Tick Size, Order Handling Rules, and Trading Costs

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We show that the effect of the tick-size change on NASDAQ spreads depends critically on the Order Handling Rules (OHR). Our empirical results show that the tick-size reduction has no impact on the spread of NASDAQ issues that were not subject to the new OHR, but has a significant effect on the spread of NASDAQ issues that were subject to the OHR. These results indicate that smaller tick sizes are valuable in reducing market friction only if market makers compete on price with public traders. Our results are in line with the finding of prior studies that execution costs are lower in auction markets than in pure dealer markets.

In this study, we examine how market structure moderates the effect of the minimum price variation on execution costs. Our study is in the same spirit of a recent study by Huang and Stoll (2001) who show that the need for and effect of the minimum price variation rule are a function of market structure. The New York Stock Exchange (NYSE) is an auction market in which both the specialists and public traders (through their limit orders) establish prices. In contrast, until 1997 NASDAQ was a quote-driven dealer market in which dealers established prices. However, with the implementation of the new Order Handling Rules (OHR) in 1997, NASDAQ has become more of an order-driven auction market like the NYSE.

Prior studies (see Huang and Stoll, 1996; Barclay, 1997; Chung, Van Ness, and Van Ness, 2001; and Huang and Stoll, 2001) show that traders incur greater execution costs in dealer markets than in auction markets. Heidle and Huang (2002) show that the probability of encountering an informed trader is higher in dealer markets than in auction markets. Whether one market structure is better than the other is an important concern to regulators as well as traders. It is also of considerable interest to corporate managers, because the location of their stock listings can affect investor trading costs, required returns, and thus the cost of capital. Prior studies show that stock returns are significantly and positively related to the bid-ask spread (see Amihud and Mendelson, 1986, 1989; Amihud, Mendelson, and Lauterbach, 1997; Amihud, 2002; and Easley, Hvidkjaer, and O'Hara, 2002).

Tick size and order handling rules are two important protocols of securities markets that affect trading costs and market quality. Tick size affects market quality because it limits the prices that traders can quote and thus restricts price competition. Order handling rules affect market quality because they determine the nature and degree of competition among market participants in the price discovery process. In this study, we show how tick size and order handling rules affect execution costs on NASDAQ.

On June 2, 1997, the minimum price variation (i.e., tick size) on NASDAQ was reduced from $1/

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8 to $1/16 for stocks selling at prices greater than or equal to $10. In addition, the Securities and Exchange Commission (SEC) enacted major changes in the OHR on NASDAQ from January 20, 1997 through October 13, 1997. The new rules allow greater competition between liquidity providers (dealers and public traders) in the quote-setting process. The close timing of these two changes provides an excellent opportunity to analyze the complementary nature of their effects on market quality.

Although prior studies (see, e.g., Barclay, Christie, Harris, Kandel, and Schultz, 1999 and Bessembinder, 2000) examine the effects of changes in the OHR or tick size on NASDAQ spreads, whether these effects are interdependent has not been well understood. In this paper, we show that the effect of the tick-size change on NASDAQ spreads depends critically on the OHR. We show that changes in tick sizes exerted a significant impact on NASDAQ spreads only after the implementation of the new OHR. This finding is important, because it underscores the fact that smaller tick sizes are valuable in reducing market friction (Stoll, 2000) only if market makers compete on price with public traders for order flow.

Ahn, Cao, and Choe (1996) examine the change in liquidity when the Amex reduced the minimum price variation. They find that the bid-ask spread declined after the tick-size reduction. Bacidore (1997), Porter and Weaver (1997), Ahn, Cao, and Choe (1998), and Griffiths, Smith, Turnbull, and White (1998) examine the impact of the tick-size change on liquidity for stocks listed on the Toronto Stock Exchange (TSE) and show that the spread declined after the tick-size reduction. Bollen and Whaley (1998) and Goldstein and Kavajecz (2000) find similar results for NYSE-listed stocks.

Harris (1994, 1997) holds that the effect of tick size on execution costs is likely to be significant only in markets with a price-time priority rule. Harris conjectures that the tick-size change will have a significant effect on NASDAQ spreads only if market makers compete with public traders. Although previous studies show that the tick-size change has a significant effect on spreads in hybrid (e.g., NYSE and Amex) or purely order-driven (e.g., TSE) markets, its effect on the spread of NASDAQ issues has not been well documented. In this study, we perform empirical analysis of the effect of the tick-size change on NASDAQ spreads.

Simaan, Weaver, and Whitcomb (1998) analyze the quotation behavior of NASDAQ dealers after the tick-size change. However, their main focus is whether NASDAQ dealers continue to avoid odd ticks after the tick-size reduction. Bessembinder (2000) shows that quoted and effective spreads on NASDAQ are two to four cents less when stocks trade below $10 per share with a smaller tick size. Bessembinder finds that the largest spread reductions occur for stocks whose market makers avoid odd-eighth quotes. Van Ness, Van Ness, and Pruitt (2000) examine the effect of tick size on volume, volatility, and execution costs for both NYSE and NASDAQ issues.

Weston (2000) analyzes the effect of the new OHR on the execution costs of NASDAQ issues. His study finds that changes in inventory and information costs cannot explain the post-reform decrease in NASDAQ spreads. In addition, he provides evidence that the rule change led to a significant reduction in the difference between NYSE and NASDAQ spreads. However, the main thrust of Weston's study was to examine how the new OHR affected competition among liquidity providers on NASDAQ.

