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Effects of Market Reform on the Trading Costs and Depths of Nasdaq Stocks

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ABSTRACT

The relative merits of dealer versus auction markets have been a subject of significant and sometimes contentious debate. On January 20, 1997, the Securities and Exchange Commission began implementing reforms that would permit the public to compete directly with Nasdaq dealers by submitting binding limit orders. Additionally, superior quotes placed by Nasdaq dealers in private trading venues began to be displayed in the Nasdaq market. We measure the impact of these new rules on various measures of performance, including trading costs and depths. Our results indicate that quoted and effective spreads fell dramatically without adversely affecting market quality.

THE ORGANIZATION OF FINANCIAL MARKETS is of great importance to both the suppliers and the demanders of capital, as well as to those charged with the regulatory oversight of these markets. There is a long-standing debate as to whether an auction or a dealer market is best suited to promote a competitive trading environment. Auction markets, such as the New York Stock Exchange (NYSE), are order-driven, with liquidity supplied primarily by public limit orders. In contrast, dealer markets are typically quote-driven, and are centered around multiple marketmakers whose competition for order flow is presumed to ensure that the trading costs faced by investors reflect the true costs of market making. Traditionally, the Nasdaq Stock Market has operated as a pure dealer market, with the public unable to compete directly with marketmakers through the submission of their limit orders.

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The debate regarding the organization of markets was rekindled by Christie and Schultz (1994), who find that Nasdaq dealers avoided odd-eighth quotes in 70 of the 100 largest Nasdaq stocks in 1991. Their results led them to question the competitiveness of the Nasdaq market, and to propose that dealers had tacitly colluded to inflate bid-ask spreads. Excluding the public from the price-setting process by ignoring limit orders enhanced the opportunity for dealers to sustain economic rents. Furthermore, dealers routinely traded at more competitive prices with other dealers or large institutions through proprietary trading systems that were generally outside the reach (or knowledge) of retail investors.

The publicity surrounding the Christie and Schultz (1994) results led to regulatory investigations, legal activity, and numerous academic studies that seek to better understand the structure and trading practices on Nasdaq.[1] The ensuing scrutiny of the Nasdaq market, culminating with the Department of Justice (DOJ (1996)) and the Securities and Exchange Commission (SEC (1996)) settlements, resulted in a series of reforms. First, in conjunction with the DOJ settlement, marketmakers agreed to end the convention of avoiding odd-eighth quotes. Second, the regulatory responsibilities of the National Association of Securities Dealers (NASD) have been separated from the operation and ownership of the Nasdaq market through the formation of NASD Regulation Inc.

This paper focuses on the impact of a third outcome: the SEC's imposition of sweeping changes in the rules governing trading on Nasdaq. These reforms are designed to offer investors more competitive quotes through the mandatory display of customer limit orders and the dissemination of superior prices placed in proprietary trading systems. Although the new order handling rules apply to all U.S. markets, they are specifically targeted toward issues traded on Nasdaq. The display of limit orders and the reduced fragmentation of trading between Nasdaq and proprietary venues impart auction market characteristics to a market that was traditionally quote-driven.

The market reforms have been phased in gradually to provide marketmakers and the reporting infrastructure time to adapt to the new trading environment. The new rules applied to the first group of 50 stocks on January 20, 1997, and to a second group of 50 stocks on February 10, 1997. All Nasdaq National Market System (NMS) issues fell under the umbrella of the new rules by October 13, 1997. This paper examines the success of these market reforms by computing changes in quoted and effective spreads, trading volume, quoted depth, and other measures of liquidity for the first 100 stocks phased in under these rules.

[1] Examples of empirical and theoretical research linked to the competitive issues raised by Christie and Schultz (1994) include Barclay (1997), Bessembinder (1997), Cason (1996), Christie and Schultz (1995), Christie, Harris, and Schultz (1994), Demsetz (1997), Doran, Lehn, and Shastri (1997), Dutta and Madhavan (1997), Furbush and Smith (1996), Garvey and McCorry (1996), Godek (1996), Grossman et. al. (1997), Harris and Schultz (1997, 1998), Huang and Stoll (1996), Kandel and Marx (1997a, 1997b), Kleidon and Willig (1995), Lamoureux and Schnitzlein (1997), and Laux (1995).

Our results confirm that many of the objectives of the SEC have been met. We find that quoted and effective spreads narrow by approximately 30 percent, with the largest benefit accruing to investors in stocks with relatively wide spreads prior to the implementation of the new SEC rules. Thus, the significantly higher trading costs among Nasdaq issues previously identified in the literature (see Huang and Stoll (1996)) have largely disappeared. However, we also find that approximately 60 percent of the total decline in trading costs for Nasdaq stocks in the period from January 1994 to February 1997 arose prior to the introduction of the new rules, and is largely attributable to the various government investigations and negative publicity directed at Nasdaq.

Ideally, we would like to examine the effects of the new order-handling rules holding all other factors constant. However, for the stocks phased in on January 20, the SEC permitted dealers to reduce the minimum size of proprietary quotes from either 1,000 or 500 shares to 100 shares. The similarity in trading cost reductions for the stocks phased in on January 20 and February 10 implies that the savings stem from the display of limit orders and quotes from proprietary trading systems rather than from the decline in minimum quote sizes. We do, however, find that the reduction in the minimum quote size has had important effects on measures of depth. For example, the average trade size declines for stocks whose dealers could reduce their minimum quote size to 100 shares. The frequency of 1,000 share trades is dramatically lower, offset by proportionally larger frequencies of smaller trade sizes, particularly 100 share trades. Thus, as dealers post smaller quote sizes as principals or smaller sized limit orders as agents, average trade sizes decline, particularly among trades executed through the Small Order Execution System (SOES).

In light of the smaller trade sizes, we examine whether overall market depth is adversely affected. We estimate a "quote" book using the posted depths and bid-ask quotes from individual dealers and proprietary trading systems to compute execution costs assuming that trades are executed against the posted depths. We find that average round-trip costs decline by almost 30 percent, with large reductions across all trade-size categories. Thus, although trade sizes at the narrower spreads decline, the total quoted size in close proximity to the bid-ask midpoint increases.

Finally, the SEC also modified the Excess Spread Rule (ESR) for *all* Nasdaq stocks effective January 20, 1997.[2] This market-wide rule change afforded dealers greater flexibility in determining the width of their individual spreads by having to conform to monthly rather than continuous requirements. Since

[2] In conjunction with the implementation of the order handling rules on January 20, 1997, for all Nasdaq stocks, dealers were provided with the option of using an auto-decrement feature to reduce their quote sizes in response to SOES executions. Once the quote decrements to zero, marketmakers could use the auto-refresh option to update their quote. In effect, the NASD made auto-changing of quotes easier once the order handling rules were implemented. However, this rule would not be expected to alter marketmaker behavior in ways that could be measured in this paper.

the stocks phased in on February 10 were subject to the market-wide changes beginning January 20, we assess the marginal impact of the change to the ESR by studying the second phase-in sample between January 20 and February 10. Our results indicate that modifying this rule had no material effect on quoted or effective inside spreads. However, we observe an increase in the number of quote revisions, along with an increase in both the average dealer spread and the variability of spreads across dealers. These results suggest that the previous constraint on the width of individual dealer spreads was binding, although it did not affect their willingness to post tighter inside spreads.

