotes. Although the specialist's limit order book is not public knowledge, limit orders coming to the NYSE from investors constitute the majority of the quotes that are available for public trading.

Until January 1997, limit orders on the Nasdaq market were not exposed to the rest of the market. They were strictly private information for the dealers who received them. Investors could only trade on the best inside quotes posted by the market makers. Investors' limit orders are treated as offers to the market makers and cannot trade before the dealers even when they offer better prices for trade execution. For example, a limit order to buy at 20.5 when the spread is 20 bid and 21 ask will not change the best inside quotes on the Nasdaq market. The incoming market sell orders are still executed at dealer's bid of 20, although the limit order offers a better price for trade execution. The limit order must wait until the dealer's ask reaches the limit price of 20.5.

This structural difference is likely to have a great impact on the sources of spread on these two markets. On the NYSE a large portion of the spreads are calculated from the limit orders submitted by public investors, while on Nasdaq the spreads are calculated exclusively from the inside quotes quoted by dealers. The potential set of market makers on Nasdaq is much smaller than it is on the NYSE. As

argued by Demsetz, this alone (without appeal to Nasdaq collusion) must yield an average NYSE spread that, for similar stocks, is smaller than on Nasdaq. If Nasdaq market makers collude, the spreads they quote, which are for trading on their own account, should be greater than the quotes by the NYSE specialists when they offer to trade on their own account. Most of the existing studies compare the spreads using all the quotes on the NYSE and Nasdaq markets without identifying the NYSE specialists quotes when they offer to trade on their own account. Ignoring this important structural difference will likely overstate the probability of the existence and the economic significance of implicit collusion.

Similar ideas have been adopted in Chung, Van Ness, and Van Ness (2001). Their methodology for identifying specialist quotes is different from our study. Our identification of specialist quotes is obtained directly from the Trade and Quote (TAQ) database and is a more objective algorithm for extracting such quotes. Our results are generally consistent with the previous study and provide further evidence on the possibility of overstating trading costs on Nasdaq before OHR in 1997.

He and Wu (2003) study the differences between the NYSE and Nasdaq spreads before and after OHR reform. They find that although the post-reform (i.e., after OHR is implemented) spreads on Nasdaq are still larger than those on the NYSE, after controlling for information trading, the spreads on Nasdaq and on the NYSE are insignificantly different. That is, information trading can account for a large portion of the differences in spreads between these two markets. This is consistent with our empirical results, which show that after considering the differences in limit order handling and other economic variables, the spreads on the NYSE and Nasdaq are not significantly different, even before OHR is implemented.

In this paper, we separate the NYSE specialists' quotes when they trade on their own account (principal quotes) from the rest of the quotes that come from either the limit orders or specialists when they trade on behalf of their clients. Then, we compare the trading costs between these two markets using only the principal quotes from the NYSE specialists. This comparison will eliminate the confusion that arises from the structural difference in treating limit orders between these two markets and provide a more meaningful way of comparing the spreads on the NYSE and Nasdaq markets. If Nasdaq dealers collude, the trading costs associated with the principal quotes from the NYSE specialists would still be significantly lower than on Nasdaq market. In the absence of collusion, however, we would expect to find little difference in the cost of comparable trades.

The cost of market making is known to be affected by various kinds of economic attributes. These include firm size, stock price, trading volume, and price volatility.⁴ In this paper we first divide the sample into three matched NYSE and

⁴ See Bessembinder (1997), Bessembinder and Kaufman (1997), Demsetz (1968), Huang and Stoll (1996), and Petersen and Fialkowski (1994).

Nasdaq sub-groups according to firm size or stock price. These sub-samples are also similar in terms of return volatility and trading volume. We then measure the trading costs. Average trading cost measures include quoted half spreads and effective half spreads (which account for the trades inside the quoted prices). Quoted spreads are calculated using the difference between bid and ask quotes immediately preceding the trade. Effective spreads are calculated using the difference between the trade price and the mid-point of the preceding quotes. We also calculate the realized half spread, which measures the gross profit of dealers.

When we consider principal trades only for all the firms in the sample, average effective half spreads are 13.3 basis points larger (0.346 percent versus 0.213 percent of trade value) on Nasdaq compared to the NYSE, and the difference is marginally significant at 1 percent level. If we check across firm size and stock price groups, our results show that the trading cost on Nasdaq is not significantly different from that on the NYSE for small firms and low price stocks. For small firms, the effective spreads are 15 basis points higher (0.557 percent versus 0.407 percent) on Nasdaq, but the difference is not statistically significant. For low price stocks, the effective spreads are 9.1 basis points higher (0.493 percent vs. 0.402 percent) on Nasdaq, but not statistically significant. This contrasts with other studies, which generally find a bigger and strongly significant difference in trading costs between these two markets. This finding provides support for the argument that Nasdaq has a comparative advantage in executing trades of smaller firms as proposed by Chan and Lakonishok (1997).

Because the trading costs are likely to be affected by some economic factors other than firm size and stock price, we regress the average trading costs on a set of economic variables. After controlling for these economic factors by a regression framework, we do not find any significant differences in spread sizes between these two markets for all stocks, not only for smaller firms or lower price stocks. We conclude that the trading costs between these two markets are not significantly different.

Measures of Trading Costs

The first measure of trading costs that we use is the quoted half-spread, which measures half of the difference between the quoted bid price and ask price. Because we want to look at the trading costs for a single trade, but the entire difference between bid and ask prices measures a round-trip trading cost, we divide the quoted spread by two. All of the measures of trading costs reported in our study are in percentage terms. The percentage quoted half spread (QS) is calculated as

$$QS_{it} = 100(A_{it} - B_{it}) / (2M_{it}), \quad (1)$$

where A_{it} is the quoted ask price for security i at time t , B_{it} is the quoted bid price for security i at time t , and M_{it} is the mid-point of quoted ask and bid prices.

