Intraday variation in the bid-ask spread: evidence after the market reform

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Abstract

In this article we show that intraday variation in spreads for Nasdaq-listed stocks has converged to intraday variation in spreads for NYSE-listed stocks after the implementation of the new order handling rules. We attribute this convergence to the Limit Order Display Rule, which requires that limit orders be displayed in Nasdaq best bid and offer (BBO) when they are better than quotes posted by market makers. Our findings suggest that the different patterns of intraday spreads between NYSE and Nasdaq stock reported in prior studies can largely be attributed to the different treatments of limit orders between the NYSE and Nasdaq before the market reform.

I. Introduction

Numerous studies examine intraday variation in the spreads of NYSE and Nasdaq stocks. McInish and Wood (1992), Brock and Kleidon (1992), Lee, Mucklow, and Ready (1993), and Chan, Chung, and Johnson (1995) show that the average spread for NYSE stocks is widest at the open, drops sharply during the first hour of trading, and increases slightly before the market close.[1] In contrast, Chan, Christie, and Schultz (1995) find that the Nasdaq inside spread remains relatively wide after the open, narrows gradually during the day, and then declines sharply during the last 30 minutes of trading. The different patterns of intraday spreads between NYSE and Nasdaq stocks motivate market microstructure researchers to look for possible explanations.

In this article, we shed further light on possible causes of intraday spread variation based on inter-market comparisons of intraday spreads before and after the 1997 Nasdaq market reform. The market reform called for several major changes in the order handling rules and allowed, among others, limit-order traders to become direct participants in the quote-setting process. Hence, the results of the present study help understand the extent to which limit-order quotes explain the difference in intraday spreads between Nasdaq and NYSE stocks reported in previous studies.

Stoll and Whaley (1990) and Brock and Kleidon (1992) suggest that wide NYSE spreads at the open and close may be explained by specialists' privileged knowledge about order imbalance and their market power over traders with inelastic transaction demand. Madhavan (1992) and Foster and Viswanathan (1994) suggest that wider spreads during early hours of trading may be attributed to greater informational

[1]See Wood, McInish, and Ord (1985) for one of the path-breaking attempts to understand the intraday behavior of securities markets.

asymmetry between specialists and informed traders during this period. Chan, Christie, and Schultz (1995) attribute the observed difference between NYSE and Nasdaq spreads during early hours of trading to differential market power between NYSE specialists and Nasdaq dealers. They also suggest that the sharp decline in Nasdaq spreads near the close may be due to inventory control by dealers who post more competitive quotes to "go home flat."

Chung, Van Ness, and Van Ness (1999) propose an alternative explanation for the intraday pattern of NYSE spreads. Using the NYSE's Trades, Orders, Reports, and Quotes (TORQ) database, the authors determine whether each quote is from the specialist, the limit-order book, or both. The authors then examine intraday variation in spreads that originate from specialists as well as that originate from the limit-order book. The study finds that competition among limit-order traders is lower during the early and late hours of trading than midday and shows that the observed intraday pattern of NYSE spreads mirrors intraday variation in limit-order competition.[2] Based on this finding, the authors conclude that the U-shaped intraday pattern of NYSE spreads is largely determined by limit orders placed by outsiders rather than by specialists' quotes.

The Securities and Exchange Commission (SEC) enacted major changes in the order handling rules (OHR) on Nasdaq in 1997. The Limit Order Display Rule was phased in for all Nasdaq National Market System (NMS) issues from January 20, 1997 to October 13, 1997. The rule requires that limit orders be displayed in Nasdaq best bid and offer (BBO) when they are better than quotes posted by market makers. This allows the general public to compete directly with Nasdaq market makers in the price-discovery process.

[2] Kugele, McInish, Van Ness, and Van Ness (2000) also examine the effect of limit orders on spreads.

If the U-shaped intraday pattern of NYSE spreads is driven by limit orders as suggested in Chung, et al. (1999), limit-order traders are expected to play an important role in shaping intraday variation in Nasdaq spreads, and the intraday pattern of Nasdaq spreads after the OHR changes is likely to converge to that of NYSE spreads.[3] In contrast, if the differences in market power and/or inventory problems between NYSE specialists and Nasdaq dealers are major driving forces behind the observed differences in intraday spreads between NYSE and Nasdaq stocks, we do not expect to see such a convergence. Hence, the analysis of whether and how the new OHR have changed intraday variation in Nasdaq spreads will not only help understand the role of limit orders in the quote-setting process, but may also provide a powerful test of alternative hypotheses regarding the intraday behavior of spreads.

McInish, Van Ness, and Van Ness (1998) analyze the impact of the OHR changes on Nasdaq and show that the number of reported quotes increases and the bid-ask spread decreases following the implementation of the new rules. The study also finds that the number of trade executions increases while the average trade size decreases. Barclay, et al. (1999) examine the effect of the OHR changes on Nasdaq trading costs for the first 100 stocks phased in under the new rules. The authors find that quoted and effective spreads decline by about 30%, with the largest decline observed for stocks with relatively wide spreads prior to the OHR changes. While Barclay, et al. report the intraday pattern of spreads before and after the OHR changes and note a shift in the pattern, they do not fully explain how and why the OHR changes have altered the intraday pattern of spreads.