The rest of the paper is organized as follows. Section I describes the market reforms and their expected effect on trading costs. Section II describes the data used in our empirical work. Section III presents the impact of the SEC rules changes on inside quoted spreads, and Section IV examines the changes in effective spreads. Section V assesses whether the depth and liquidity of the Nasdaq market have been influenced by the change in quotation patterns and inside spreads. Section VI explores how the introduction of auction market features and changes to the excess spread rule affect the general characteristics of quoted spreads, including their intraday patterns, quotation frequency, and the width of individual dealer quotes. Our concluding remarks appear in Section VII.

I. SEC Order Handling Reforms

Christie and Schultz (1994), Godek (1996), Huang and Stoll (1996), and Kandel and Marx (1997a), among others, note that price competition on Nasdaq was hampered by structural impediments that reduced the incentives for brokers or dealers to act as advocates for investors seeking price improvement. Retail brokers would commonly preference their order flow to particular marketmakers in exchange for a few cents per share. Retail brokers fulfilled their obligation for best execution because the marketmaker receiving the order was required to execute it at the national best bid or offer. Since these orders were already captured, other dealers could not obtain this order flow by competing more aggressively using quoted prices. Indeed, dealers with preferenced orders faced a disincentive to improve the posted quotes, for they would likely fail to attract significant new order flow but would reduce the profits on preferenced orders that they (and other dealers) were already receiving. Thus, public investors were placed at a disadvantage when trading on Nasdaq because they could not bypass dealers who quoted issues with wide inside spreads.

The SEC rules changes force dealers to reveal their best prices and permit investors to compete directly with dealers for order flow. These changes can be divided into four main categories. Nasdaq's "Integrating the SEC Order Handling Rules" (1997) serves as our primary source for the details of the rules changes.

A. Limit Order Display Rule

Traditionally, competition from limit orders on Nasdaq was considered unnecessary because competitive spreads were assumed to prevail when multiple dealers competed for orders on the basis of price. However, Dutta and Madhavan (1997) and Kandel and Marx (1997a, 1997b) show theoretically that discrete price increments and access to alternative methods of securing order flow could result in bid-ask spreads that exceed competitive levels. Prior to 1994, Nasdaq dealers could disregard public limit orders. In 1994, the NASD implemented a limit order protection rule that specifically prohibited dealers from trading through or ahead of their own customer limit orders. This rule was strengthened in 1995 to offer protection to limit orders that were forwarded to marketmakers by other dealers. However, dealers could trade at the limit price without executing the other marketmaker's limit order, thereby limiting the usefulness of placing such an order. Moreover, other marketmakers were not bound by the limit order price in trading with their own customers.

Under the new SEC rules, dealers have four options when they receive a customer limit order: (1) execute the order against their own inventory, (2) post the order as their own quote with the corresponding quote size, (3) forward the order to another marketmaker who would comply with the rule, or (4) place the order in a proprietary trading system (see below).[3] If the marketmaker chooses to display the limit order, he/she cannot trade at the limit order price or better until the order is executed. These restrictions *do not* apply to other dealers, who could trade at the limit order price without having to execute the limit order.[4] However, the display of the improved limit order price disciplines other dealers who must trade with their own customers at the limit order price even if they do not execute the limit order. This rule was applied to the first sample of stocks on January 20, 1997, and to the second sample on February 10.

B. Display of Electronic Communication Network Quotes

The second rule change gives the public access to superior prices posted by marketmakers in electronic communication networks (ECNs). ECNs are proprietary trading systems, such as Instinet, that are used exclusively by marketmakers and large institutions. Prior to the SEC rules changes, the presence of an alternative pricing system permitted dealers to quote one set of prices for retail customers on Nasdaq, while offering more favorable prices to other

[3] Exceptions to the rule include the following: Limit orders received prior to or shortly after the open are to be displayed as soon as possible rather than within the 30 seconds required under normal conditions. The rule also excludes block trades or limit orders that would lock or cross the market. These limit orders are converted into market orders to ensure better execution. All-or-none limit orders are not displayed, and customers can request that their limit order not be displayed. Finally, dealers retain the right to refuse to accept customer limit orders.

[4] This feature implies that to increase the probability of execution investors should submit limit orders to marketmakers (brokers) who actively trade the stock.

marketmakers or institutions. Under the new SEC rules, if a dealer places a limit order either as agent or principal into Instinet or another ECN, the price and quantity are incorporated in the ECN quote displayed on Nasdaq. Under this option, the dealer directly offers price improvement, but is not required to display quote sizes larger than their minimum on Nasdaq.[5]

Parties who are not marketmakers but trade via ECNs have the option of displaying their orders on Nasdaq through the ECN quote. SelectNet, which permits brokers and dealers to submit orders for exclusive execution by marketmakers, is not recognized as an ECN. Thus, dealers are required to reflect their SelectNet quotes directly on Nasdaq. The ECN rule change was applied to the first sample of stocks on January 20, 1997, and to the second sample on February 10. The rule eliminates the fragmentation of price discovery across trading venues and increases competition, which we expect will lead to benefits similar to those that arise from the display of limit orders.

C. Reduction in the Minimum Quote Size

Prior to January 20, 1997, marketmakers in the most active issues were required to post quotes that represented commitments to trade at least 1,000 (or for some stocks 500) shares per order. Under a pilot program, the minimum quote size fell to 100 shares for the stocks phased in on January 20, 1997. The philosophy underlying this change held that because marketmakers must compete directly with the public, and customers could submit limit orders as small as 100 shares, marketmakers should not be placed at a disadvantage by requiring 1,000 share quotes. In other words, marketmakers might be reluctant to match a limit order price for 100 shares if they are required to quote a minimum of 1,000 shares. This rule could increase the incentives for dealers to improve their quotes. Stocks that were phased in on February 10, 1997, were not subject to the reduction in minimum quote size.