Quoted half-spreads are likely to be biased estimators of the trading costs because the trades do not always occur at the quoted prices. According to Huang and Stoll (1996), on the NYSE, specialists and traders who receive a market order have the option to better the posted quotes or let the trade take place at the posted quote. If they decide to better the quotes, then the trade occurs inside the quotes. Trade inside the quotes can also happen when a market order hit a hidden limit order quote inside the disseminated quotes. The specialists are required to post representative quotes, not necessarily the best quotes. Thus, limit orders for small quantities that would better the disseminated quotes are often not posted. On Nasdaq, customers trading large amount or institutional investors can often negotiate with the market makers and trade inside the best quotes. As reported by Bessembinder and Kaufman (1997), the percentages of trades inside the quotes are about 25 percent for the NYSE and 27 percent for Nasdaq, which happens often. All these practices make the quoted spread an upward biased measure of trading costs.

To overcome this bias, a second measure of trading costs, the effective half-spread is computed. It measures the difference between the actual trade price and the mid-point of the quoted bid and ask prices and provides a better measure of the actual trading costs. The percentage effective half spread (ES) is calculated as

$$ES_{it} = 100D_{it}(P_{it} - M_{it})/M_{it}, \quad (2)$$

where P_{it} is the transaction price for security i at time t and M_{it} is the mid-point of bid ask prices of the quotes immediately preceding the current transaction. D_{it} is an indicator variable which is -1 if P_{it} is less than M_{it} (a customer sell order) or 1 if P_{it} is greater than M_{it} (a customer buy order). Lee and Ready (1991) note that the trades are often reported with a delay. They recommend use the quotes that are time-stamped at least five seconds preceding the current trades. Hasbrouck, Sofianos, and Sosebee (1993) report a median trade reporting delay of 14 seconds. We use the quotes that are at least 20 seconds prior to the reported trade time, to be conservative.

Glosten and Milgrom (1985) show that the spread includes a component for compensating the dealer's loss to potentially better informed traders. After a customer buy (sell) order, which refers to a trade that occurs at the ask (bid) or between quoted mid point and ask (bid), the asset value tends to increase (decrease). This permanent increase or decrease represents the market's assessment of information conveyed in the trade, i.e., the price impact of a trade. The price impact will not be equal to the entire effective half spread unless all the trades on the market are information motivated. Generally, there would be a price reversal after each trade and the difference between the effective spread and the price impact is the gross profit to dealers or the realized half spread.

To gauge the extent of information trading on both the NYSE and Nasdaq markets, we further decompose the effective half spreads into realized half spread and price impact. Following Huang and Stoll (1994), we measure the price reversal after

trades and market-making revenue net of losses to better informed traders as the realized spread. We use both the transaction prices five minutes and 30 minutes after the current trade as the proxies of stock's post-trade economic value. The price impact (PI) and realized spread (RS) are calculated as

$$PI_{it} = 100D_{it}(P_{it+n} - M_{it})/M_{it} \quad (3)$$

$$RS_{it} = 100D_{it}(P_{it} - P_{it+n})/M_{it} \quad (4)$$

where P_{it+n} is the first trade price at least n minutes (five or 30 minutes) after the trade at time t . Note that the effective half spread is the sum of price impact and realized spread.

Data and Research Methodology

Data Sources

The transaction and quote prices are obtained from TAQ database published by the NYSE. The data used in this study include trade and quote prices for sets of NYSE-listed and Nasdaq-listed stocks from April 3, 1994 to December 31, 1994. Trades and quotes before April 1994 are excluded because trade prices on Nasdaq before April 1994 are rounded to the nearest eighth for reporting purpose, even though the transactions occur at finer prices (see *NASD Subscriber Bulletin*, April 1994).

This will likely upward bias the trading costs on Nasdaq as measured by the effective spreads. It is possible that after April 1994, the Nasdaq spreads may have decreased because the article by Christie and Schultz (1994) was made public. This could be the reason why we cannot find a strong evidence of different trading cost between these two markets. Bessembinder and Kaufman (1997), looking at the same sample period as ours, still report a significant difference of trading cost between the NYSE and Nasdaq using all the quotes in their sample. Thus, it is less likely that our results are driven by a general decrease in Nasdaq spreads after April 1994.

The trades and quotes of NYSE-listed firms used in this study only include those that are principal, i.e., trades and quotes where specialists trade on their own account. The NYSE requires that a member trading for its own account must publicly identify that the order is principal (see *NYSE Constitution and Rules*, ¶2090, Rule 90).⁵

Principal trades that involve the NYSE member firms on both sides of the trade are rare.⁶ This will downward bias the trading costs on the NYSE, because for most

⁵ The TAQ database explicitly records the principal trades with a field called G127. It also indicates if the member firms are on the buy side, sell side, or both sides of the trade. See "*The TAQ Database*," New York Stock Exchange, Inc. Version 3.1, January 1995, pp. 18.

⁶ For all the NYSE-listed firms with data available during April 1994 to December 1997, there are a total of 8,750 principal trades. Of these principal trades, only 51 trades involve specialists on both buy and sell sides of the trade.

of the principal trades, only one side of the trade is represented by the principal interest and the other side of the trade still comes from either public limit orders or specialists trading on behalf of their clients. This bias will not affect the conclusions of our study; even with the downward biased trading costs of the NYSE trades, we still could not find strong evidence that the trading cost on Nasdaq is greater than that on the NYSE.