In our study, we examine whether the effect of the tick-size change on NASDAQ spreads differs between NASDAQ issues that were subject to the new OHR before and after the introduction of the new tick size. Because the new OHR allows limit order traders on NASDAQ to become direct participants in the quote-setting process (i.e., the rule requires the display of customer limit orders and thereby, allows limit orders to compete with dealer quotes), the results of the present study shed further light on the role of limit order traders in price

discovery and the difference in execution costs between auction and dealer markets.[1]

Our empirical results show that for both NASDAQ stocks and a control sample of NYSE stocks, the tick-size reduction led to narrower spreads. When we separate our NASDAQ stocks into two groups according to whether a stock was subject to the new OHR before or after the tick-size change, we find that the tick-size reduction has a significant impact on the spread of NASDAQ issues that were subject to the new OHR before the tick-size change. However, for the group of NASDAQ issues that were not subject to the OHR at the time of the tick-size change, we find no evidence of spread changes. Our empirical results suggest that together, the new OHR and the smaller tick size narrow spreads on NASDAQ and that execution costs are smaller in auction markets than in dealer markets.

The article is organized as follows. In Section I, we discuss the likely effects of the tick-size change on the bid-ask spread of NASDAQ stocks. Section II explains our data and methodology. Section III presents our empirical findings. Section IV provides a brief summary and concluding remarks.

I. Price-Time Priority Rule, Tick Size, and Execution Costs

One of the important protocols of exchange markets is the price-time priority rule. The price priority rule ensures that buyers who are willing to pay the highest price will be the first to buy and sellers who are willing to sell at the lowest price will be the first to sell. The time priority rule assures that the first order placed will be executed first among those orders submitted with the same bid (or ask) price. The price-time priority rule promotes competition among liquidity providers and thereby lowers trading costs.

A reduction in the minimum price variation is likely to decrease execution costs in markets with a price-time priority rule, such as the NYSE.[2] The minimum price variation limits the prices that traders can quote and thus restricts price competition-traders cannot improve the best bid or offer when the spread is equal to the minimum price variation.[3] Because the minimum price variation is less likely to be a binding constraint on absolute spreads when tick size is small, we can expect the spread to decrease when there is a reduction in tick size.

NASDAQ does not generally enforce the time priority rule among dealer quotes. The time priority rule is enforced only among dealer quotes for dealers who participate in the Small Order Execution System (SOES). Harris (1997) holds that a smaller tick size will narrow spreads on NASDAQ only if traders compete on price to obtain order flow. Prior to the 1997 NASDAQ OHR changes, only a few dealers competed on price because they did not face competition from public traders (because their limit orders were not displayed). A dealer who improves price does not attract larger order flows because all other dealers will match the price for their clients. Brokers route most retail orders to dealers according to prearranged preferencing

[1]See Chung, Van Ness, and Van Ness (1999, 2001) and Kavajecz (1999) for the discussion of the role of limit order traders in the quote-setting process.

[2]On the NYSE, Rule 2072 requires that the time priority rule be strictly enforced for the first public bid (or offer) at a given price. The NYSE enforces price priority and uses a combination of order size and order placement time to determine priority for limit orders that are tied on price. Price and time priority rules are not enforced, however, across the markets that trade NYSE-listed stocks. For example, limit orders left with Boston, Pacific, or Cincinnati Exchanges do not have time priority over limit orders left with the NYSE. In the present study, we exclude off-NYSE quotes from the study sample.

[3]Harris (1994) suggests that the negative correlation between the percentage spread and share price reported in previous studies can be explained by the fact that price level determines the percentage spreads of low-price stocks for which the minimum price variation is a binding constraint on absolute spreads.

agreements. Hence, for NASDAQ stocks, we expect that a reduction in tick size will have a significant effect on spreads only after the implementation of the new OHR, which requires the display of public limit orders.

Based on these considerations, we predict that a reduction in tick size will narrow the spreads of NASDAQ stocks that were subject to the new OHR before the tick-size change. For NASDAQ stocks that were not subject to the new OHR at the time of the tick-size change, we predict that the effect of the tick-size change on spreads will be insignificant.

II. Data Source and Sample Selection

We obtain our data from the NYSE's Trade and Quote (TAQ) database. Although our main purpose is to examine the effect of the tick-size change on the spread of NASDAQ stocks, we include a control group of NYSE stocks in the study sample to help ensure that our results are not solely driven by the attributes of our NASDAQ study sample.

We use trade and quote data during 30 trading days before and after the dates on which the tick size changed from \$1/8 to \$1/16 on NASDAQ (June 2, 1997) and the NYSE (June 24, 1997). Since the tick-size reduction on NASDAQ applies only to stocks that have a bid price of \$10 or more, we exclude NASDAQ and NYSE stocks that had a bid price of less than \$10 at least once during the study period. We also restrict our NASDAQ sample to only those stocks with four-letter ticker symbols. This sample selection procedure gives us a sample of 2,073 NASDAQ stocks and 2,242 NYSE stocks.

To check whether our results are sensitive to different sample selection methods, we obtain a sample of NASDAQ and NYSE stocks with at least 300 trades during the study period. This second sample comprises 1,641 NASDAQ stocks and 2,150 NYSE stocks.

We exclude off-NYSE quotes for our NYSE stocks. We also exclude the following trades and quotes to minimize data errors: 1) quotes if either the bid or ask price is non-positive; 2) quotes if either the bid size or the ask size is non-positive; 3) quotes if the bid-ask spread is greater than \$5 or negative; 4) trades and quotes that are out of time sequence, involve an error, or involve a correction; 5) quotes associated with trading halts or designated order imbalance; 6) before-the-open and after-the-close trades and quotes; 7) trades whose price or volume is non-positive; 8) trade price, p_t, if $|(p_t - p_{t-1})/p_{t-1}| > 0.1$; and 9) ask quote, a_t, if $|(a_t - a_{t-1})/a_{t-1}| > 0.1$ and bid quote, b_t, if $|(b_t - b_{t-1})/b_{t-1}| > 0.1$.