D. Relaxation of the Excess Spread Rule

Prior to January 20, 1997, Nasdaq continuously calculated the average of the three narrowest individual spreads for each stock. The ESR forced all dealers to keep their spreads within 125 percent of this average (rounded up to the nearest eighth of a dollar). As Kandel and Marx (1997a) discuss, this rule reduced the flexibility of dealers to act independently to change the width of their spreads, and may have contributed to excessively wide dealer spreads. On January 20, 1997, the ESR was amended for all Nasdaq stocks to stipulate that each dealer's average spread during the month could not

[5] One feature of this rule is that SOES is immobilized when the inside quote is established by an ECN because ECNs are not required to participate in SOES. Furthermore, ECN quotes, which were on a finer quotation grid than Nasdaq quotes, were rounded to the nearest eighth on Nasdaq. Effective June 3, 1997, the Nasdaq market moved to quote increments of one-sixteenth, implying that rounding would take place to the nearest sixteenth.

exceed 150 percent of the three lowest average dealer spreads over the month. The new ESR defines compliance on a monthly basis rather than continuously, placing no limits on the marketmakers' ability to vary their spread during the month as long as their monthly average is in compliance.

II. Data Description

The data used for this study are supplied by the NASD, and consist of intraday inside quotes, trades, and individual dealer quotes for the period from November 1, 1996, through February 28, 1997, for the fifty Nasdaq stocks phased in under the new SEC rules on January 20, 1997, and the fifty issues phased in on February 10, 1997. We exclude all trades and quotes before 9:30 a.m. and after 4:00 p.m. The first fifty issues that were subject to the new rules include the top ten issues by dollar volume from among all Nasdaq NMS stocks in the period September to November of 1996, and eight additional stocks from each of the remaining dollar volume categories 21–100, 101–200, 201–300, 301–400, and 401–500. The fifty stocks subject to the rules changes on February 10 include the remaining top twenty issues, and a sample of eight issues from each of the remaining categories. The stocks are selected by the NASD, and may or may not be representative of the remaining stocks in each category.

III. Inside Spreads

We test for the impact of the new SEC rules on inside quotes by computing a time-weighted average inside spread for each stock, and averaging the daily values across stocks for each of the two phase-in samples. Table I reports the average inside quoted spread during three time intervals: (1) November 1, 1996, through January 19, 1997, (2) January 20 through February 9, 1997, and (3) February 10 through February 28, 1997. The statistical significance of univariate differences in means across SEC regimes is determined using standard *t*-tests.

Table I shows that issues phased in under the new SEC rules on January 20, 1997, experience a decline in average inside spreads from \$0.38 to slightly under \$0.24 once the SEC rules are implemented. Similarly, the average inside spread falls from approximately \$0.34 to \$0.23 for stocks phased in on February 10, 1997. Thus, inside spreads decline by fully one-third under the new SEC order handling rules.

Figure 1 plots the time series of time-weighted average inside spreads for each sample to confirm that the decline in spreads can be attributed to the SEC-mandated rules changes. The figure shows that average inside spreads for stocks subject to the new SEC rules on January 20 fluctuate between \$0.35 and \$.40 per share before the rules change. However, immediately upon implementation of the new SEC rules, average inside spreads collapse to under \$0.25, and remain at approximately \$0.25 for the rest of the sample

Table I

Quoted Inside Spreads Surrounding the Introduction of the SEC Order Handling Rules

Quoted inside spreads, or the difference between the inside ask and the inside bid, are estimated by forming a daily time-weighted average per stock, then averaging across stocks. The volume categories are formed using the median dollar volume of all Nasdaq National Market System stocks for September to November of 1996 (as reported by the NASD). For each quote revision, we average the total depth at the inside bid and ask, and compute a time-weighted average depth per stock, and average across all stocks within each phase-in sample. Electronic communications networks (ECNs) are proprietary trading systems, such as Instinet, that are used exclusively by marketmakers and large institutions.

	Stocks with 1/20 Rule Change			Stocks with 2/10 Rule Change		
	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97
Inside spreads						
All stocks ($)	0.380	0.239**	0.234	0.338	0.345	0.228**
Dollar volume rank						
1–20	0.183	0.142**	0.140	0.212	0.194*	0.154**
21–100	0.272	0.194**	0.192	0.203	0.214	0.166**
101–200	0.435	0.262**	0.259	0.334	0.320	0.231**
201–300	0.370	0.241**	0.263	0.399	0.472**	0.202**
301–400	0.603	0.340**	0.305	0.461	0.397*	0.225**
401–500	0.465	0.281**	0.267	0.449	0.513*	0.315**
Inside depths (shares)						
Including ECNs	3,883	3,887	3,899	4,595	4,626	5,227*
Excluding ECNs	3,883	3,591	3,656	4,595	4,626	4,806

*, ** Indicates that the value is statistically different at the 5 percent (1 percent) level from the preceding value in the same row, within each rule change category.

period. The decline in average spreads coincides with the date that the new rules are implemented, confirming that the reduction in trading costs stems from the SEC rules.

A similar result appears in the time series of average inside spreads for the February 10, 1997 sample. The only significant rule change that applies to these stocks on January 20, 1997, is the relaxation of the ESR. Table I shows that the average inside spread remains virtually unaffected by the modification in this rule. As Figure 1 shows, once the ECN quotes and limit orders are displayed, the average inside spread immediately declines from $0.35 to $0.22 per share for the rest of February, much as spreads narrow for the January 20 sample. Thus, the adoption of this rule change has no impact on the width of inside spreads.

The aggregate distribution of time-weighted inside spreads surrounding the implementation of the new SEC rules is plotted in Figure 2. During the period preceding the rules changes, spreads of $0.25 comprise 32 percent of all quotes. Spreads of one-eighth arise in approximately 25 percent of the quotes, and the third most frequent inside spread is $0.50, with a frequency

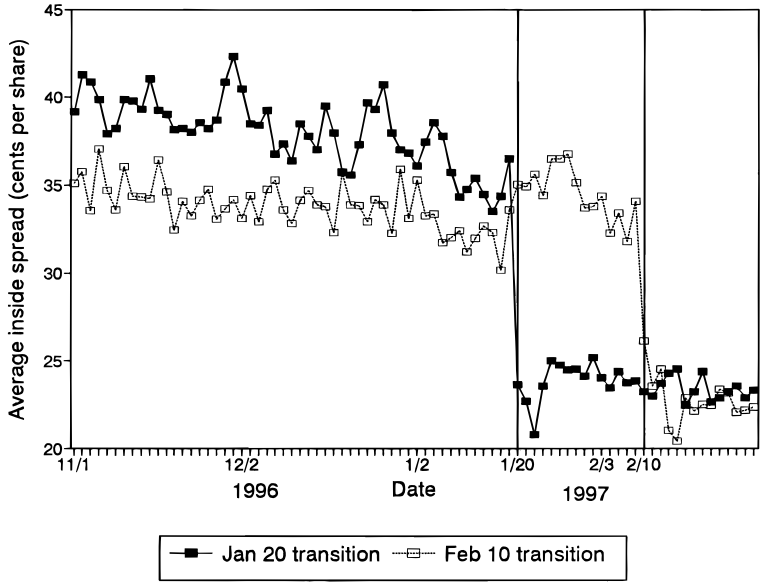


Figure 1. The time-series of time-weighted average dollar inside spreads for stocks phased in under the new SEC order handling rules. The first fifty stocks are phased in on January 20, 1997, and the second fifty stocks are phased in on February 10, 1997. Average inside spreads are computed by weighting each spread by the fraction of the trading day that particular spread was in effect. The averages are computed daily for each stock, then averaged across all stocks in the particular sample.