Besides using the TAQ database, the data for stock price and market capitalization (price times shares outstanding) at the end of 1993 are obtained from the Center for Research in Securities Prices (CRSP) data tapes. We filter a set of trade and quote prices because they are likely to be erroneous or do not reflect the true trading cost that investors will face on the market.⁷ We also exclude the trades and quotes that are time-stamped outside regular NYSE trading hours, 9:30 a.m. to 4:00 p.m.

Sample Selection Procedure

The relation between trading cost and firm characteristics has long been noted in the literature. Demsetz (1968) shows that dollar spreads are related to stock price, trading volume, and number of shareholders. Petersen and Fialkowski (1994) show that although the dollar spreads are unrelated to firm size, the percentage spreads decline with firm size. Small firms do not have smaller dollar spreads but they do have lower price. Therefore, the percentage spreads for small firms are higher. We therefore group firms into three size groups and three price groups to control for the difference of percentage spreads across firm size and stock price.

All of the NYSE-listed firms that have trade and quote data available on the TAQ database on January 1994 are identified. All the trades of these firms from April 1994 to December 1994 are then retrieved from the database. Due to the nature of large trade and quote data and the larger size of NYSE firms, it is difficult to match each of the NYSE firms with a corresponding Nasdaq firm. Thus, only those firms having ten or more principal trades during the sample period are retained. There are 171 firms left after this selection process. Further, only those firms that have market capitalization data available at the end of 1993 on CRSP tapes are used because otherwise the size of the firm is unknown. There are 167 firms with more than ten principal trades and for which market capitalization data are available.

A notable characteristic of these 167 sample firms is their large size. This creates a problem in matching the sample NYSE firms with Nasdaq firms because the

⁷ Following Bessembinder (1997), trades are excluded if they are coded in the TAQ database as out of sequence, involve an error or a correction, represent exchange distribution or exchange acquisition, involve non-standard settlement, involve price changes of 25 percent (since prior trade) or more if the prior trade price is more than \$2. Also, trades that are not preceded by valid same day quotes are omitted. Quotes are also excluded if either bid or ask is non-positive, the difference between ask and bid exceeds \$4 or is non-positive, or if the quotes are associated with trading halts or designated order imbalances or are non-firm.

Nasdaq firms are generally smaller. As of the end of 1993, the largest Nasdaq firm is Intel Corporation with a market capitalization of \$25,900 million while in these 167 sample NYSE firms, there are 19 firms with market capitalization larger than that of Intel. In order to make our matching samples more comparable, we circumvent this problem by excluding those NYSE firms whose market capitalization exceeds \$30,000 million—13 NYSE firms are excluded.⁸

We group the biggest ten Nasdaq firms with those NYSE firms that are at least as large as these ten Nasdaq firms and call this group the large firm sample. There are 55 NYSE firms in this large firm sample. Next, the remaining 99 NYSE firms are divided into two groups. The 49 smallest firms are each matched with one Nasdaq firm with the closest market capitalization. This makes up the small firm sample. The remaining 50 NYSE firms are in the medium firm sample. These medium NYSE firms are still bigger than most of the Nasdaq firms, so we are unable to find a matching Nasdaq firm for each NYSE firms in this medium size group. For the medium Nasdaq sample, we instead include all the Nasdaq firms with market capitalization between the largest medium NYSE firm and the smallest medium NYSE firm. There are a total of 40 Nasdaq firms in this medium firm sample.

The stock prices of these NYSE firms at the end of 1993 are used to calculate the 66.7 percent and 33.3 percent percentiles of stock prices. All the NYSE and Nasdaq firms having price higher than \$49 (the 66.7 percent percentile) are grouped into the high-price sample. Those having price between \$49 and \$29 (the 33.3 percent percentile) are in the medium-price sample. The rest is the low-price sample.

Table 1 reports some descriptive statistics for each firm size group. Because the descriptive statistics for stock price groups are qualitatively similar to those of the firm size groups, we do not report them to save space. Market capitalization is well matched for the small firm sample but not for the big and medium firm samples. The average trading volume is not exactly comparable between these two markets because Nasdaq is a dealer market; therefore, every transaction goes through the dealers and the volume is thus counted twice compared to similar trades on the NYSE. There is no simple and unambiguous adjustment that would make the volume exactly comparable across exchanges. As for the price statistic, it is the best matched characteristic, although the price on the NYSE is generally higher than that on Nasdaq.

Research Methodology

The final sample includes 11.82 million trades and 5.86 million quotes. Because of the large number of observations and the limitations of computing power and storage space, we are unable to group all the trades and quotes together and compute the

⁸ The excluded firms account for 8.9 percent of the available principal trades of these 167 sample firms.

measures of trading costs in a single pass. Instead, we follow the methodology employed by Bessembinder and Kaufman (1997) who use a two-stage computation procedure. In the first stage, we compute averages of trading costs for each firm in each month and record the number of trades or quotes used in each computation. For example, we compute the averages of quoted and effective half-spreads for IBM on April 1994 and also record the number of trades and quotes in calculating these averages. In the second stage, we apply a set of weighted least squares regressions (WLS) of these monthly means on a pair of dummy variables that correspond to the respective listing exchanges. The regression equation is

$$C_{it} = \alpha_{nys} NYSDUM + \alpha_{nas} NASDUM + \varepsilon_{it} \quad (5)$$

where C_{it} is the measure of average trading cost (QS, ES or RS) during month t for firm i . $NYSDUM_i$ is one if firm i is a NYSE-listed firm and zero otherwise. $NASDUM_i$ is one if firm i is a Nasdaq-listed firm and zero otherwise. The weighting variable is the number of observations in calculating each of the first stage averages. The α estimates would be the same as the sample means by exchange that would have been obtained if it had been possible to do the OLS regression of all the individual trades or quotes on the dummy variables in a single stage.