[3]We note that inferring the effect of limit orders on Nasdaq spreads based on the corresponding effect on the NYSE has a limitation, given structural differences between the two markets. Whether the fragmented limit-order book on Nasdaq has a similar effect on spreads as the consolidated limit-order book on the NYSE is, therefore, an empirical question.

Chung and Van Ness (2001) analyze the effect of the OHR changes on intraday variation in spreads using data for the first 150 stocks phased in under the new rules. The authors find that the rule changes reduce Nasdaq spreads throughout the day and the magnitude of the reduction is particularly large during midday. As in Barclay, et al. (1999), Chung and Van Ness also show that Nasdaq spreads drop sharply during the first hour of trading, decline steadily throughout the day, and fall sharply during the last 30 minutes.

In this study, we analyze the intraday pattern of spreads using a large matching sample of NYSE and Nasdaq stocks before and after the market reform.[4] We analyze the role of limit orders on Nasdaq spreads by examining whether the implementation of the Limit Order Display Rule has induced a shift in the intraday pattern of spreads. As a robustness check, we also perform a post-reform analysis of intraday variation in Nasdaq spreads using individual dealer quotes.

Our empirical results indicate that under the new OHR, the intraday pattern of Nasdaq spreads converges to that of NYSE spreads near the open as well as the close. We also find that the intraday pattern of spreads using individual dealer quotes for Nasdaq stocks is quite similar to that for NYSE stocks. Our findings suggest that the difference in intraday spreads between NYSE and Nasdaq stocks reported in prior studies can largely be attributed to the differential treatments of limit orders between the two markets before the OHR changes.

[4] In a similar vein, He and Wu (2002) compare execution costs between NYSE and Nasdaq issues, before and after the Nasdaq market reform. However, the study does not examine the intraday pattern of the spread.

II. Data sources, sample selection procedure, and descriptive statistics

To compare intraday variations in spreads between NYSE and Nasdaq stocks, we use a matching sample of NYSE and Nasdaq stocks. The data on matching variables are obtained from the Center for Research in Security Prices (CRSP) file. We use December 1996 and April 1999 as the pre- and post-reform sample periods, respectively. We delete Nasdaq stocks with a fifth letter identifier in the ticker symbol because the fifth letter refers to an American Depository Receipt or a stock with several classes. This leaves us with an initial sample of 2,773 NYSE stocks and 4,913 Nasdaq stocks.

We match each NYSE stock with Nasdaq stocks based on two stock attributes in December 1996: share price and market capitalization. We measure share price by the mean value of the closing price (or the midpoint of quoted bid and ask prices), and market capitalization by the product of the number of shares outstanding and the closing price on December 31, 1996.

To obtain a matching sample of NYSE and Nasdaq stocks, we first calculate the following matching score for each NYSE stock using our entire study sample of Nasdaq stocks:

$$\sum_{i=1}^{2} \{(Y_i^N - Y_i^T)/[(Y_i^N + Y_i^T)/2]\}^2 , \tag{1}$$

where Y_i represents one of the two stock attributes, and N and T refer to NYSE and Nasdaq, respectively. Then for each NYSE stock, we select a Nasdaq stock with the smallest score. When two or more NYSE stocks are matched with the same Nasdaq stock, we select the pair with the smallest matching score. This procedure results in 1,374 pairs of NYSE and Nasdaq stocks that are similar in share price and market capitalization. Of these 1,374 pairs, we find complete data on 734 pairs in April 1999. We use these 734 matching pairs of NYSE and Nasdaq stocks as our study sample.

Table 1 shows descriptive statistics for our study sample in December 1996. The average share price of our NYSE sample is \$21.28 and the corresponding figure for the Nasdaq sample is \$21.30. The average market capitalizations for our NYSE and Nasdaq samples are \$836 millions and \$846 millions, respectively. The mean number of transactions is 1,014 for our NYSE sample and 3,899 for the Nasdaq sample.[5] The mean number of shares traded is 17,226,986 for the NYSE sample and 5,372,761 for the Nasdaq sample. The mean standard deviations of daily returns for NYSE and Nasdaq stocks are 0.0173 and 0.0339, respectively.

Place Table 1 about here.

We obtain trade and quote data for this study from the NYSE's Trade and Quote (TAQ) database. We use inside quote data for the entire months of December 1996 and April 1999. As in Huang and Stoll (1996), we apply the following filters to minimize data errors: (1) exclude bid-ask quotes if the spread is greater than \$5 or less than zero; (2) exclude before-the-open and after-the-close quotes; (3) exclude trade price p_t if $|(p_t-p_{t-1})/p_{t-1}| > 0.10$; (4) exclude ask quote a_t if $|(a_t-a_{t-1})/a_{t-1}| > 0.10$; and (5) exclude bid quote b_t if $|(b_t-b_{t-1})/b_{t-1}| > 0.10$.