The effect of the tick-size change on spreads could vary with stock attributes. For example, the spread of low-price stocks is more likely to be affected by the tick-size change than is the spread of high-price stocks, because the minimum price variation is more likely to be a binding constraint on absolute spreads for low-price stocks. For the same reason, the spread of high-volume stocks could be more affected by the tick-size change than is the spread of low-volume stocks. Hence, we obtain the control sample of NYSE stocks that are similar in share price, number of trades, trade size, return volatility, and firm size to our sample of NASDAQ stocks.

We measure share price by the average daily closing price, and return volatility by the standard deviation of daily returns during 30 trading days before the tick-size change. We measure trade size by the average dollar transaction size during the same period.[4] We measure

[4]We note that although NASDAQ uses the same volume counting rules as the NYSE, the reported number of trades on NASDAQ is not directly comparable to that on the NYSE, because there are many inter-dealer trades on NASDAQ. Because the recommended adjustment factor for NASDAQ volume that will neutralize the effect of interdealer trades is about 30 to 50% (see, e.g., Atkins and Dyl, 1997), we replicate our matching procedure after we multiply NYSE volume by 1.4. However, the results from the new matching sample do not change our main results in any significant manner.

firm size by the market value of equity on May 31, 1997.

To obtain the control sample of NYSE stocks, we first calculate the following composite match score (CMS) for each NASDAQ stock against each of 2,242 NYSE stocks in our sample:

$$CMS = \Sigma[(Y_k^N - Y_k^Y)/\{(Y_k^N + Y_k^Y)/2\}]^2, \quad (1)$$

where Y_k represents one of the five stock attributes, the superscripts, N and Y, refer to NASDAQ and NYSE, respectively; and Σ denotes the summation over $k = 1$ to 5.

Then, for each NASDAQ stock, we select the NYSE stock with the lowest score. Once we match a NYSE stock with a NASDAQ issue, we no longer consider that particular NYSE stock for subsequent matches. This procedure results in 518 pairs of NASDAQ and NYSE stocks with similar attributes.[5]

We report descriptive statistics of the variables in Table I. The average share price of our sample of NASDAQ stocks is $24.98 and the corresponding figure for our control sample is $24.89. The average daily number of transaction and trade size for the NASDAQ sample are 50.66 and $38,946, respectively, and the corresponding figures for the control sample are 48.55 and $40,312. The mean values of the standard deviation of daily returns for our NASDAQ and NYSE stocks are 0.0231 and 0.0215, respectively. The average market values of equity for our NASDAQ and NYSE firms are $656.2 millions and $691.6 millions, respectively. The results of a t-test show that the mean values of these stock attributes are not significantly different between our NASDAQ and NYSE study samples.

III. Effects of the Tick-Size Change on Spreads

In this section, we measure the effect of the tick-size change on spreads and examine whether the effect is a function of the OHR.

A. Tick Size and Spreads

We use three measures of trading costs in this study: the quoted dollar spread, quoted percentage spread, and effective spread.[6] The quoted dollar spread is the difference between the posted ask and bid prices. The quoted percentage spread is obtained by dividing the quoted dollar spread by the quote midpoint. We calculate the effective spread using the following formula:

$$\text{Effective Spread}_{it} = 2D_{it}(P_{it} - M_{it}), \quad (2)$$

where P_{it} is the transaction price for security i at time t, M_{it} is the midpoint of the most recently posted bid and ask quotes for security i, and D_{it} is a binary variable which equals +1 for customer buy orders and -1 for customer sell orders. We estimate D_{it} using the algorithm in Lee and Ready (1991). The effective spread measures the actual execution cost paid by the trader.

Table II shows the average time-weighted dollar and percentage spreads and the average

[5]We find that differences in one or more stock attributes between NASDAQ and NYSE stocks become considerable when the CMS exceeds three. Hence, to ensure the quality of our matching sample, we include only those pairs (518 pairs) with a CMS of less than three in our study sample.

[6]A large number of quote updates for NYSE-listed stocks originate from off the NYSE. As Blume and Goldstein (1997) show, however, quotes that originate from off the NYSE are only occasionally better NYSE quotes. Hence, we use only NYSE quotes in our study.

Table I. Descriptive Statistics for 518 NASDAQ Stocks and the Control Sample of NYSE Stocks

To obtain the control sample of NYSE stocks, we first calculate the composite match score (CMS) for each NASDAQ stock against each of 2,242 NYSE stocks in our sample: $CMS = \Sigma[(Y_k^N - Y_k^Y)/\{(Y_k^N + Y_k^Y)/2\}]^2$ where Y_k represents one of the five stock attributes; superscripts N and Y refer to NASDAQ and NYSE, respectively; and Σ denotes the summation over $k = 1$ to 5. Then, for each NASDAQ stock, we select the NYSE stock with the lowest score. Once we match a NYSE stock on a NASDAQ issue, we no longer consider the NYSE stock for subsequent matches. This procedure results in 518 pairs of NASDAQ and NYSE stocks that are reasonably similar in their attributes. We measure share price by the average daily closing price and return volatility by the standard deviation of daily returns during 30 trading days before the tick-size change. We measure trade size by the average dollar transaction size. We measure firm size by the market value of equity (in $millions) on May 31, 1997.