Table 1—Descriptive Statistics for Size-Matched Sample Firms

This table reports the simple averages for each size group. The NYSE firms that have more than ten principal trades, end of 1993 market capitalization data on CRSP, and market capitalization less than 30 billion are identified. The Nasdaq firms with the closest market capitalization are matched to the NYSE firms. Market capitalization is the product of share prices and shares outstanding at the end of 1993 from CRSP tapes. Trading volume is the daily average of the sample during the sample period from April 1994 to December 1994. Share price is the simple average of end of day share price during the sample period

	NYSE	NASDAQ
Panel A: Large Firm Sample		
Number of Firms	55	10
Market Capitalization (\$000)	13,878,080	11,898,508
Trading Volume (Shares per Day)	699,903	2,477,536
Share Price (\$)	52.038	47.850
Panel B: Medium Firm Sample		
Number of Firms	50	40
Market Capitalization (\$000)	3,635,755	2,771,005
Trading Volume (Shares per Day)	425,184	670,046
Share Price (\$)	33.228	35.565
Panel C: Small Firm Sample		
Number of firms	49	49
Market Capitalization (\$000)	892,482	886,489
Trading Volume (Shares per Day)	215,052	209,368
Share Price (\$)	25.887	23.833

Empirical Results

All of the trades used for the NYSE-listed firms are those involving specialists trading on their account. The final number of principal trades used in our study is 6,351.

Quoted Half Spreads

Table 2 reports the quoted spreads for each firm size group or price group and the p-values for assessing the significance of the difference in quoted spreads between the NYSE and Nasdaq markets. Quoted half spreads are generally larger on Nasdaq. For the full sample, the difference between the NYSE and Nasdaq is 0.236 percent, and it is statistically significant. If we inspect the differences across firm size groups, the differences in quoted half spreads become larger while the differences become less significant. The same pattern is also observed across price groups. This contradicts the findings of some other studies, which show that trading cost between these two markets are significantly different. After controlling for the treatment of limit orders across exchanges, the differences in trading costs measured by quoted half spreads become less significant, especially for the smaller size firms and low price stocks. Again, since the trades often take place inside the quoted prices, the quoted half spreads may be upward biased. We compute effective spreads in the next section and find a weaker difference in trading cost across exchanges.

Table 2—Quoted Half Spreads (percent)

Quoted half spreads (QS) are in percentage terms and calculated as $100(\text{ASK}-\text{BID})/2\text{MID}$, where MID is the mid-point of bid and ask of the immediate preceding quote, which is defined as the quote that is at least 20 seconds before the current trade. The reported spreads are simple averages of all the quoted half spreads in each size group or price group during the sample period from April 1994 to December 1994. We employ a two-stage computation procedure. In the first stage, the average of the quoted half spreads for each firm in each month is computed with the number of observations in getting each firm-month average recorded. In the second stage, the grand averages are calculated by a weighted least square regression (WLS) which regresses each firm-month average on two dummy variables indicating market listings. The weighting variable is the number of observations in calculating each of the first stage firm-month average. The WLS equation is:

$$QS_{it} = \alpha_{\text{nys}} \text{NYSEDUM} + \alpha_{\text{nas}} \text{NASDUM} + \varepsilon_{it}$$

	Sample Size		Quoted Half-Spreads			
	NYSE	NASDAQ	NYSE	NASDAQ	Difference	p-value
Panel A: All Firms	6,351	376,956	0.252	0.488	-0.236	0.000
Panel B: Firm Size						
Large	3,991	77,695	0.193	0.284	-0.091	0.001
Medium	1,386	202,351	0.292	0.426	-0.135	0.141
Small	974	96,910	0.434	0.781	-0.346	0.102
Panel C: Stock Price						
High	1,690	137,939	0.165	0.338	-0.173	0.009
Medium	3,455	145,917	0.224	0.491	-0.267	0.000
Low	1,206	93,100	0.451	0.706	-0.255	0.190

Effective Half Spreads and Price Improvement

Table 3 shows the frequency of trades that occur inside the posted quotes. For the full sample as well as each size and price group, the frequency that a trade is bettered is higher on the Nasdaq market. The differences between improvement rates are all statistically significant, except for the high price group. Although the quoted spreads on Nasdaq are generally higher, the probability that a trade is bettered by the dealers is also higher on Nasdaq. Thus, quoted spreads are likely to upward bias the trading costs on Nasdaq more than on the NYSE. This upward bias effect is shown in the effective spread.

Table 3—Improvement Rates

Improvement rates (IMP) are the proportion of trades that are transacted inside the most recent bid and ask quotes, i.e., the percentage of effective spreads less than quoted spreads. The reported improvement rates is the simple average of improvement rates in each size group or price group during the sample period from April 1994 to December 1994. We employ a two-stage computation procedure. In the first stage, the average of the improvement rates for each firm in each month is computed with the number of observations in getting each firm-month average recorded. In the second stage, the grand averages are calculated by a weighted least square regression (WLS) which regresses each firm-month average on two dummy variables indicating market listings. The weighting variable is the number of observations in calculating each of the first stage firm-month average. The WLS equation is:

$$IMP_{it} = \alpha_{nys} NYSDUM_i + \alpha_{nas} NASDUM_i + \varepsilon_{it}$$

Panel A:	NYSE	NASDAQ	Difference	p-value
All Firms	0.236	0.328	-0.093	0.000
Panel B: Firm Size				
Large	0.234	0.316	-0.082	0.000
Medium	0.233	0.331	-0.098	0.002
Small	0.245	0.332	-0.087	0.000
Panel C: Stock Price				
High	0.284	0.330	-0.046	0.103
Medium	0.221	0.331	-0.110	0.000
Low	0.211	0.321	-0.109	0.000

Table 4 reports the average effective spreads for the full sample and each size and price group. For the full sample, the average effective spread on Nasdaq is about 13.3 basis points higher than that on the NYSE and it is marginally significant at 1 percent level. The most interesting results come from the small firm and low price stock sample. After controlling for the different methods in treating limit orders across exchanges, the differences of trading costs for small firm and low price stock as measured by effective spread are not statistically significant. The differences of effective spreads between these two markets for large, medium, and small firms are 5.1, 3.5, and 15 basis points, respectively.