To perform a robustness check on our results, we also obtain data from Nastraq® Trade and Quote Data. We use dealer quote and trade data for our Nasdaq sample for the entire month of April 1999. We omit the following to minimize data errors: (1) quotes if either the ask or the bid is less than or equal to zero; (2) quotes if either the ask size or the bid size is less than or equal to zero; (3) quotes if the bid-ask spread is greater than \$10 or less than zero; (4) before-the-open and after-the-close trades and quotes; (5) trades if the price or volume is less than or equal to zero; (6) trade price, p_t, if $|(p_t - p_{t-1})/p_{t-1}| > 0.5$; (7) ask quote, a_t, if $|(a_t - a_{t-1})/a_{t-1}| > 0.5$; and (8) bid quote, b_t, if $|(b_t - b_{t-1})/b_{t-1}| > 0.5$.

III. Intraday variation in the spread

Intraday variation in the inside spread

We partition each day into 13 successive 30-minute intervals and calculate the mean spread during each 30-minute period. As our empirical analysis involves a cross-sectional aggregation of spreads, it is necessary that we normalize inter-stock differences in spreads while retaining variations in spreads across the time of day. We calculate the standardized spread using the following formula:

$$STSPRD_{k,i} = (S_{k,i} - M_i)/SD_i \quad , \qquad (2)$$

where $STSPRD_{k,i}$ denotes the standardized inside spread of quote k for stock i, $S_{k,i}$ is the posted inside spread of quote k for stock i, and M_i and SD_i, respectively, are the mean and standard deviation of $S_{k,i}$ during the study period.[6] We then calculate the mean value of $STSPRD_{k,i}$ across all stocks during each 30-minute interval.

We show the intraday patterns of raw and standardized spreads in Table 2 as well as in Figure I through Figure IV. Figures I and III show that NYSE spreads are widest at the

[5] We obtain data on number of trades and number of shares traded from the NYSE's TAQ database.

[6] We use the mean and standard deviation of $S_{k,i}$ during the study period instead of during each day because

open, narrow during the day, and increase slightly before the market close during both the pre and post market reform period. These results are in line with the U-shaped intraday spread pattern previously documented by McInish and Wood (1992), among others. Hence, for the case of NYSE stocks, the intraday pattern of spreads remains relatively stable between our two study periods.

Place Table 2 and Figure I through IV about here.

For our Nasdaq sample, however, we find a significant shift in the intraday pattern of spreads after the market reform. During the pre market reform period, the spreads remain relatively wide after the open, narrow gradually during the day, and then decline sharply during the last 30 minutes of trading (see Figure II). These results are similar to the findings of Chan, Christie, and Schultz (1995). After the market reform, however, we find that Nasdaq spreads are widest at the open, narrow sharply during the day, and become stable during afternoon hours until the market close (see Figure IV). Overall, intraday variation in Nasdaq spreads after the market reform appears quite similar to the intraday pattern of NYSE spreads.

To test the apparent result formally, we estimate the following model of the standardized spread (STSPRD) using the time-series data for each stock:

$$STSPRD = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \varepsilon \quad , \qquad (3)$$

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there are too few quotes for some stocks during certain days.

where dummy variables D_1, D_2, and D_3 represent, respectively, the first three 30-minute intervals of the trading day: 9:30-10:00 a.m., 10:01-10:30 a.m., and 10:31-11:00 a.m. and D_4, D_5, and D_6 represent, respectively, the last three 30-minute intervals: 2:31-3:00 p.m., 3:01-3:30 p.m., and 3:31-4:00 p.m. The intercept term measures the average standardized spread during the time period from 11:01 a.m. to 2:30 p.m. The coefficients for dummy variables, β_1 through β_6, measure the difference between the mean spread during the respective 30-minute interval and the mean spread during 11:01 a.m. to 2:30 p.m.

We report the regression results for each period in Table 3. For each dummy variable we report the average coefficient from stock-by-stock regressions. To determine whether each dummy variable coefficient is significantly different from zero, we calculate both the t-statistic and z-statistic with their respective p-values. The t-statistic is obtained by dividing the average coefficient by the cross-sectional standard deviation of the coefficient. We obtain the z-statistic by adding the individual regression t-statistics across stocks and then dividing the sum by the square root of the number of stocks.

Place Table 3 about here.

The regression results indicate that, for both NYSE and Nasdaq samples, the spread during the first three 30-minute intervals is significantly greater than the spread during midday in both study periods. For the NYSE sample, the spread during the last 30-minute interval is significantly greater than the average spread during midday for both sample periods. For the Nasdaq sample, the spread during the last 30-minute interval is significantly less than the average spread during midday before the market reform. After the market reform, the mean spread for the last interval is also significantly negative, but to a much less extent compared to the pre-reform results. The negative regression coefficient for the last interval simply reflects the fact that the mean spread during the last interval is smaller than the mean spread during midday, despite the fact that the former is greater than the narrowest spread during the day.

Robustness check: Intraday variation in dealer spreads

Since the inside market quotes on Nasdaq reflect the lowest ask and highest bid prices among those quotes posted by different dealers, the intraday pattern of spreads obtained from the inside market quotes could be different from the intraday pattern obtained from the individual dealer quotes. Theoretical models of market making consider how individual market makers deal with adverse selection and inventory problems. Hence, it is appropriate to use the individual dealer quote data (rather than the inside market quote data) if one desires to interpret the observed intraday pattern from the perspective of these models. In this section, we examine intraday variation in spreads using the individual dealer quote data. Due to limited availability of data, we examine only individual dealer quotes in April 1999 obtained from Nastraq® Trade and Quote Data.