slightly more than 15 percent. The fraction of quotes that exceed \$0.50 is approximately 17 percent prior to the SEC rules changes. Once the new rules are implemented, the most frequent spread width is \$0.125, which constitutes the inside spread more than 50 percent of the time. The most dramatic shift occurs among stocks whose spreads are initially the widest, as quotes exceeding \$0.50 occur less than 3 percent of the time after the SEC rules take effect.

These results offer insight into the benefits of introducing auction market features to a dealer market in the absence of a strategic management decision to change trading venue. Specifically, Christie and Huang (1994) and Barclay (1997) report significant reductions in quoted and effective spreads when stocks change their listing location from Nasdaq to either the NYSE or the American Stock Exchange (AMEX). However, their results are biased to the extent that the managers of these firms *voluntarily* elected to list on the NYSE or AMEX, and might have sought listing in the belief that such cost reductions would materialize. Our evidence implies that the source of the benefits reported by Barclay (1997) and Christie and Huang (1994) is structural, and that the reduction in trading costs could be extended to other issues that might have listed, but did not.

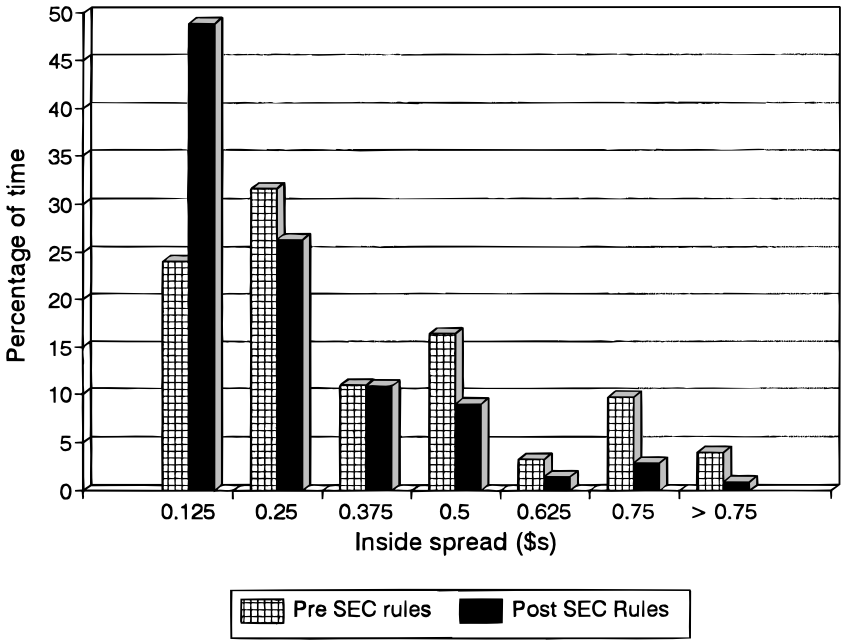


Figure 2. The distribution of time-weighted average inside spreads conditional on the presence of the new SEC order handling rules. The first fifty stocks are phased in on January 20, 1997, and the second 50 stocks are phased in on February 10, 1997. For each stock, we compute a daily time-weighted distribution of specific spread widths at the inside market. We then average these fractions at each spread width across stocks separately for the two phase-in samples. These figures are then averaged across samples.

A. Spread Reductions by Dollar Volume

Table I also presents the average decline in spreads for issues categorized by their dollar volume prior to the implementation of the new SEC rules. Stratifying issues by volume permits an examination of the differential effect of the order handling rules across an important determinant of spreads. The results in Table I convey two important patterns, independent of the specific phase-in sample. First, average dollar spreads are wider for stocks with lower average volume, both prior to and subsequent to the introduction of the new SEC rules. Second, average spreads decline across *all* volume categories, with the largest percentage impact observed among the less active issues. Indeed, spreads decline by approximately $0.04 per share among the twenty most active issues, but average reductions in excess of $0.15 per share occur among the less active issues.

The magnitude of the decline among the lower volume stocks is interesting because these issues are often identified as those best suited for trading under a dealer market structure (e.g., Aggarwal and Angel (1996)). Specifically, the wider spreads associated with smaller stocks serve as an incentive for dealers to promote the stock. Such an incentive would not exist under a

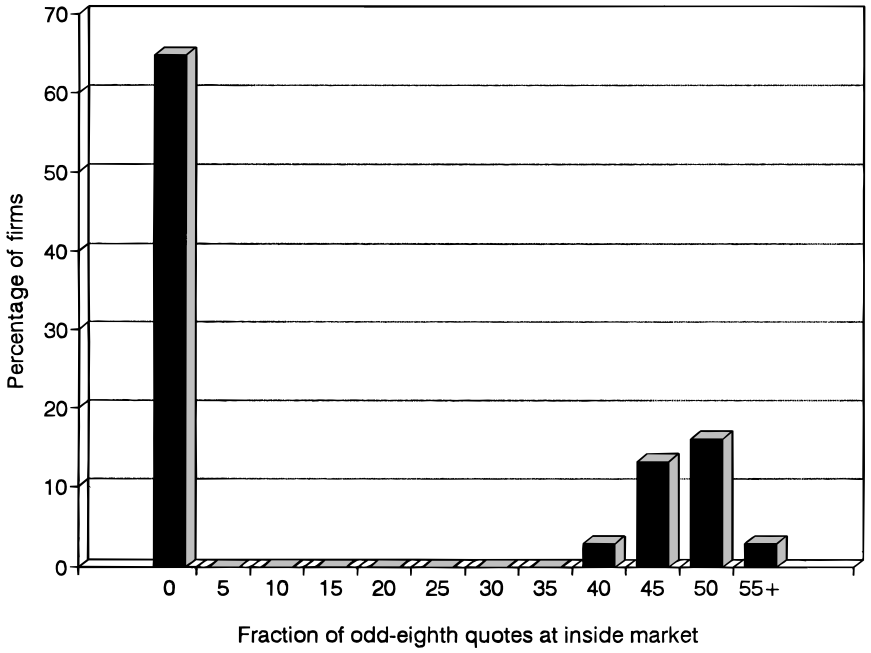
specialist system where public orders would not be sufficient to maintain a liquid market. However, our evidence shows that displaying limit orders and/or better-priced ECN quotes lowers spreads by up to 40 percent.