				Percentile				
Variable	**Exchange**	**Mean (*t*-value[a])**	**Std. Dev.**	**5**	**25**	**50**	**75**	**95**
Share Price ($)	NASDAQ	24.98 (0.13)	11.69	12.28	16.33	21.96	31.02	46.10
	NYSE	24.89	13.11	11.23	15.95	20.91	30.39	54.04
Number of Trades	NASDAQ	50.66 (0.64)	108.42	3.80	10.43	23.73	51.07	186.90
	NYSE	48.55	92.46	3.70	10.57	22.57	51.30	158.73
Trade Size ($)	NASDAQ	38,946 (-1.07)	24,635	11,917	20,709	32,756	51,251	86,941
	NYSE	40,312	34,933	11,396	19,958	32,688	54,155	108,011
Return Volatility	NASDAQ	0.0231 (1.62)	0.0131	0.0110	0.0154	0.0203	0.0273	0.0432
	NYSE	0.0215	0.0144	0.0081	0.0137	0.0182	0.0248	0.0404
Market Value of Equity	NASDAQ	656.2 (-0.94)	979.8	53.8	139.8	321.6	702.8	1,997.8
	NYSE	691.6	1,196.0	52.3	141.3	327.6	734.7	2,441.6

[a]Indicates the *t*-statistic testing the equality of the mean between NASDAQ and NYSE stocks.

trade-weighted effective spread for our NASDAQ stocks and the control sample of NYSE stocks. Spreads are equally weighted across stocks. The dollar, percentage, and effective spreads during the post-tick-size-change period are all smaller than those during the pre-tick-size-change period for both NASDAQ stocks and the control sample. NASDAQ stocks experience an average 4.1% decline in the dollar spread, but NYSE stocks experience an 8.8% decline. Similarly, NASDAQ stocks experience an 11.2% decline in the percentage spread, but the corresponding figure for NYSE stocks is 15.5%.[7] NASDAQ stocks experience a 6% decline in the effective spread, but the control stocks experience a 15.8% decline. When we replicate this analysis using only those stocks that have at least 300 trades during the study period, the results (see Panel B) are qualitatively similar.

These results indicate that the tick-size reduction led to narrower spreads for both NYSE and NASDAQ stocks, although the magnitude of decline for NASDAQ stocks was smaller than the corresponding figure for NYSE stocks.

To the extent that spreads are correlated with the attributes of underlying stocks, it is

[7]These figures are smaller than the prediction (30%) made in Harris (1994). The observed discrepancy may be due to the differences in stock attributes between Harris' and our study sample of stocks.

Table II. The Effects of the Tick-Size Change on the Spreads of NASDAQ Stocks and the Control Sample of NYSE Stocks

We use three measures of trading costs: the quoted dollar spread, quoted percentage spread, and effective spread. The quoted dollar spread is the difference between the posted ask and bid prices. We obtain the quoted percentage spread by dividing the quoted dollar spread by the quote midpoint. We calculate the effective spread using the formula: Effective spread$_{it}$ = 2D$_{it}$(P$_{it}$ - M$_{it}$) where P$_{it}$ is the transaction price for security i at time t, M$_{it}$ is the midpoint of the most recently posted bid and ask quotes for security i, and D$_{it}$ is a binary variable which equals +1 for customer buy orders and -1 for customer sell orders. The effective spread measures the actual execution cost paid by the trader. This table shows the average time-weighted dollar and percentage spreads and the average trade-weighted effective spread during the pre- and post-tick-size-change periods.

	NASDAQ Stocks				Control Sample of NYSE Stocks			
	Before the Change	After the Change	Difference (Before-After)	t-value[a]	Before the Change	After the Change	Difference (Before-After)	t-value[a]
Panel A. Results From the Whole Study Sample (N = 518)								
$ Spread	0.4855	0.4655	0.0200***	3.26	0.2102	0.1918	0.0184***	3.62
% Spread	0.0215	0.0191	0.0024***	3.34	0.0097	0.0082	0.0015***	6.01
E. Spread	0.4072	0.3829	0.0243***	2.94	0.1784	0.1502	0.0282***	5.68
Panel B. Results From Stocks with at Least 300 Trades (N = 480)								
$ Spread	0.4589	0.4333	0.0256***	3.43	0.1997	0.1786	0.0211***	5.38
% Spread	0.0203	0.0178	0.0025***	3.78	0.0093	0.0077	0.0016***	6.45
E. Spread	0.3888	0.3640	0.0248***	3.17	0.1699	0.1420	0.0279***	8.89

***Significant at the 0.01 level.

[a]Indicates the *t*-statistic testing the equality of the mean between the pre- and post-tick-size-change periods.
N denotes the number of matching stocks.

possible that the observed changes in the spread may be due to changes in the stock attributes between the two periods, rather than to the change in tick size per se. To measure the effect of the tick-size change on the spread after controlling for concurrent changes in the stock attributes, we estimate the following regression model:

$$\text{Spread}^{pre} - \text{Spread}^{post} = \alpha_0 + \Sigma\alpha_i (X_i^{pre} - X_i^{post}) + \varepsilon; \quad (3)$$

where superscripts "pre" and "post" denote, respectively, the pre- and post-tick-size-change values of the variables; X$_i$ (i = 1 to 5) represents one of the five stock attributes in Table I; Σ denotes the summation over i = 1 to 5; αs are the regression coefficients; and ε is the error term. We find that the estimates of α_0 are all significantly different from zero and are similar to the observed spread differences between the two periods we see in Table II. These results suggest that most of the observed decline in spread is due to the change in tick size, not due to any concurrent changes in the stock attributes.

We note that our NASDAQ sample consists of two very distinct groups of stocks, stocks that were subject to the new OHR before the tick-size change and stocks that were subject to the rules after the tick-size change. In the next section, we perform empirical analysis of whether the observed changes in NASDAQ spreads are driven by only the first group of stocks.