We calculate the standardized dealer spread using the following formula:

$$STSPRD_{k,i,j} = (S_{k,i,j} - M_{i,j})/SD_{i,j} \quad , \tag{4}$$

where $STSPRD_{k,i,j}$ denotes the standardized spread of quote k for stock i by market maker j, $S_{k,i,j}$ is the posted spread of quote k for stock i by market maker j, and $M_{i,j}$ and $SD_{i,j}$, respectively, are the mean and standard deviation of $S_{k,i,j}$ during the study period.[7] We then

[7]We use the mean and standard deviation of $S_{k,i,j}$ during the study period instead of during each day because

calculate the mean of $STSPRD_{k,i,j}$ across all market makers and subsequently across all stocks during each 30-minute interval.

We show the intraday pattern of spreads in Figure V (see also Table 4). The results show that the individual dealer spread is widest at the beginning of the day, narrows during the day, and then rises slightly during the last hour of trading. Hence, intraday variation in Nasdaq dealer spreads is very similar to intraday variation in NYSE spreads. The regression results (see Table 5) indicate that indeed dealer spreads during the first and last hours of trading are significantly greater than the corresponding figure during midday.

Place Table 4, Table 5, and Figure V about here.

Discussion of the results

The observed intraday variation in Nasdaq spreads after the market reform is quite different from the findings of Chan, Christie, and Schultz (1995), Barclay, et al. (1999), and Chung and Van Ness (2001). Chan, Christie, and Schultz (1995) show that the average inside spread of Nasdaq stocks remains relatively wide after the open, narrows gradually during the day, and then declines sharply during the last 30 minutes of trading. Barclay, et al. (1999) and Chung and Van Ness (2001) show that the intraday pattern of Nasdaq spreads has changed after the introduction of the new SEC order handling rules. The authors show that inside spreads are widest immediately after the open and drop sharply during the first 30-minute interval. Barclay, et al. hold that the similar pattern between NYSE and Nasdaq spreads during the early hour of trading indicates that wider

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some dealers make very few quotes during certain days.

spreads on the NYSE cannot be attributed to the specialist's market power. As in Chan, Christie, and Schultz (1995), both Barclay, et al. (1999) and Chung and Van Ness (2001) also show that spreads decline during the last 30 minutes of trading, although the magnitude of the decline is significantly reduced under the new SEC rules.

According to the results of the present study, the intraday pattern of Nasdaq spreads has changed further since the studies of Barclay, et al. and Chung and Van Ness. As noted above, we find that in April 1999, the average spread during the last 30 minutes of the trading day is significantly wider than the average spread during midday for individual dealer quotes. Contrary to earlier evidence, we do not observe a sharp decline in inside spreads during the last 30 minutes of trading. Therefore, our findings suggest that under the new SEC rules and after a sufficient time for market assimilation, the intraday pattern of Nasdaq spreads converges to that of NYSE spreads near the close as well as the open.[8]

These results indicate that the previously observed difference in intraday spreads between the two markets may not be due to the differences in market power and/or inventory problem between Nasdaq dealers and NYSE specialists. Our empirical results are consistent with the finding by Chung, et al. (1999) for NYSE stocks that intraday variation in spreads is largely determined by limit orders placed by outsiders. To the extent that limit orders on Nasdaq play a similar role as those on the NYSE, the observed

[8] The difference between the result of the present study and that of Barclay, et al. (1999) and Chung and Van Ness (2001) may be attributed, at least in part, to two factors. First, we use data after a two-year assimilation period for the new SEC rules, whereas Barclay, et al. (1999) and Chung and Van Ness (2001) use data immediately after the introduction of the new SEC rules. Second, our study sample includes a broad cross-section of 734 stocks, whereas Barclay, et al. (1999) and Chung and Van Ness (2001) use only the first two and three batches of 100 and 150 stocks, respectively, phased in under the new SEC rules.

U-shaped pattern of Nasdaq spreads may now reflect intraday variation in competition among limit-order traders in the quote-setting process.

The 1997 SEC Nasdaq market reform involves other rule changes. The Quote Rule gives the public access to quotes posted by dealers in ECNs. The Actual Size Rule reduces the minimum quote size to 100 shares. The amended Excess Spread Rule 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. Although we attributed the observed shift in the intraday pattern of Nasdaq spreads to the Limit Order Display Rule, it is possible that the shift may also have resulted, at least in part, from other rule changes. While the study reported by Chung, et al. (1999) offers a testable hypothesis regarding the effect of Limit Order Display Rule on the intraday pattern of Nasdaq spreads, it is unclear how other rule changes may affect the intraday pattern. Although the observed shift in intraday spread variation is consistent with our conjecture, we cannot rule out other possible explanations.

IV. Conclusion

The role of limit orders in price discovery has not been well understood until very recently. Several recent studies provide evidence that limit-order traders play an important role in the quote-setting process on the NYSE. These studies show that limit-order traders determine not only the overall magnitude of the bid-ask spread but also the shape of its intraday variation. In the present study, we provide additional evidence regarding the role of limit orders in price discovery using a sample of Nasdaq issues before and after the implementation of the new order handling rules.