B. Spread Reductions in a Historical Context

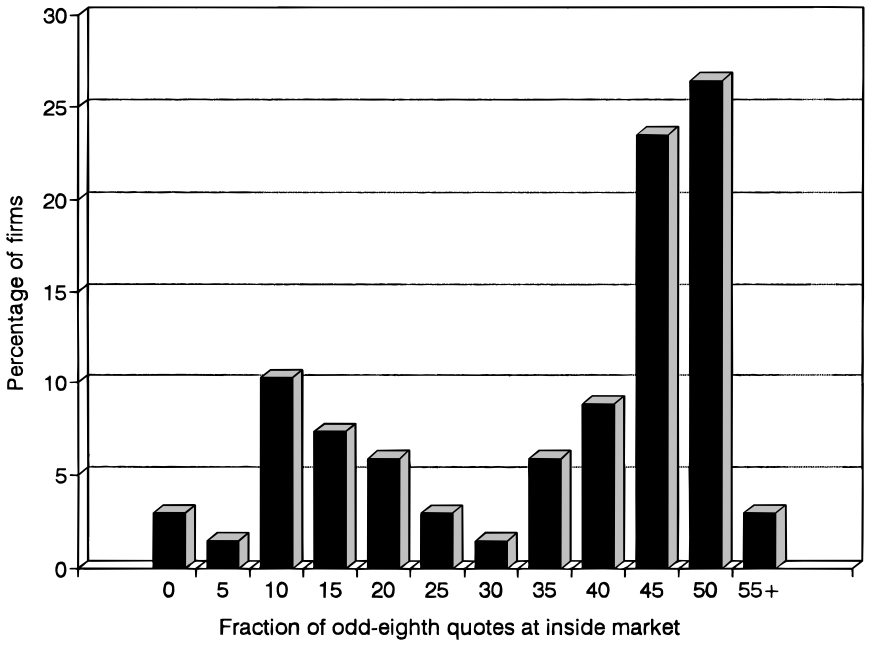
Although the reduction in trading costs triggered by the new SEC order-handling rules is impressive, Nasdaq dealers had been under pressure to narrow spreads prior to the adoption of these rules. Specifically, the public disclosure of the results of Christie and Schultz (1994) led to a rapid narrowing of spreads for four of the most active Nasdaq issues in May of 1994, as Nasdaq dealers simultaneously adopted odd-eighth quotes (see Christie et al. (1994)). Additional pressure from the ensuing negative publicity, in conjunction with parallel investigations by the DOJ and the SEC, induced further declines in spreads and a more widespread use of all price fractions (see Appendix Exhibits A and E in the DOJ Competitive Impact Statement (1996)). Thus, the decline in trading costs in Table I was preceded by significant reductions that were independent of these rules changes.

This section assesses the magnitude of the decline in spreads and the avoidance of odd-eighth quotes prior to the new SEC order-handling rules for the 100 stocks that we study. We first isolate the sixty-eight issues from our sample that trade continuously on Nasdaq during the period from January 1, 1994, to February 28, 1997. For each issue, we compute the average frequency of odd-eighth quotes at the inside bid and ask within three intervals: (1) January 1–May 1, 1994, (2) November 1, 1996–January 19, 1997 and (3) February 10–February 28, 1997. The first two intervals share a common market structure, even though the period ending in April of 1994 precedes the various investigations of anticompetitive conduct by Nasdaq marketmakers. Since these investigations were complete by the summer of 1996, the results for the second period incorporate changes in marketmaker behavior that are unrelated to shifts in the structure of the market. The final period corresponds to the interval when all sixty-eight issues are traded under the new SEC order-handling rules.

Figure 3 plots the distribution of the proportion of odd-eighth quotes. Panel A shows a bimodal distribution with almost 65 percent of the stocks quoted exclusively in even-eighths. Thus, odd-eighth avoidance is similar for this sample and the 100 stocks sampled by Christie and Schultz (1994) in 1991. Panel B presents the fraction of odd-eighth quotes at the inside market for November 1, 1996, to January 19, 1997. Despite the similarity in market structure between these two periods, the pattern of odd-eighth avoidance changes dramatically, with most stocks quoted using all price fractions by late 1996. The avoidance of odd-eighth quotes remains intact for a small fraction of issues relative to the levels measured in 1994. Finally, Panel C displays the frequency of odd-eighth quotes across stocks under the new SEC rules. More than 50 percent of the stocks are quoted on odd-eighths between 45 percent and 50 percent of the time, and no stock is quoted with

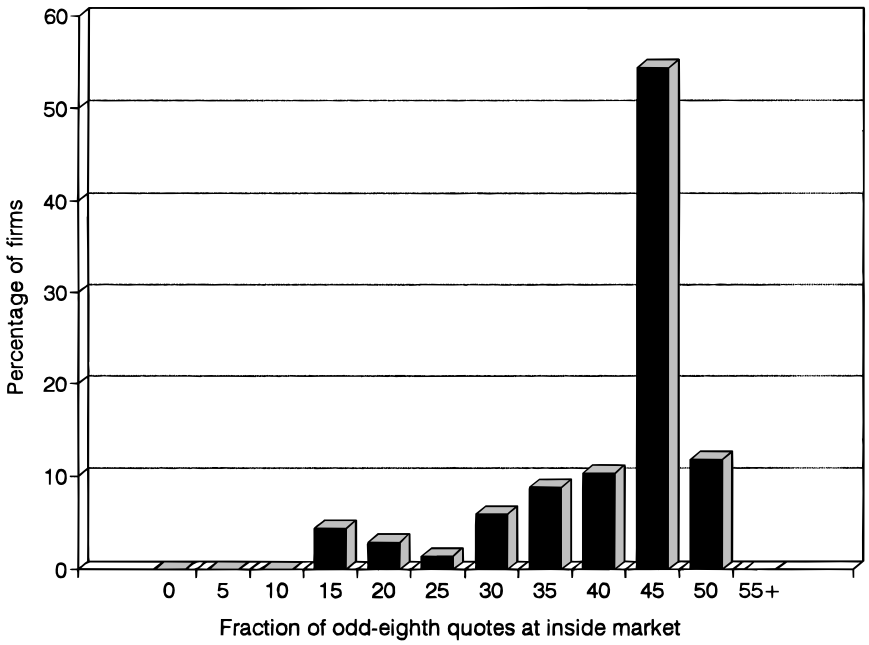


Panel A: Frequency of Odd-Eighth Use from January 1 to April 30, 1994



Panel B: Frequency of Odd-Eighth Use from November 1, 1996 to January 19, l997

Figure 3. ***Figure continues on facing page.***



Panel C: Frequency of Odd-Eighth Use from February 10 to February 28, 1997

Figure 3. A comparison of the frequency of inside quotes using odd-eighth price fractions for the period from January 1994 to February 1997. We compute the average frequency of odd-eighth quotes at the inside market for the sixty-eight phase-in stocks that trade continuously between January 1994 and February 1997 during three periods: (1) January 1 to April 30, 1994, (2) November 1, 1996, to January 19, 1997, and (3) February 10 to 28, 1997. We then plot the number of issues with a specific fraction of odd-eighth quotes. Panel A presents the 1994 results. Panel B reports the use of odd-eighth quotes for November 1, 1996, to January 19, 1997. Panel C reports the use of odd-eighth quotes for February 10 to February 28, 1997.