B. Order Handling Rules and the Effect of the Tick-Size Change on NASDAQ Spreads

The SEC enacted major changes in the OHR on NASDAQ in 1997. The first rule, known as the "Limit Order Display Rule," was phased-in for all NASDAQ National Market System issues between January 20, 1997 and October 13, 1997. The rule requires that limit orders be displayed in the NASDAQ BBO (i.e., best bid and offer) when they are better than quotes posted by market makers.

This new rule allows the general public to compete directly with NASDAQ market makers in the quote-setting process. Although NASDAQ dealers are subject to the Manning Rule (MR), which prohibits dealers from trading ahead of a customer at the same price, the rule alone does not require limit order transparency.[8] Together, the OHR and the MR substantially increase market transparency and ensure that market orders interact with standing limit orders to a degree unprecedented on NASDAQ.

The second SEC rule, known as the "Quote Rule," requires market makers to publicly display their most competitive quotes. This rule allows the public access to superior quotes posted by market makers in Electronic Communication Networks (ECNs). Under the new rule, if a dealer places a limit order into Instinet or another ECN, the price and quantity are incorporated in the ECN quote displayed on NASDAQ.[9]

NASDAQ does not have a Central Limit Order Book (CLOB). Limit orders placed with dealers might have to be displayed in the quotes due to the OHR, but these limit orders do not necessarily have time priority over other limit orders posted with a different dealer at the same price. Thus, NASDAQ is a market in which the better prices get posted across many dealers, but it is a market without a strict time priority. Nevertheless, under the new OHR NASDAQ more closely resembles the system under which NYSE-listed stocks are traded.

Harris (1997) predicts that NASDAQ spreads will narrow with a smaller tick size if public limit orders have sufficient precedence to compete effectively with dealers. Since our NASDAQ sample includes stocks that were subject to the new OHR both before and after the tick-size change, the observed effect of tick size on NASDAQ spreads may have been driven by those stocks that were subject to the rules before the tick-size change.

To examine whether the impact of tick size on NASDAQ spreads differs according to whether or not dealers were subject to competition from public limit orders, we compare the effect of the tick-size change on spreads between NASDAQ stocks that were subject to the new OHR before the tick-size reduction (hereafter, the OHR stocks) and NASDAQ stocks that were not subject to the new OHR at the time of the tick-size reduction (hereafter, the non-OHR stocks).

Since our study period covers 30 trading days before and after the event date (June 2, 1997), we select the first group of NASDAQ stocks from the first four batches of 50 stocks that were subject to the new OHR from January 20, February 10, February 24, and April 21,

[8]The Manning Rule prohibits a member firm from trading ahead of a customer order. A member cannot buy (sell) at a price that is the same or lower (higher) than a customer buy (sell) order held by the member unless it contemporaneously executes the limit order. Manning I, approved by the SEC on June 29, 1994, instituted the limit order protection described above for non-NASD member limit orders. Manning II, approved on May 19, 1995, extended the protection to limit orders placed by NASD member customers (e.g., a market maker holding a limit order placed by another broker-dealer).

[9]Another feature of the OHR changes involves an amendment in the "Excess Spread Rule (ESR)." Prior to January 20, 1997, the ESR required NASDAQ dealers to maintain their spreads within 125% of the average of the three narrowest spreads for each stock. The amended ESR requires that each dealer's average spread during each month be smaller than 150% of the average of the three narrowest spreads over the month. The new ESR defines compliance on a monthly basis rather than continuously and therefore poses less restriction on dealers' ability to change their spreads. See Barclay et al. (1999) for a detailed description of these rules.

and the second group from those NASDAQ stocks that were subject to the new rules after July 15. Thus, our study sample excludes ten batches (April 28, May 5, May 12, May 19, May 27, June 2, June 9, June 23, June 30, and July 7) of 50 stocks that were subject to the new OHR during the 30 days before and after the change in tick size.

We obtain a control sample of NYSE stocks for the OHR stocks using the same procedure described in Section II (i.e., we use 83 pairs of NASDAQ and NYSE stocks with a CMS of less than three). Likewise, we obtain a control sample of NYSE stocks for the non-OHR stocks (i.e., we use 388 pairs of NASDAQ and NYSE stocks with a CMS of less than three).

Panel A of Table III shows that the average dollar spreads during the pre- and post-tick-size-change periods are \$0.3209 and \$0.2808, respectively, for the OHR stocks. When we replicate the analysis using the percentage and effective spreads, we also find smaller spreads after the tick-size change. The results of t-test indicate that the changes in spreads are all statistically significant. When we limit our study sample to stocks with at least 300 trades, the results are identical to those based on the whole sample.[10]

Overall, our empirical results are consistent with Harris' (1997) conjecture that the tick-size reduction will narrow spreads for NASDAQ issues if public limit orders compete with dealer quotes in the quote-setting process. NASDAQ dealers are more likely to improve prices with a smaller tick size because the Limit Order Display Rule subjects them to competition from limit order traders.

We note that the 1997 market reform involves other rule changes, and therefore the observed effect of the tick-size change on spreads may reflect the effects of other rule changes. However, our empirical measures cannot separate out these different effects.

Table III shows the effect of the tick-size change on spreads for the non-OHR stocks. We find that the tick-size reduction has only marginal and insignificant effects on the dollar, percentage, and effective spreads. We note that in all cases, the changes in spreads are not statistically significant.

Overall, our empirical result indicates that the smaller tick size did not narrow spreads on NASDAQ prior to the implementation of the new OHR. This result is consistent with Harris' (1997) prediction that the tick-size reduction will probably not affect the spreads of stocks traded in a dealer market where a dealer faces no competition from public traders.