Prior to the implementation of the Limit Order Display Rule, Nasdaq dealers were not subject to competition from limit-order traders in the quote-setting process. Limit orders were treated as offers to dealers, not as offers to the general public. Hence, limit-order traders on Nasdaq did not compete with dealer as they did on the NYSE. As the Limit Order Display Rule requires that limit orders be displayed as BBOs if they are better than dealer quotes, the analysis of intraday variation in Nasdaq spreads using data after the OHR changes helps understand the role of limit orders in price discovery.

Our empirical results show that the intraday pattern of Nasdaq spreads has converged to the intraday pattern of NYSE spreads after the implementation of the new order handling rules. We find that after the OHR changes, the intraday pattern of Nasdaq spreads follows the familiar "U-shape," which has been observed for stocks traded on the NYSE. We interpret this result as evidence that limit-order traders play a significant role on Nasdaq in the quote-setting process. Overall, our findings suggest that the differential patterns of intraday spreads between NYSE and Nasdaq issues reported in previous studies may be explained by the differential treatments of limit orders between the two markets, not by differential market power between NYSE specialists and Nasdaq dealers, or inventory considerations.

Although the present study attributes the observed change in the intraday pattern of Nasdaq spreads to the Limit Order Display Rule, we note that the Nasdaq market reform involves three additional concurrent rule changes. It is unclear how much of the observed shift in intraday spread variation can be attributed to these other rule changes. A fruitful area for future research may be the analysis of the effects of these other rule changes on intraday spread variation.

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TABLE 1. Descriptive Statistics for 734 Matching Pairs of NYSE and Nasdaq Stocks in December 1996

				Percentile				
Variable	Exchange	Mean	Standard Deviation	Min	25	50	75	Max
Share Price	NYSE	21.28	14.33	1.13	11.00	17.00	28.25	102.38
($)	Nasdaq	21.30	14.27	1.03	11.13	17.06	28.13	104.00
Market value of	NYSE	835,653	4,148,080	9,599	95,250	216,771	569,961	95,983,160
Equity (in thousands)	Nasdaq	846,185	4,251,288	9,248	95,326	217,959	570,564	98,984,750
Number of trades	NYSE	1,014	2,108	11	262	519	1,052	34,061
	Nasdaq	3,899	12,337	5	318	1,000	2,870	191,108
Number of shares traded	NYSE	1,726,986	3,623,128	4,800	297,000	658,500	1,643,700	49,632,701
	Nasdaq	5,372,761	14,461,495	1,500	528,975	1,606,203	4,212,678	158,330,000
Standard deviation	NYSE	0.0173	0.0101	0.0045	0.0107	0.0147	0.0208	0.0967
of daily returns	Nasdaq	0.0339	0.0163	0.0073	0.0229	0.0307	0.0417	0.1232

We match NYSE and Nasdaq stocks based on two stock attributes: share price and market capitalization in December 1996. We measure share price by the mean value of the daily closing price (or the midpoint of quoted bid and ask prices), and market capitalization by the product of the number of shares outstanding and the closing price on December 31, 1996 using data from the CRSP file. Number of trades and total volume are obtained from the NYSE's TAQ database. We calculate the standard deviation of daily returns using data from the CRSP file.

TABLE 2. Intraday Variation in Inside Spreads for NYSE and Nasdaq Stocks

	December 1996				April 1999			
	NYSE		Nasdaq		NYSE		Nasdaq	
Time interval	Standardized	Raw	Standardized	Raw	Standardized	Raw	Standardized	Raw
09:30 – 10:00	0.2592	0.2171	0.1197	0.4649	0.2792	0.1946	0.2527	0.2941
10:01 - 10:30	0.0467	0.1978	0.0457	0.4339	0.0740	0.1754	0.0912	0.2706
10:31 - 11:00	-0.0119	0.1936	0.0654	0.4243	-0.0110	0.1667	0.0424	0.2587
11:01 - 11:30	-0.0301	0.1917	0.0342	0.4242	0.0012	0.1692	-0.0011	0.2502
11:31 - 12:00	-0.0523	0.1908	0.0300	0.4270	-0.0350	0.1677	-0.0256	0.2515
12:01 - 12:30	-0.0592	0.1899	0.0145	0.4212	-0.0567	0.1636	-0.0443	0.2470
12:31 - 13:00	-0.0588	0.1886	-0.0015	0.4307	-0.0507	0.1667	-0.0632	0.2395
13:01 - 13:30	-0.0630	0.1893	-0.0029	0.4227	-0.0785	0.1618	-0.0800	0.2376
13:31 - 14:00	-0.0710	0.1871	-0.0050	0.4165	-0.0973	0.1648	-0.0960	0.2390
14:01 - 14:30	-0.0913	0.1871	-0.0331	0.4172	-0.0900	0.1593	-0.0921	0.2380
14:31 - 15:00	-0.0863	0.1880	-0.0338	0.4173	-0.0747	0.1618	-0.0710	0.2376
15:01 - 15:30	-0.0846	0.1872	-0.0780	0.3950	-0.0793	0.1626	-0.0808	0.2370
15:31 - 16:00	-0.0276	0.1919	-0.1253	0.4040	-0.0444	0.1648	-0.0850	0.2370