Table 4—Effective Half Spreads (percent)

Effective half spreads (ES) are calculated as $100D(P-MID)/MID$, where P is the transaction price and MID is the immediate mid-point of the quote preceding the trade. D is an indicator variable which is -1 if P is less than M (a customer sell order) or 1 if P is greater than M (a customer buy order). The immediate preceding quote is defined as the quote that is at least 20 seconds before the current trade. The reported spreads are simple averages of all the effective half spreads in each size group or price group during the sample period from April 1994 to December 1994. We employ a two-stage computation procedure. In the first stage, the average of the effective half spreads for each firm in each month is computed with the number of observations in getting each firm-month average recorded. In the second stage, the grand averages are calculated by a weighted least square regression (WLS) which regresses each firm-month average on two dummy variables indicating market listings. The weighting variable is the number of observations in calculating each of the first stage firm-month average. The WLS equation is:

$$ES_{it} = \alpha_{nys} NYSDUM_i + \alpha_{nas} NASDUM_i + \varepsilon_{it}$$

Panel A:	NYSE	NASDAQ	Difference	p-value
All Firms	0.213	0.346	-0.133	0.009
Panel B: Firm Size				
Large	0.147	0.198	-0.051	0.050
Medium	0.266	0.301	-0.035	0.603
Small	0.407	0.557	-0.150	0.356
Panel C: Stock Price				
High	0.156	0.243	-0.088	0.111
Medium	0.175	0.348	-0.173	0.000
Low	0.402	0.493	-0.091	0.539

This result contrasts with previous studies, which mostly conclude that trading costs on Nasdaq are significantly higher than on the NYSE.⁹ For example, Bessembinder and Kaufman (1997) report that the differences of effective spreads between the NYSE and Nasdaq for large, medium, and small firms are 8.1, 45.7, and 53.9 basis points, respectively. The structural difference between the NYSE and Nasdaq in treating limit orders does account for a large portion of the excess trading costs on Nasdaq market. Without controlling for this effect, the conclusion that the Nasdaq dealers implicitly collude to keep the spreads wide is likely to be overstated in probability. Or, if tacit collusion does exist among dealers, its economic significance is also likely to be overstated.

This result also provides support for the argument by Chan and Lakonishok (1997) who argue that the Nasdaq market has a comparative advantage in market making for small firms.

Possible Selection Bias of Principal Trades

The specialists on the NYSE have the obligation to maintain a “fair and orderly” market,¹⁰ which includes maintaining a market presence. The specialists act as

⁹ For example, see Christie and Schultz (1994), Christie and Huang (1994), Bessembinder and Kaufman (1997), Bessembinder (1997), Huang and Stoll (1996), and Barclay (1997).

¹⁰ NYSE Rule 104.10 “Functions of Specialists.”

“liquidity suppliers of last resort” and cannot avoid trading even when no other traders are willing to trade because of severe information asymmetry. Compared to the specialist, the Nasdaq dealers are only required to post firm quotes for the incoming orders, but they can choose not to trade by not providing quotes. Although the trading costs between the NYSE and Nasdaq are less significant after we control for the difference in treating limit orders, the results could be driven by the fact that specialists need to trade even when the market is characterized by a high degree of information asymmetry. Specialists increase the spreads to protect themselves from possible losses due to information trading.

To address this issue, we examine the intraday patterns of principal trades. It has been shown that, on the NYSE, the return volatility, trading frequency, trading volume, and adverse selection component of the spreads exhibit a U-shaped pattern during the day. Jain and Joh (1988) and Wei (1992) show that trading activity, price variability, and the information component of the spread are the highest in the early trading period. Foster and Viswanathan (1993) and Madhavan, Richardson, and Roomans (1997) both document that the adverse selection costs are high in the early trading hours, fall during the middle of the trading day, and increase toward the close of trading.

We divide the normal trading hours on the NYSE (from 9:30 a.m. to 4:00 p.m.) into six trading periods, each having an equal length of 65 minutes. The return volatility (RETV) for each period is the average of standard deviations of period returns of all sample firms on the NYSE during month m of the sample period (April 1994 to December 1994), i.e.,

$$\text{RETV}_{m,t} = \sqrt{\frac{1}{n} \sum_i \left(R_{m,it} - \bar{R}_{m,t} \right)^2} \quad (6)$$

$$\text{RETV}_t = \bar{R}_{m,t} \quad (7)$$

$m = 4$ to 12 , $i = 1$ to n , and $t = 1$ to 6 where m indicates the month of the sample period, n is the number of the NYSE sample firms, t indicates the trading period, and $R_{m,it}$ is the return of firm i in period t of month m .

Table 5 reports the return volatility in each trading period. From Panel A, the return volatility shows a typical U-shaped intraday pattern as found in the literature. Panel B tests if the return volatility is significantly different across periods. The return volatility in the first period is significantly higher than any other subsequent trading period.

To examine if the specialists do trade when the information asymmetry is high, we compute the percentages of trading frequency and trading volume for each period. Table 6 reports the average of monthly percentage trading frequency and percentage trading volume. The trading frequency and trading volume also exhibit an U-shaped pattern for both principal and non-principal trades. It can be seen from

Panel A that, compared to the non-principal trades, the specialists trade more often in the first period, when the return volatility is higher and information asymmetry is more severe. From Panel B, the percentage of trading volume of the specialists in the first period is not higher than that of the non-principal trades. This confirms that, as stated in Mann and Seijas (1991), specialists may be forced to trade during high market information asymmetry but they have discretion of trading with orders of smaller quantity, which are less likely to be motivated by information.