Panel B of Table III shows the results from the control sample of NYSE stocks. The results show that both groups of NYSE stocks experienced a significant reduction in spreads. Because our control sample of NYSE stocks (with attributes similar to those of the NASDAQ sample) experienced a significant decline in spreads, the lack of a significant change in spreads for the non-OHR stocks is not likely to be due to their attributes.

Although our results suggest that the tick-size change on NASDAQ affected only those stocks subject to the new OHR, it is possible that our results are due to the difference in the pre-tick-size-change spread between the OHR stocks and the non-OHR stocks. For example, if the old tick size were a binding constraint for the OHR stocks but not for the non-OHR stocks, the smaller tick size would lead to narrower spreads only for the OHR stocks. To examine this issue, we perform a matching sample comparison of spreads between the two groups of NASDAQ stocks.

To obtain matching samples of NASDAQ stocks, we calculate the composite match score (CMS) for each NASDAQ stock that was subject to the new OHR before the tick-size change against each of 1,525 NASDAQ issues that were subject to the new OHR after the tick-size change. Then, for each stock from the first group, we select the stock from the second group

[10]The results are available from the authors upon request.

Table III. Comparisons of NASDAQ Spreads Between Stocks That Were Subject to the New Order Handling Rules (OHR) Before and After the Tick-Size Change

To examine whether the impact of the tick-size reduction on NASDAQ spreads differs according to whether or not dealers were subject to competition from public limit orders, we compare spread changes between stocks that were subject to the new order handling rules (OHR) before and after the tick-size change. We obtain the control sample of 83 NYSE stocks for NASDAQ stocks that were subject to the OHR at the time of the tick-size reduction. We obtain the control sample of 388 NYSE stocks for NASDAQ stocks that were subject to the OHR only after the tick-size change. We show the mean spread during the pre- and post-tick-size-change periods, respectively, and the difference between the two periods.

Panel A. Results From the NASDAQ Study Sample

	NASDAQ Stocks Subject to the New OHR Before the Tick-Size Change (the OHR Stocks)				NASDAQ Stocks Subject to the New OHR After the Tick-Size Change (the Non-OHR Stocks)			
	Before the Change	After the Change	Difference (Before-After)	t-value[a]	Before the Change	After the Change	Difference (Before-After)	t-value[a]
$ Spread	0.3209	0.2808	0.0401***	3.46	0.5373	0.5548	-0.0075	-0.37
% Spread	0.0106	0.0086	0.0020***	3.49	0.0256	0.0247	0.0009	1.36
E. Spread	0.2895	0.2519	0.0376***	3.08	0.4457	0.4410	0.0047	0.31
Panel B. Results From the Control Sample of NYSE Stocks								
$ Spread	0.1828	0.1506	0.0322***	3.79	0.2172	0.2022	0.0150***	3.65
% Spread	0.0067	0.0053	0.0014***	3.34	0.0108	0.0093	0.0015***	5.35
E. Spread	0.1598	0.1248	0.0350***	4.89	0.1839	0.1584	0.0255***	5.44

***Significant at the 0.01 level.

[a]Indicates the *t*-statistic testing the equality of the mean between the pre- and post-tick-size-change periods.

that has the lowest score. This procedure results in 77 pairs of NASDAQ stocks. To ensure the quality of our matching sample, we include in our study sample only those 77 pairs with a CMS of less than three.

We show the results in Table IV. We note that for the OHR stocks, the reduction in tick size has a significant effect on all three measures of execution cost, but we find no such effect for the non-OHR stocks. We obtain similar results (not reported) from stocks with at least 300 trades during the study period. On the whole, these results suggest that the different effects of tick size on spreads shown in Table III cannot be attributed to the difference in spreads between the two NASDAQ samples before the tick-size change.

Table IV shows the proportions of even-eighth quotes among all eighths during the pre- and post-tick-size-change periods for both groups of NASDAQ stocks. Our results show that the average proportion of even-eighth quotes for the non-OHR stocks is significantly higher than the corresponding figure for the OHR stocks during both periods. (The *t*-values for testing the equality of the mean between the two groups are 8.49 and 11.47, respectively, during the pre- and post-tick-size-change periods.) These results support the view that NASDAQ dealers have less incentive to compete on price before the implementation of the new OHR. The table also shows that although the proportions of even-eighth quotes decline significantly after the tick-size reduction for the OHR stocks, such is not the case for the non-OHR stocks. These results are consistent with our earlier finding that the tick-size reduction led to smaller spreads only for the OHR stocks.

Table IV. Matching Sample Comparisons of NASDAQ Spreads Between Stocks That Were Subject to the New Order Handling Rules (OHR) Before and After the Tick-Size Change

To examine whether the impact of the tick-size reduction on NASDAQ spreads differs according to whether or not dealers were subject to competition from public limit orders, we replicate Table III using NASDAQ stocks that were subject to the new OHR before the tick-size reduction and their matching NASDAQ stocks that were subject to the new OHR after the tick-size reduction. To obtain matching samples of NASDAQ stocks, we calculate the composite match score (CMS) for each NASDAQ stock that was subject to the new OHR before the tick-size change against each of 1,525 NASDAQ issues that were subject to the new OHR after the tick-size change. Then, for each stock from the first group, we select the stock from the second group that has the lowest score. This procedure results in 77 pairs of NASDAQ stocks. We show the mean spread during the pre-and post-tick-size-change periods, respectively, and the difference between the two periods.