This table presents the intraday pattern of inside spreads for our NYSE and Nasdaq sample. To calculate the standardized spread (STSPRD), we use the following formula: $STSPRD_{k,i} = (S_{k,i} - M_i)/SD_i$, where $STSPRD_{k,i}$ denotes the standardized inside spread of quote k for stock i, $S_{k,i}$ is the posted inside spread of quote k for stock i, and M_i and SD_i, respectively, are the mean and standard deviation of $S_{k,i}$ during the study period. We then calculate the mean of $STSPRD_{k,i}$ across all stocks during each 30-minute interval.

TABLE 3. Regression Results from Inside Spread Data for NYSE and Nasdaq Stocks

		December 1996		April 1999	
		NYSE	NASDAQ	NYSE	Nasdaq
D1	Mean coefficient	0.3165	0.1048	0.3300	0.2991
	t-statistics	36.73	7.10	33.11	24.78
	(p-value)	0.0001	0.0001	0.0001	0.0001
	z-statistics	78.00	8.89	110.52	117.57
	(p-value)	0.0001	0.0001	0.0001	0.0001
D2	Mean coefficient	0.1046	0.0469	0.1243	0.1367
	t-statistics	11.57	2.94	12.06	11.52
	(p-value)	0.0001	0.0034	0.0001	0.0001
	z-statistics	24.87	4.28	35.98	43.72
	(p-value)	0.0001	0.0000	0.0001	0.0001
D3	Mean coefficient	0.0444	0.0529	0.0391	0.0852
	t-statistics	4.75	3.16	4.07	8.15
	(p-value)	0.0001	0.0017	0.0001	0.0001
	z-statistics	10.15	4.47	11.10	25.33
	(p-value)	0.0001	0.0000	0.0001	0.0001
D4	Mean coefficient	-0.0297	-0.0184	-0.0263	-0.0277
	t-statistics	-3.16	-1.00	-2.72	-2.47
	(p-value)	0.0016	0.3173	0.0066	0.0138
	z-statistics	-4.77	-1.77	-5.43	-5.55
	(p-value)	0.0000	0.0769	0.0000	0.0000
D5	Mean coefficient	-0.0283	-0.0652	-0.0331	-0.0369
	t-statistics	-3.26	-4.28	-3.14	-3.40
	(p-value)	0.0012	0.0001	0.0018	0.0007
	z-statistics	-5.56	-4.31	-10.07	-8.23
	(p-value)	0.0000	0.0000	0.0001	0.0000
D6	Mean coefficient	0.0287	-0.1258	0.0053	-0.0412
	t-statistics	3.33	-7.93	0.53	-4.09
	(p-value)	0.0009	0.0001	0.5961	0.0001
	z-statistics	5.75	-13.32	3.55	-12.87
	(p-value)	0.0000	0.0000	0.0004	0.0001

This table reports the results of the following regression model: $STSPRD = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \varepsilon$, where STSPRD is the standardized spread, dummy variables D_1, D_2, and D_3 represent, respectively, the first three 30-minute intervals of the trading day: 9:30-10:00 a.m., 10:01-10:30 a.m., and 10:31-11:00 a.m., and D_4, D_5, and D_6 represent, respectively, the last three 30-minute intervals: 2:31-3:00 p.m., 3:01-3:30 p.m., and 3:31-4:00 p.m. The intercept term measures the average standardized spread during the time period from 11:01 a.m. to 2:30 p.m. The coefficients for dummy variables, β_1 through β_6, measure the difference between the mean spread during the respective 30-minute interval and the mean spread during 11:01 a.m. to 2:30 p.m. For each dummy variable, we report the average coefficient, t-statistic, and z-statistic with their respective p-values. The t-statistic is obtained by dividing the average coefficient by the cross-sectional standard deviation of the coefficient. We obtain the z-statistic by adding the individual regression t-statistics across stocks and then dividing the sum by the square root of the number of stocks.

TABLE 4. Intraday Variation in Nasdaq Dealer Spreads in April 1999

Time interval	Standardized spread	Raw spread
09:30 – 10:00	0.7257	1.4870
10:01 – 10:30	-0.1509	1.2541
10:31 – 11:00	-0.1551	1.2348
11:01 – 11:30	-0.1910	1.2064
11:31 – 12:00	-0.2757	1.1998
12:01 – 12:30	-0.3247	1.2017
12:31 – 13:00	-0.3538	1.1869
13:01 – 13:30	-0.3564	1.1667
13:31 – 14:00	-0.4052	1.1734
14:01 – 14:30	-0.3712	1.1722
14:31 – 15:00	-0.3818	1.1791
15:01 – 15:30	-0.3306	1.2058
15:31 – 16:00	-0.2283	1.2249

This table shows the intraday pattern of Nasdaq dealer spreads in April 1999. To calculate the standardized spread (STSPRD), we use the following formula: $STSPRD_{k,i,j} = (S_{k,i,j} - M_{i,j})/SD_{i,j}$, where $STSPRD_{k,i,j}$ denotes the standardized spread of quote k for stock i by market maker j, $S_{k,i,j}$ is the posted spread of quote k for stock i by market maker j, and $M_{i,j}$ and $SD_{i,j}$, respectively, are the mean and standard deviation of $S_{k,i,j}$ during the study period. We then calculate the mean of $STSPRD_{k,i,j}$ across all market makers and subsequently across all stocks during each 30-minute interval.