fewer than 10 percent odd-eighths. The dramatic shift toward the equal distribution of even- and odd-eighth quotes prior to the implementation of the SEC order-handling rules undermines the claim that the odd-eighth avoidance is merely a structural feature of dealer markets (see Demsetz (1997) and Grossman et al. (1997)).

The impact of the adoption of odd-eighth quotes on inside spreads is reported in Table II. We compute the average time-weighted inside spread for each of the sixty-eight issues that traded on Nasdaq from January 1, 1994, to February 28, 1997. For these sixty-eight issues, average spreads decline from 42.4 cents per share in the 1994 sample period to 30.5 cents per share during the months preceding the implementation of the SEC rules changes. This reduction in average spreads can be directly traced to those stocks that are quoted exclusively in even-eighths in 1994. Specifically, the average inside spread for the forty-four stocks that are not quoted in odd-eighths in 1994 declines from 52.6 to 33.6 cents per share from 1994 to the months

Table II

Comparison of Average Time-Weighted Inside Spreads from 1994 to 1997 for Stocks Phased In under the SEC Order-Handling Rules

For each stock, we compute the daily time-weighted inside spread for three time intervals: (1) January 1 through May 1, 1994, (2) November 1, 1996 through January 19, 1997, and (3) February 10 through February 28, 1997. The first time interval corresponds to the period preceding the negative publicity surrounding the Christie and Schultz (1994) study. The second time interval immediately precedes the introduction of the new SEC order-handling rules for the first of our two samples of Nasdaq stocks. The final time interval corresponds to the period when each of the two Nasdaq samples are traded under the new SEC rules. The reported figures are equally weighted averages of the daily time-weighted inside spreads, measured in cents-per-share. Results are computed for the sixty-eight stocks traded on Nasdaq throughout the period January 1, 1994 to February 28, 1997. We further differentiate between the forty-four stocks that are quoted solely in even-eighths in 1994 and the twenty-four stocks that are quoted in mixed-eighths in 1994.

Sample Criterion	1/1/94—5/1/94	11/1/96—1/19/97	2/10/97—2/28/97
All sample stocks	42.4	30.5**	22.3**
Quoted in even-eighths in 1994	52.6	33.6**	22.6**
Quoted in mixed-eighths in 1994	23.8	24.2	21.6**

** Indicates that the value is statistically different at the 1 percent level from the preceding value in the same row.

immediately prior to the new SEC rules. In contrast, the average inside spread for the mixed-eighth stocks in 1994 is virtually unchanged over the same thirty-month period. Thus, the decline in the avoidance of odd-eighth quotes has a significant and dramatic impact on the width of average inside spreads. This result contrasts with that of Bessembinder and Kaufman (1997) who observe that from May 1994 to December 1994, the fraction of firms avoiding odd-eighth quotes declines without a corresponding decline in the average width of inside spreads.[6]

IV. Effective Spreads

One limitation of measuring trading costs using inside quotes is that trades frequently occur within the quoted spread, but some large trades may occur outside the quoted prices. A commonly used measure of transactions costs that allows for trades at prices other than the bid or ask quote is the effective spread. The effective spread for a trade at time t is estimated as

$$Effective\ Spread_t = 2\left|Price_t - \left(\frac{Ask_t + Bid_t}{2}\right)\right|, \tag{1}$$

[6] Christie and Schultz (1998) also find a direct link between changes in the frequency of odd-eighth quotes and the average inside spreads of Nasdaq issues whose marketmakers initiate or withdraw odd-eighth quotes.

Table III

Effective Spreads Surrounding the Introduction of the SEC Order-Handling Rules

Effective spreads are calculated as the absolute difference between the trade price and the average of the inside bid and ask quotes in effect at the time of the trade. Effective spreads are volume-weighted and averaged across stocks. Electronic communications networks (ECNs) are proprietary trading systems, such as Instinet, that are used exclusively by marketmakers and large institutions.

Panel A: Aggregate Results

	Stocks with 1/20 Rule Change			Stocks with 2/10 Rule Change		
	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97
Spreads						
Effective ($)	0.255	0.180**	0.179	0.229	0.229	0.169**
Effective (%)	0.710	0.490**	0.500	0.740	0.720	0.560**
Effective ($):						
No ECN at inside	0.255	0.192**	0.189	0.229	0.229	0.179**
Effective ($):						
ECN at inside	na	0.165	0.166	na	na	0.160

Panel B: Results by Trade Size

	Stocks with 1/20 Rule Change		Stocks with 2/10 Rule Change	
	11/1/96–1/19/97	2/10/97–2/28/97	11/1/96–1/19/97	2/10/97–2/28/97
Trade Size (shares)				
100	0.303	0.214**	0.268	0.202**
200–400	0.298	0.206**	0.269	0.196**
500	0.263	0.193**	0.243	0.183**
600–900	0.242	0.186**	0.215	0.170**
1,000	0.269	0.178**	0.242	0.173**
1,100–5,000	0.236	0.165**	0.209	0.155**
5,100–10,000	0.224	0.174**	0.203	0.166**
>10,000	0.220	0.179**	0.199	0.160**

** Indicates that the value is statistically different at the 1 percent level from the preceding value in the same row, within each rule change category.

where $Price_t$ is the transaction price, and Bid_t and Ask_t are the respective inside bid and ask quotes posted at the time of the trade. Effective spreads have been used to measure trading costs in numerous studies, including those by Barclay (1997), Bessembinder (1997), Christie and Huang (1994), Christie et al. (1994), and Huang and Stoll (1996).

Panel A of Table III provides effective spreads before and after the change in the order-handling rules. The volume-weighted effective spread per stock is calculated daily, then averaged across days. A grand mean is then calcu-

lated for each of the two samples. As Table III shows, the mean volume-weighted spread for the first fifty stocks is \$0.26 before January 20, and approximately \$0.18 thereafter. The stocks subject to the rules change on February 10 have a mean volume-weighted spread of about \$0.23 prior to February 10 that falls to \$0.17 afterward. Recall that the minimum quote size was decreased to 100 shares only for the first fifty stocks. Thus, our finding that changes in effective spreads are similar for both samples suggests that the display of limit orders and ECN quotes and not the reduction of the minimum quote size produces the change in trading costs.