	NASDAQ Stocks Subject to the New OHR Before the Tick-Size Change (the OHR Stocks)				NASDAQ Stocks Subject to the New OHR After the Tick-Size Change (the Non-OHR Stocks)			
	Before the Change	After the Change	Difference (Before-After)	t-value[a]	Before the Change	After the Change	Difference (Before-After)	t-value[a]
$ Spread	0.2956	0.2626	0.0330***	2.98	0.4856	0.4794	0.0062	0.08
% Spread	0.0126	0.0101	0.0025***	3.20	0.0184	0.0164	0.0020	1.81
E. Spread	0.2670	0.2373	0.0297***	3.21	0.4083	0.3864	0.0219	0.42
Prop. of Even-Eighth Quotes	0.5903	0.5111	0.0792***	5.35	0.6974	0.6717	0.0257	1.21

***Significant at the 0.01 level.

[a]Indicates the *t*-statistic testing the equality of the mean between the pre- and post-tick-size-change periods.

C. Robustness Test

To examine whether the observed differences in the effect of the tick-size change on spreads between the OHR stocks and non-OHR stocks are due to differences in stock attributes between the two groups rather than the OHR *per se,* we estimate the following regression model using the pooled sample of the OHR and non-OHR stocks:

$$\text{Spread}^{pre}_i - \text{Spread}^{post}_i = \alpha_0 + \Sigma\alpha_k X^k_i + \alpha_6 \text{DOHR}_i + \varepsilon_i; \quad (4)$$

where Spread^{pre}_i (Spread^{post}_i) is the spread of stock i before (after) the tick size reduction; X^k_i (k = 1 through 5) denotes the five stock attributes (share price, number of trades, trade size, return volatility, and market capitalization); Σ denotes the summation over k = 1 through 5; and DOHR is a dummy variable that equals one for the OHR stocks and zero otherwise.

If the differences in the spread change between the OHR and non-OHR samples reported in Table III and Table IV are due to differential attributes between the two samples, we would expect α_6 to be insignificantly different from zero. On the other hand, α_6 would be significant and positive if the observed differences are due to the OHR.

Table V presents the regression results. Panel A shows the regression results from the two groups of NASDAQ stocks that we used to produce the results in Table III and Panel B

Table V. Effect of the Order Handling Rule and Stock Attributes on the Spread Change

This table reports the results of the following regression model:

$$\Delta\text{Spread}_i \text{ (i.e., } \text{Spread}^{pre}_i - \text{Spread}^{post}_i) = \alpha_0 + \Sigma\alpha_k X^k_i + \alpha_6 \text{DOHR}_i + \varepsilon_i;$$

where Spread^{pre}_i (Spread^{post}_i) is the spread of stock i before (after) the tick size reduction; X^k_i (k = 1 through 5) denotes the five stock attributes (PRICE_i, NTRADE_i, TSIZE_i, VOLA_i, and MVE_i); Σ denotes the summation over k = 1 through 5; and DOHR_i is a dummy variable that equals one for the OHR stocks and zero otherwise. PRICE_i is the mean daily closing price, NTRADE_i is the average daily number of transactions, TSIZE_i is the average dollar transaction size, VOLA_i is the standard deviation of daily returns, and MVE_i is the market value of equity. We use the pooled sample of the OHR and non-OHR stocks in the regression. Numbers in parentheses are the *t*-statistics.

Panel A. Results from Non-Matching Sample of the OHR and Non-OHR Stocks

	Intercept	PRICE	NTRADE	TSIZE	VOLA	MVE	DOHR	F-value	Adj. R^2
Δ$ Spread	0.0711	-0.0176	-0.0107	-0.0053	0.0635***	0.0248	0.0205***	7.37***	0.075
	(0.60)	(-0.97)	(-1.45)	(-0.47)	(4.79)	(1.77)	(4.13)		
Δ% Spread	0.0031	-0.0025**	-0.0009	0.0006	0.0034***	0.0013**	0.0005***	8.40***	0.087
	(0.61)	(-2.20)	(-1.75)	(1.17)	(6.00)	(2.38)	(3.86)		
ΔE. Spread	0.0794	0.0086	-0.0113	0.0052	0.0636***	0.0101	0.0241***	6.86***	0.069
	(0.72)	(0.51)	(-1.65)	(0.50)	(5.17)	(1.22)	(3.94)		

Panel B. Results from Matching Sample of the OHR and Non-OHR Stocks

Δ$ Spread	-0.0168	0.0114	0.0005	0.0168	0.0050	-0.0133	0.0301***	3.18***	0.079
	(-0.10)	(0.45)	(0.05)	(0.82)	(0.25)	(-1.08)	(5.57)		
Δ% Spread	0.0002	-0.0021	-0.0005	0.0008	0.0012	0.0005	0.0007***	4.13***	0.109
	(0.04)	(-1.54)	(-1.68)	(1.16)	(1.66)	(1.33)	(4.97)		
ΔE. Spread	0.1811	0.0321	-0.0131	-0.0148	0.0234	0.0024	0.0314***	3.76***	0.098
	(1.76)	(1.04)	(-1.18)	(-1.17)	(1.68)	(0.32)	(5.39)		

***Significant at the 0.01 level.
**Significant at the 0.05 level.

shows the results from the matching samples of NASDAQ stocks that we used to produce the results in Table IV. In both panels, we find that the estimated coefficients for DOHR are all positive and significant at the 1% level. Therefore, we conclude that the observed differences in the spread change between the OHR and non-OHR groups shown in Table III and Table IV are not driven by the difference in stock attributes between the two groups.

D. The Actual Size Rule and the Effect of the Tick-Size Change on NASDAQ Spreads

The 50 stocks that became subject to the Order Handling Rules on January 20, 1997 also came under the Actual Size Rule (ASR). The ASR removed the regulatory minimum sizes for proprietary quotes in these stocks. All stocks that came under the Order Handling Rules during subsequent stages of the phased-in schedule remained subject to the regulatory minimum sizes.