TABLE 5. Regression Results from Nasdaq Dealer Spread Data in April 1999

		Standardized spread	Raw spread
D1	Mean coefficient	0.3950	0.1547
	t-statistics	28.83	38.20
	(p-value)	0.0001	0.0001
	z-statistics	209.16	219.41
	(p-value)	0.0000	0.0001
D2	Mean coefficient	0.1059	0.0600
	t-statistics	7.16	13.70
	(p-value)	0.0001	0.0001
	z-statistics	83.41	87.46
	(p-value)	0.0001	0.0001
D3	Mean coefficient	0.0588	0.0312
	t-statistics	4.15	7.48
	(p-value)	0.0001	0.0001
	z-statistics	41.96	4 4.0073
	(p-value)	0.0001	0.0001
D4	Mean coefficient	-0.0319	-0.0155
	t-statistics	-2.12	-3.42
	(p-value)	0.0344	0.0006
	z-statistics	-11.54	-10.71
	(p-value)	0.0001	0.0001
D5	Mean coefficient	-0.0122	0.0049
	t-statistics	-0.86	1.12
	(p-value)	0.3892	0.2636
	z-statistics	4.27	5.01
	(p-value)	0.0000	0.0000
D6	Mean coefficient	0.0443	0.0297
	t-statistics	3.16	6.92
	(p-value)	0.0016	0.0001
	z-statistics	34.02	36.59
	(p-value)	0.0001	0.0001

This table reports the results of the following regression model: STSPRD $= \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 D_3 + \beta_4 D_4 + \beta_5 D_5 + \beta_6 D_6 + \varepsilon$, where STSPRD is the standardized dealer spread, dummy variables D_1, D_2, and D_3 represent, respectively, the first three 30-minute intervals of the trading day: 9:30-10:00 a.m., 10:01-10:30 a.m., and 10:31-11:00 a.m., and D_4, D_5, and D_6 represent, respectively, the last three 30-minute intervals: 2:31-3:00 p.m., 3:01-3:30 p.m., and 3:31-4:00 p.m. The intercept term measures the average standardized spread during the time period from 11:01 a.m. to 2:30 p.m. The coefficients for dummy variables, β_1 through β_6, measure the difference between the mean spread during the respective 30-minute interval and the mean spread during 11:01 a.m. to 2:30 p.m. For each dummy variable, we report the average coefficient, t-statistic, and z-statistic with their respective p-values. The t-statistic is obtained by dividing the average coefficient by the cross-sectional standard deviation of the coefficient. We obtain the z-statistic by adding the individual regression t-statistics across stocks and then dividing the sum by the square root of the number of stocks.

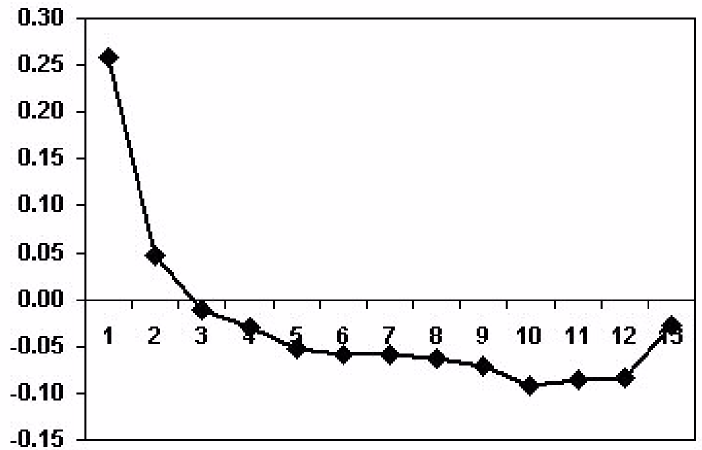

Figure I. Intraday Variation in the Standardized Spread for NYSE Sample in December 1996

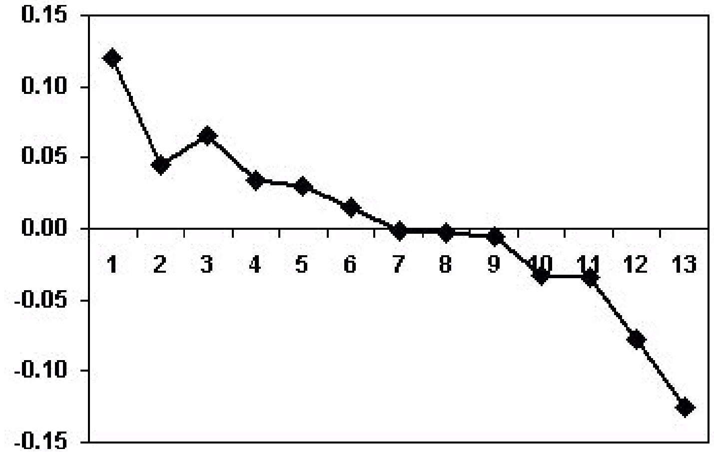

Figure II. Intraday Variation in the Standardized Spread for Nasdaq Sample in December 1996