Table 5—Intraday Return Volatility on the NYSE

Panel A reports the intraday return volatility. The normal trading hours on the NYSE (from 9:30 a.m. to 4:00 p.m.) are divided into six trading periods, each having an equal length of 65 minutes. The return volatility (RETV) for each period is the average of standard deviations of period returns of all sample firms on the NYSE during month m of the sample period (April 1994 to December 1994). The return volatility in period t is calculated as:

$$m = 4 \text{ to } 12, i = 1 \text{ to } n, \text{ and } t = 1 \text{ to } 6$$

$$RETV_{m,t} = \sqrt{\frac{1}{n} \sum_i (R_{m,it} - \bar{R}_{m,t})^2}$$

$$RETV_t = \bar{R}_{m,t}$$

where m indicates the month of the sample period, n is the number of the NYSE sample firms, t indicates the trading period, and $R_{m,it}$ is the return of firm i in period t of month m . Panel B presents the differences of period standard deviations from Panel A. The symbol in each cell indicates the sign of the standard deviation of the period in the row minus that of the period in the column. The meaning of the symbols is: +++ indicates significant at 1 percent level. ++ indicates significant at 5 percent level. + indicates not significant at 5 percent level. The same signing convention is used for negative values

Panel A: Average and Standard Deviation of Return Volatility

	Period					
	1	2	3	4	5	6
RETV ($\times 10^{-3}$)	9.73	7.61	6.54	5.77	6.21	7.45
Std. Dev. ($\times 10^{-4}$)	8.21	14.00	9.94	7.86	8.41	5.82

Panel B: Difference of Return Volatility Across Time Periods

	Period				
Period	2	3	4	5	6
1	+++	+++	+++	+++	+++
2		++	+++	+++	+
3			+	+	--
4				-	---
5					---

We further address this issue by investigating the intraday pattern of quoted half spreads and effective half spreads. Table 7 reports the average of monthly percentage quoted half spread and effective half spread for each trade type and trading period group. The quoted half spreads are comparable between principal and non-principal trades and the effective half spreads are generally higher for principal trades. Both the quoted and effective half spreads of principal trades do not show distinct systematic intraday patterns. Thus, we have little evidence that the specialists raise the

quotes substantially when they trade on their own accounts. This finding is consistent with Madhavan and Smidt (1993), who examine specialist trading behavior and find little evidence supporting the notion that specialists act like price-setting monopolists to maximize their profits. This can also be explained by the fact that although the NYSE specialists have the obligation of maintaining an orderly market, they have discretion over how many shares they will trade at a given quote and protect themselves from information trading.

Table 6—Intraday Distribution of Trade Frequency and Volume between Principal and Non-Principal Trades on the NYSE

The normal trading hours on the NYSE (from 9:30 a.m. to 4:00 p.m.) are divided into 6 trading periods, each having an equal length of 65 minutes. Panel A shows the percentage of the number of trades in each time period. The number of trades for principal or non-principal trades in each period is summed over a month and divided by the total number of trades in that month. The sample period is from April 1994 to December 1994, thus we have 9 observations for each trade type-trading period classification. P-values are calculated based on the standard deviation of these 9 observations. Same computation method is used for calculating the percentage of volume in each period presented in Panel B. The percentage of volume is the sum of trading volume in each period during a month over the total trading volume in that period during the same month

Trade Type	Period					
	1	2	3	4	5	6
Panel A: Percentage of Trade Frequency						
Principal	0.282	0.177	0.125	0.114	0.153	0.148
Non-Principal	0.221	0.179	0.144	0.122	0.147	0.186
Difference	0.061	-0.002	-0.019	-0.008	0.006	-0.038
(p-value)	(0.000)	(0.733)	(0.017)	(0.332)	(0.461)	(0.000)
Panel B: Percentage of Trade Volume						
Principal	0.253	0.187	0.138	0.121	0.155	0.146
Non-Principal	0.267	0.175	0.137	0.115	0.136	0.169
Difference	-0.014	0.012	0.001	0.006	0.019	-0.023
(p-value)	(0.106)	(0.169)	(0.976)	(0.459)	(0.030)	(0.007)

Another potential source of selection bias comes from the possible cross-subsidization between the specialists' two separate businesses—brokerage business and dealership business. The specialists act as brokers when executing limit orders and get paid commissions. When the specialists trade on their own account, they expect to unload their positions in later trades and earn the difference between bid and ask prices. It is likely that the specialists are earning minimum profits or even losing money in the brokerage business, so they try to recoup the losses when acting as dealers by widening the spreads.

Information on revenues of the specialists is not routinely available, because most of the specialist firms are closely held and generally do not carry customer accounts. Sofianos (1995) uses the specialist equity trade (SPET) file, which records daily specialist inventory positions, to infer the trading revenues of the specialists as dealers. The files do not have enough information to infer the specialists' brokerage

revenues. The only study that we are aware of, which compares brokerage and dealership revenues is Stoll (1985), who uses SEC's quarterly survey of specialists¹¹ data to estimate the specialist's revenue as broker and as dealer. He concludes that per share brokerage revenues are about one half of per share dealer revenues. Because specialists participate in a minimal amount of trades on the NYSE, if the specialists do lose money as brokers, it is unlikely that they would be able to make up the losses with the dealer revenues that are only twice as large as brokerage revenues. The higher dealership revenues more likely serve as compensation to the specialist for bearing extra risk and managing inventories.