If the stocks that were subject to the ASR (the ASR stocks) show a larger reduction in spreads than do the other OHR stocks (the non-ASR stocks), the difference in spread changes between the OHR and non-OHR stocks might be explained, at least in part, by the ASR. If the ASR stocks exhibit a significant reduction in spreads but the non-ASR stocks exhibit no change in spreads at all, the difference in spread changes between the OHR and non-OHR stocks could be attributed entirely to the ASR rather than the Limit Order Display Rule.

Table VI compares the observed changes in spreads between the ASR stocks and the non-ASR stocks. Panel A shows the results from the OHR stocks that we used in Table III. Panel B shows the results from the entire sample of the first four batches of 50 stocks that were subject to the new OHR. In both panels, we find that the mean reductions in the dollar, percentage, and effective spreads for the ASR stocks are not statistically different from the corresponding figures for the non-ASR stocks. Therefore, we conclude that the difference in spread changes between the OHR and non-OHR stocks cannot be attributed to the Actual Size Rule.

IV. Concluding Remarks

Prior studies show that the cost of equity capital is positively and significantly related to the bid-ask spread. The evidence also indicates that, all else equal, stocks traded in auction markets have smaller spreads than do stocks traded in dealer markets. These results have an important implication for corporate managers, because exchange-listing decisions can affect the cost of capital for their companies. With the implementation of the new order handling rules in 1997, NASDAQ moved from a dealer market to an auction market.

We examine the effect of the tick-size change on the spreads of NASDAQ issues. Although the effect of tick size on the liquidity of stocks traded in purely order-driven or hybrid markets has been well documented, the corresponding effect in dealer markets without a price-time priority rule has received relatively little attention. Researchers conjecture that the impact of the tick-size change on NASDAQ spreads will be insignificant before the OHR change, but there is no direct evidence available on this issue.

Our empirical results indicate that the smaller tick size narrows spreads on both the NYSE and NASDAQ. When we separate NASDAQ stocks into two groups according to whether the tick-size change preceded or followed the order handling rules change, we find that the tick-size change has no impact on the spread of stocks for which the tick-size change preceded the order handling rules change. These results suggest that NASDAQ dealers did not compete

Table VI. Comparisons of NASDAQ Spreads Between the OHR Stocks That Were Subject to the Actual Size Rule (ASR) and the OHR Stocks That Were Not Subject to the Actual Size Rule (Non-ASR)

To examine whether the impact of the tick-size reduction on NASDAQ spreads for OHR stocks differs according to whether or not the OHR stocks were subject to the Actual Size Rule (ASR), we calculate spread differences between the pre and post tick size change periods using the OHR stocks that were and were not subject to the ASR. We show the spread difference between the pre- and post-tick-size-change periods for the ASR and non-ASR stocks. Panel A shows the results from the OHR stocks that we used in Table III and Panel B shows the results from the entire sample of the first four batches of 50 stocks that were subject to the new OHR.

	OHR Stocks Subject to the Actual Size Rule (ASR Stocks)	OHR Stocks Not Subject to the Actual Size Rule (Non-ASR Stocks)	
	Spread Difference (Before-After)	Spread Difference (Before-After)	*t*-value[a]
Panel A. Results from the OHR Stocks Used in Table III			
$ Spread	0.0395	0.0412	-0.46
% Spread	0.0019	0.0021	-0.88
E.Spread	0.0366	0.0387	-0.29
Panel B. Results from the First Four Batches of 50 Stocks Subject to the OHR			
$ Spread	0.0299	0.0306	-0.38
% Spread	0.0017	0.0019	-0.79
E.Spread	0.0310	0.0329	-0.35

[a]Indicates the *t*-statistic testing the equality of the mean between the ASR and the non-ASR stocks.

on price for order flow prior to the order handling rules change. This finding is not surprising, because NASDAQ dealers had little incentive to do so without a time priority rule.

For the group of NASDAQ issues that were subject to the new order handling rules prior to the tick-size change, we find that the tick-size reduction has a significant effect on spreads. This result suggests that the new OHR effectively subjects NASDAQ dealers to competition from limit order traders and thereby forces them to offer competitive quotes. On the whole, our results are in line with the findings of previous studies that bid-ask spreads are narrower in auction markets than in pure dealer markets.

The NASDAQ Stock Market began its decimal test phase on March 12, 2001 with 14 securities, followed by another 197 securities on March 26, 2001. All remaining NASDAQ securities converted to decimal trading on April 9, 2001. Some researchers suggested that a smaller price increment would shift power from public traders to professional traders by making it easier for professionals to step in front of public limit orders. As a result, public traders would display their orders less often and switch from limit order strategies to market order strategies. Others argued that decimal prices are easier to use than fractional prices and that a smaller price increment would encourage price competition and narrow bid-ask spreads. The results of our study suggest that decimalization is likely to narrow spreads.

The early evidence supports our prediction. NASDAQ reports that both quoted and effective spreads fell by an average of 50% for most stocks.[11] The report also indicates that small retail orders benefited the most from the reduced spreads and that large institutional

[11]The impact of decimalization on the NASDAQ Stock Market, Final Report to the SEC, NASDAQ Economic Research, The NASDAQ Stock Market, Inc., June 11, 2001.

orders' transactions costs do not appear to have increased. In addition, Chakravarty, Harris, and Wood (2001a, 2001b), Bessembinder (2002), and Chung, Van Ness, and Van Ness (2002) find a significant decrease in spreads on both the NYSE and NASDAQ after decimalization.■

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