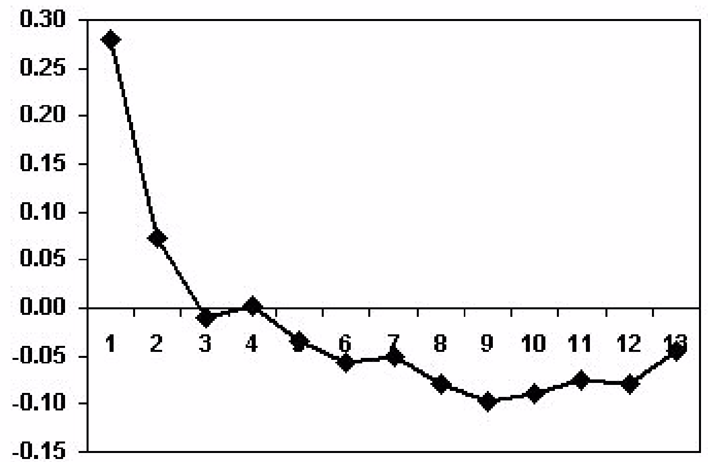

Figure III. Intraday Variation in the Standardized Spread for NYSE Sample in April 1999

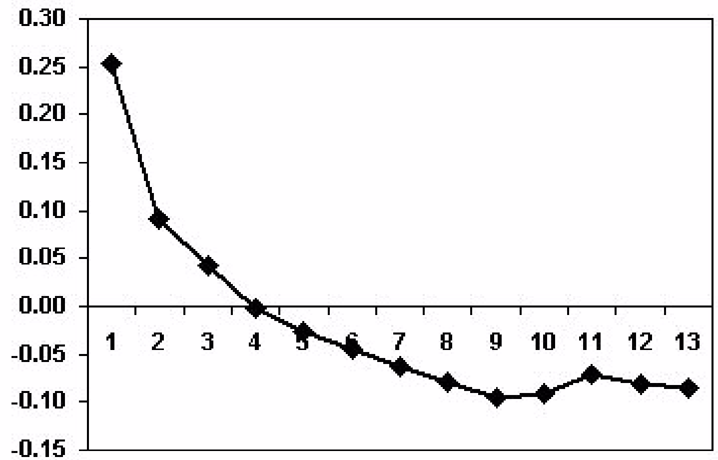

Figure IV. Intraday Variation in the Standardized Spread for Nasdaq Sample in April 1999

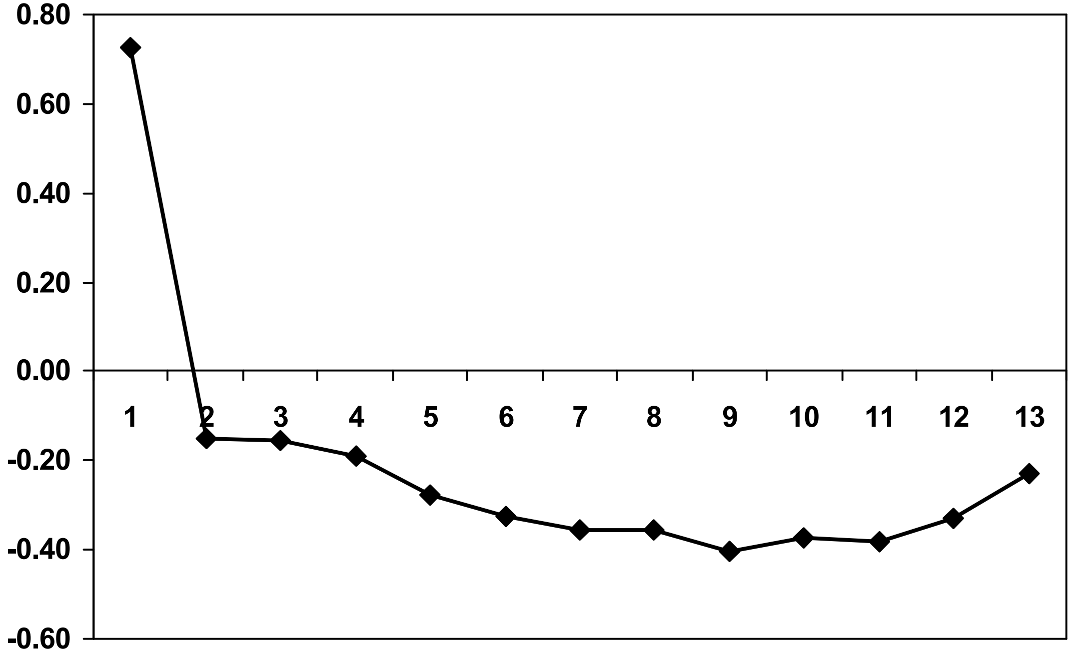

Figure V. Intraday Variation in the Standardized Spread of Market Maker Quotes for April 1999 Nasdaq Sample