The posting of ECN quotes and limit orders appears to contribute to the narrowing of effective spreads. For the first fifty stocks, average effective spreads fall from \$0.255 prior to the new SEC rules to approximately \$0.19 afterward when no ECN is at the inside, and to about \$0.165 when at least one of the inside quotes originates from an ECN. For the second fifty stocks, effective spreads fall from an average of \$0.229 to \$0.179 when no ECN is at the inside, and to \$0.16 when at least one of the inside quotes originates from an ECN. These results suggest that the majority of the decline in trading costs is due to limit orders.

Panel B of Table III provides mean effective spreads by trade size before and after the rules changes for both groups of stocks. For each trade size, a mean effective spread is calculated for each stock. A simple average across stocks is then calculated and reported in the table. We find that effective spreads decline across all trade sizes, but the decline is particularly dramatic for smaller trades. The mean effective spread for trades of fewer than 200 shares declines by almost \$0.10 for the first fifty stocks, and by almost \$0.08 for the second group.

Huang and Stoll (1996) report significant differences in effective half-spreads for matched samples of 175 Nasdaq and NYSE/AMEX stocks in 1991: the effective spreads are \$0.374 for Nasdaq stocks and \$0.158 for listed stocks. Comparison of these numbers with the effective spreads in Table III reveals two important results. First, the effective spreads estimated prior to the new SEC rules are considerably lower than the estimates reported by Huang and Stoll. These differences could be sample-specific, although our sample is biased toward higher effective spreads because only forty-six of our stocks are selected from among the top 200 Nasdaq issues, but Huang and Stoll use the 175 most active stocks in 1991. More likely, the difference reflects the narrowing of spreads on Nasdaq in the wake of the government investigations and increased use of all price fractions. Second, the effective spreads observed after the new SEC rules are implemented are strikingly similar to those in Huang and Stoll for NYSE stocks. Specifically, the average effective spreads in Table III are \$0.179 and \$0.169 for the January 20 and February 10 samples, respectively; Huang and Stoll report an average of \$0.158 for listed stocks. These comparisons demonstrate that the trading costs for Nasdaq stocks converge to those typically estimated for NYSE stocks, underscoring the important role played by limit orders and ECN quotes in promoting competitive trading costs.

We also examine whether the reduction in per-share trading revenues for these Nasdaq stocks is accompanied by a decline in the number of marketmakers. Despite the decline in quoted and effective spreads, we identify a net increase of about one dealer per stock after the new rules took effect. However, our analysis is limited to entry and exit decisions that occur through the end of February 1997. Since these rules imply an increase in competition, we might require a longer time interval to judge the impact on dealer participation. Indeed, Wahal (1997) argues that entry/exit decisions in response to a changing market environment require several months before they are apparent. Thus, our evidence bears only on the short run impact of the SEC order-handling rules.

V. Impact of SEC Rules on Depths and Liquidity

Although our results provide strong evidence that the new SEC order-handling rules have successfully lowered quoted and effective spreads, it is important to assess whether these reductions have come at the expense of market depth. If the lower trading costs are available to only the smallest trade sizes, the benefits of the new rules are dubious. This section uses various measures of depth to assess whether the introduction of limit orders and exposure of quotes placed in proprietary trading systems have materially affected the liquidity of the Nasdaq market.

A. Quoted Depths

We first test whether there has been a significant change in the total number of shares available at the posted inside quotes. For each quote revision, we average the total depth at the inside bid and ask, compute a time-weighted average depth per stock, and average across all stocks for each sample. We also calculate depths separately for inside quotes that exclude ECNs. Table I provides the aggregate quoted depths at the inside market for each sample. The results that include the depth offered by ECNs indicate that for the January 20 stocks, the total inside depth is virtually unaffected by the rules changes. However, including ECN quotes after January 20 overestimates total depth relative to the period preceding the rules changes because the ECN depth was available to marketmakers and institutions prior to January 20, but is not captured in the figures that we report. Thus, we also compute the total depth excluding ECNs to help make cross-regime comparisons more meaningful. The table shows that the total depth excluding ECNs declines from 3,883 shares to 3,656, although this difference is not statistically significant. A reduction in total depth may imply that dealers are exercising their option to post 100 share quotes, or are displaying public limit orders whose size is generally smaller than the minimum sizes previously required of marketmakers—or both.

Finally, Table I shows that for the February 10 sample, total inside depth including ECNs rose from an average of approximately 4,600 to more than 5,200 shares after the implementation of the new SEC rules. Unlike the January 20 sample, the average depth rises from 4,600 to 4,806 shares when ECN quotes are excluded. The increase in depth for the February 10 stocks likely reflects the maintenance of the 1,000 share minimum quote size for these issues. These results suggest that although the impact of the order-handling rules on total inside depth is ambiguous, a significant decline did not materialize.

B. Distribution of Quote Sizes

Although the total depth at the inside market does not appear to have deteriorated, the distribution of quote sizes is affected. Specifically, the display of limit orders and their associated depth significantly increases the dispersion of quote sizes. Furthermore, the ability of marketmakers in the January 20 sample to quote sizes of 100 shares produces a marked shift in the distribution of quote sizes toward the minimum size of 100 shares.

Table IV documents the distribution of quote sizes before and after the rules changes for both samples.[7] Panel A presents the results for all quotes, and Panel B is restricted to inside quotes. Panel A shows that prior to the rules changes, approximately 95 percent of the quote sizes are 1,000 shares and the remaining five percent are 500 shares (the latter are the stocks with 500 minimum quote sizes on SOES). The largest difference between the two phase-in samples lies in the proportion of quote sizes equal to 100 or 1,000 shares after the implementation of the SEC order-handling rules. Among stocks in the January 20 sample, the proportion of 1,000 share quotes declines from 95 percent to 60 percent in the period from January 20 to February 10, and to roughly 70 percent from February 10 to February 28. This decline is met with an equally dramatic increase in the proportion of 100 share quotes from zero percent to greater than 10 percent after the rules changes. These patterns are not replicated for stocks phased in on February 10. For these issues, the proportion of 1,000 share trades never falls below 85 percent, and the proportion of 100 share trades never exceeds three percent after the SEC order-handling rules take effect.