Table 7—Intraday Distribution of Spreads between Principal and Non-Principal Trades on the NYSE

In Panel A, Quoted half spreads (QS) are calculated as $100(\text{ASK}-\text{BID})/2\text{MID}$, where MID is the mid-point of bid and ask of the immediate preceding quote, which is defined as the quote that is at least 20 seconds before the current trade. In Panel B, Effective half spreads (ES) are calculated as $100D(P-\text{MID})/\text{MID}$, where P is the transaction price and D is an indicator variable which is -1 if P is less than M (a customer sell order) or 1 if P is greater than M (a customer buy order). The reported spreads are simple averages of all the spreads in each size group or price group during the sample period from April 1994 to December 1994. We employ a two-stage computation procedure. In the first stage, the average of the quoted half spreads or effective half spreads for each firm in each month is computed with the number of observations in getting each firm-month average recorded. In the second stage, the grand averages are calculated by a weighted least square regression (WLS) which regresses each firm-month observation on 8 dummy variables, 2 of them indicating trade types and 6 of them indicating trading periods. The weighting variable is the number of observations in calculating each of the first stage firm-month average. The WLS equation is:

$$C_{it} = \alpha_{pn} \text{PRIDUM} + \alpha_{npr} \text{NPRIDUM} + \sum_t \beta_t \text{IND}_t$$

where C_{it} is either QS or ES. PRIDUM and NPRIDUM are indicator variables for trade types and IND_t is indicator variable for trading period

Trade Type	Period					
	1	2	3	4	5	6
Panel A: Quoted Half Spread						
Principal	0.256	0.258	0.254	0.240	0.235	0.262
Non-Principal	0.258	0.243	0.241	0.239	0.236	0.236
Difference	-0.002	0.015	0.013	0.001	-0.001	0.026
(p-value)	(0.960)	(0.740)	(0.814)	(0.970)	(0.975)	(0.617)
Panel B: Effective Half Spread						
Principal	0.211	0.204	0.21	0.203	0.22	0.209
Non-Principal	0.197	0.194	0.196	0.195	0.194	0.194
Difference	0.015	0.01	0.014	0.008	0.026	0.015
(p-value)	(0.663)	(0.682)	(0.667)	(0.792)	(0.575)	(0.660)

¹¹ SEC's quarterly survey of specialists released summary data for the specialists trading revenues from 1975 to 1980 and was discontinued in 1981.

Realized Spreads

The realized spread represents the gross profit to the dealers or specialists. We use both the first trade prices five and 30 minutes after the current trade as proxies for asset's economic value to compute the realized spreads. Because the qualitative results of these two criteria are similar, we only report the results using 30 minutes classification in Table 8. The results show that the realized spreads are higher on Nasdaq for all the firms and also each size and price group. This means that the Nasdaq dealers on average earn higher gross profit, or the price impact of a trade on Nasdaq is less than that on the NYSE. Higher realized spreads on Nasdaq do not necessarily mean that dealers earn excessive profits compared to the NYSE specialists.

Table 8—Realized Spread (percent) - 30 Minutes Classification

Realized spreads (RS) are calculated as $100D_i(P_i - P_{i+30})/MID_i$, where P_i is the transaction price and MID_i is the immediate mid-point of the quote preceding the trade. D_i is an indicator variable which is -1 if P_i is less than M_i (a customer sell order) or 1 if P_i is greater than M_i (a customer buy order). The immediate preceding quote is defined as the quote that is at least 20 seconds before the current trade. P_{i+30} is the transaction price that is at least 30 minutes after the current trade. The reported spreads are simple averages of all the realized spreads in each size group or price group during the sample period from April 1994 to December 1994. We employ a two-stage computation procedure. In the first stage, the average of the realized spreads for each firm in each month is computed with the number of observations in getting each firm-month average recorded. In the second stage, the grand averages are calculated by a weighted least square regression (WLS) which regresses each firm-month average on two dummy variables indicating market listings. The weighting variable is the number of observations in calculating each of the first stage firm-month average. The WLS equation is:

$$RS_{it} = \alpha_{nys} NYSDUM_i + \alpha_{nas} NASDUM_i + \varepsilon_{it}$$

Panel A:	NYSE	NASDAQ	Difference	p-value
All Firms	0.058	0.165	-0.108	0.383
Panel B: Firm Size Classifications				
Large	0.063	0.115	-0.052	0.573
Medium	0.050	0.155	-0.106	0.691
Small	0.046	0.306	-0.260	0.438
Panel C: Price Classifications				
High	0.012	0.093	-0.080	0.609
Medium	0.071	0.164	-0.094	0.505
Low	0.084	0.273	-0.189	0.547

As pointed out earlier, it could possibly be explained by the fact that Nasdaq is a multiple dealer market and the dealers collectively bear higher fixed costs as well as opportunity costs such as dealers' time. A multiple dealer market may provide greater market depth at the expense of wider spreads. A casual inspection of our data set reveals that the number of quote revisions on Nasdaq is only about one tenth of the number of trades, while these two numbers are about the same on the NYSE.

Assessing the Effects of Economic Variables on Costs of Market Making

It is well documented that the costs of market making vary across firms with different economic attributes. A partial list of these attributes includes market capitalization, trading volume, stock price, return volatility, and trade size. In the calculation of quoted and effective half spreads, we only control for two of these variables, namely, market capitalization and stock price. But even so, the market capitalization and stock price are likely to vary greatly within each group. In this section, we assess the effects of these economic variables on trading costs by expanding the weighted least squares regression in equation (1) to include several economic variables. These variables include 1) end of 1993 market capitalization (in billions of dollars), 2) the inverse of the average daily price for each firm by month,¹² 3) the standard deviation of daily return for each firm by month, 4) the average daily trading volume for each firm by month (in millions of shares). We include dummy variables for exchange listing and allow the slopes of the economic variables for the different exchanges to differ.

The regression results are presented in Panel A of Table 9. Note that the p-values are for the differences between slopes. All the differences between regression coefficients, except for the inverse price of quoted half spreads, are not significant at conventional levels, which means a firm will have similar trading costs on either the NYSE or Nasdaq market and the difference in trading costs across the exchanges will not be significantly different. To confirm this, we establish a firm with the economic attributes similar to an average NYSE medium firm and a firm with the economic attributes similar to an average Nasdaq medium firm and compare the effective spreads of these two firms across exchanges using the regression obtained in Panel A of Table 9.

Specifically, the average NYSE medium firm (Firm 1) has a market capitalization of \$3.636 billion, a price of \$33.228, a return standard deviation of 0.020, and a daily trading volume of 0.425 million shares. The average medium Nasdaq firm (Firm 2) has a market capitalization of \$2.771 billion, a price of \$35.565, a return standard deviation of 0.023, and a daily trading volume of 0.670 million shares. The differences of trading costs of these two firms across exchanges are reported in Panel B of Table 9. The predicted effective spreads of both Firm 1 and Firm 2 on either the NYSE or Nasdaq markets are not significantly different. The conclusion by Barclay (1997) that the spreads of firms decrease when they move from the NYSE to Nasdaq may be partially due to the different ways of treating limit orders on these two markets.

¹² We use the inverse of the stock prices because other studies have documented that inverse prices provide better fits in spread regressions. For example, see Harris (1994).

Table 9—Effects of Economic Variables on Measures of Trading Cost

Panel A reports the regression coefficients of quoted spreads (QS) and effective spreads (ES) on several economic variables. Firm size is the end of 1993 market capitalization in billions of dollars from CRSP 1995 tapes. Inverse price is the inverse of daily average price for each firm by month during the sample period. Return standard deviation is the simple average of daily return standard deviation for each firm by month during the sample period from April 1994 to December 1994. Trading volume is the simple average of daily trading volume for each firm by month during the sample period. The p-values are for the difference between the NYSE and Nasdaq coefficients. Panel B reports cross exchange comparisons of trading costs between typical NYSE and Nasdaq firms. The average NYSE medium firm (Firm 1) has a market capitalization of \$3.636 billion, a price of \$33.228, a return standard deviation of 0.020, and a daily trading volume of 0.425 million shares. The average medium Nasdaq firm (Firm 2) has a market capitalization of \$2.771 billion, a price of \$35.565, a return standard deviation of 0.023, and a daily trading volume of 0.670 million shares. Predicted effective spreads are calculated using the regression of average effective spreads on the economic variables in Panel A

Panel A: Regression of Trading Costs on Economic Variables

	Intercept		Firm Size		Inverse Price		Return SD		Trade Volume	
	NYSE	NASD	NYSE	NASD	NYSE	NASD	NYSE	NASD	NYSE	NASD
QS (%)	0.051	0.111	-0.001	0.004	6.829	11.269	0.340	2.842	-0.007	-0.091
(p)		(0.591)		(0.412)		(0.020)		(0.389)		(0.295)
ES (%)	0.041	0.080	-0.004	0.004	5.465	7.879	-0.357	2.249	0.070	-0.070
(p)		(0.676)		(0.163)		(0.132)		(0.285)		(0.038)

Panel B: Cross Exchange Comparisons of Trading Costs

	Firm 1 (Typical NYSE Firm)			
	NYSE	NASDAQ	Difference	p-value
Predicted ES (%)	0.263	0.345	-0.082	0.265
	Firm 2 (Typical Nasdaq Firm)			
	NYSE	NASDAQ	Difference	p-value
Predicted ES (%)	0.264	0.315	-0.051	0.531

Summary and Conclusions

Studies that compare the trading costs across the NYSE and Nasdaq markets before OHR generally ignore an important structural difference between these two markets: namely, the way that limit orders are handled in these two markets. The NYSE, being an auction market, has potentially more heterogeneous market makers compared to the Nasdaq market. This should account for at least part of the wider spreads on the Nasdaq market. We test this hypothesis empirically by comparing the trading costs between these two markets using only the trades on the NYSE when the specialists trade on their own account. This controls for the difference in handling limit orders. The strongly significant differences in trading costs between these two markets reported by other studies diminish considerably after we control for this structural difference. We do not find evidence of excessive spreads on the Nasdaq market.

The wider spread on the Nasdaq market is more likely due to the differences in market structures. Different procedure in treating limit orders is not the only structural difference between these two markets. Preferencing and internalization also

decrease dealers' incentives to compete with each other and contribute to the wider spreads we observed on the Nasdaq markets. Controlling for the difference in treating limit orders, the significance of the difference in spreads is reduced. The conclusion of this paper is not that collusion is absent from the Nasdaq. Instead, our results support those of Demsetz (1997) who argues that the evidence that has been given to demonstrate the presence of collusion exaggerates the probability of collusion and, if collusion is present, also exaggerates the fraction of the excess spreads of Nasdaq over the NYSE that results from the collusion.

Since January 1997, Nasdaq started to take several steps to comply with new SEC-mandated order handling rules. All Nasdaq companies have been phased in under the new SEC order handling rules as of 10/13/97. Limit orders are now displayed to all market participants when more favorably priced than the best current quotes. Market orders may be executed at prices previously only available to financial professionals trading on proprietary systems. These changes will make the spreads on the NYSE and Nasdaq markets more comparable. A recent study conducted by Nasdaq shows that the percentage quoted spreads decreased 34.3 percent and the percentage effective spreads decreased 15.4 percent after the introduction of the new SEC rules.¹³ This further confirms the impact of limit order trading on transaction costs.

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