The contrast in these results provides a useful comparison of the impact of limit orders versus the reduction in the minimum size requirement. Specifically, the increase in small quote sizes for the February 10 sample could

[7] The reported chi-square tests whether the proportions are significantly different across time intervals. The expected number of observations is computed by first calculating the proportion of all trades of a specific size using the entire sample period. The expected number of trades is given by multiplying this proportion by the total number of trades within each regime. We then square the difference between the actual and expected number of observations per trade size and scale by the expected number of observations. These values are then summed over all cells. Under the null that the proportions are constant across regimes, the sum is distributed as chi-square with $(n - 1) \times (k - 1)$ degrees of freedom, where n is the number of categories and k is the number of adjacent comparisons.

Table IV

Percentage of Time that Individual Dealers Quote Specific Sizes Surrounding the Introduction of the new SEC Order-Handling Rules

The table provides the average percentage of time that dealers post quotes of specific sizes. The fractions are first computed for each stock by dealer, and then averaged across dealers and stocks. Panel A presents the percentage of time a quote size is reflected independent of whether the quote is at the inside. Panel B is restricted to quotes that lie at either the inside bid or ask. The results exclude quotes posted by electronic communication networks, which are proprietary trading systems, such as Instinet, that are used exclusively by marketmakers and large institutions. The chi-square statistic tests whether the distribution of proportions of different quote sizes differs between the column containing the statistic and the previous column within that rule-change category. All reported chi-square statistics are significant at the 1 percent level.

	Stocks with 1/20 Rule Change			Stocks with 2/10 Rule Change		
Quote Size (shares)	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97
			Panel A: All Quotes			
100	0.0%	19.0%	11.1%	0.0%	0.7%	3.0%
200–400	0.0%	4.5%	4.3%	0.0%	0.5%	2.0%
500	3.7%	9.7%	8.2%	4.6%	2.7%	3.4%
600–900	0.0%	1.6%	1.6%	0.0%	2.1%	1.3%
1000	96.3%	59.9%	69.8%	95.4%	90.8%	84.9%
1100–2500	0.0%	3.8%	4.1%	0.0%	2.4%	4.2%
2600–5000	0.0%	1.2%	0.7%	0.0%	0.8%	0.9%
>5000	0.0%	0.2%	0.2%	0.0%	0.0%	0.2%
Chi-square		47,973	558		3,711	3,525
			Panel B: Inside Quotes			
100	0.0%	13.6%	6.7%	0.0%	0.2%	2.0%
200–400	0.0%	5.5%	4.6%	0.0%	0.6%	2.9%
500	3.4%	7.1%	5.7%	4.5%	2.8%	3.6%
600–900	0.0%	2.6%	2.3%	0.0%	2.7%	2.0%
1000	96.6%	61.2%	72.0%	95.5%	88.7%	80.6%
1100–2500	0.0%	6.7%	6.6%	0.0%	3.3%	6.3%
2600–5000	0.0%	2.9%	1.6%	0.0%	1.4%	2.0%
>5000	0.0%	0.5%	0.4%	0.0%	0.2%	0.6%
Chi-square		11,837	188		1,162	914

only arise from the display of limit orders. The additional increase in the proportion of 100 share quotes observed among the stocks phased in on January 20 is most likely due to the reduction in the minimum quote size to 100 shares.

When we expand our analysis beyond the proportion of 1,000 and 100 share quotes, we find that 25.5 percent of all quotes are less than 1,000 shares once the SEC rules changes take effect for the January 20 sample, compared to only 9.7 percent for the stocks phased in on February 10. This difference is presumably due to the low minimum quote size in the January

sample, because smaller quote sizes among the February 10 sample could only reflect limit orders. Additionally, the proportion of quote sizes exceeding 1,000 shares typically exceeds five percent after January 20, and most likely results from the display of larger limit orders. Across the entire distribution of quote sizes, we find that there is a significant decline in the average quote size among the stocks phased in on January 20, and a slight but significant increase in average quote size among the February 10 stocks.[8]

Panel B of Table IV presents the distribution of quote sizes at the inside market. The percentage of 100 share quotes is not as high as that reported in Panel A, indicating that dealers actively competing for order flow tend to post larger quotes, or that limit orders are typically placed for sizes larger than the marketmaker's minimum obligation. Moreover, the quoted size is considerably larger among quotes that exceed 1,000 shares in Panel B, which provides further evidence that inside quotes are also more aggressive along the dimension of quoted depth.

Finally, the much higher dispersion of quote sizes apparent after January 20 for both samples highlights the increase in the variability of individual dealer quote sizes. Stocks phased in on January 20 experience a greater than twentyfold increase in the standard deviation of individual dealer quote sizes. Stocks phased in on February 10 realize a ten to fifteenfold increase upon the relaxation of the ESR, and an additional increase once the limit order and ECN rules take effect. The total increase in variability of quote sizes for the February 10 sample is similar to the January 20 sample once all stocks are subject to the same rules.

C. Displayed Liquidity and the "Quote Book"

The previous results suggest that although the overall depth at the narrower inside quotes does not deteriorate, the fraction of small quote sizes increases significantly. One concern voiced by critics of the SEC rules was that inside quotes might reflect small limit orders and/or dealer quotes, making it difficult for investors to trade large amounts without affecting prices. We examine this issue by comparing the displayed depth surrounding the rules changes. We construct a "quote" book in much the same way that a "limit order" book is constructed, and estimate the per-share cost of a round-trip trade at increments between 100 and 5,000 shares assuming that trades are executed against posted quotes.[9] For example, consider an investor wishing to execute a 1,500 share market order to buy when the inside spread is $0.25 and the depth at the inside ask is 700 shares. The order is assumed to absorb the 700 shares at the inside ask, and then execute against depth posted at the next lowest ask. If the remainder of the order is exe-

[8] These comparisons are not presented in the table, but are available from the authors on request.

[9] The use of posted quotes is not fully indicative of a dealer's willingness to trade. In some cases, dealers trade larger sizes than their posted quotes. Also, marketmakers may not always honor their quotes, especially when they have just executed a trade at their posted quotes.

cuted when the "revised" inside spread is \$0.375, then the per-share cost is (7/15) ∗ \$.25 + (8/15) ∗ \$.375 = \$0.317. Thus, the quote book incorporates the depth both at the posted quotes and in close proximity to the inside. These costs are estimated every 30 minutes, and averaged across days and stocks.[10]

The results are reported in Table V. Panel A reports the results excluding ECNs, who typically offer greater depth.[11] The table shows that there is almost a 30 percent decline in the per-share costs after January 20 in the first sample, and a similar decline among the second sample of stocks after February 10. The decline is most pronounced for small trades, although the round-trip costs continue to increase with trade size. However, the costs estimated from the quote book decline significantly even among the largest trade categories. These results show that although the new inside spreads have smaller depths under the new SEC rules, overall liquidity improves. Panel B reports the results when the ECN quotes are included. As expected, the round-trip costs decline even further because ECNs offer significant quote sizes. These results hold even for the larger trade sizes, as trades of 5,000 shares realize reductions in costs from approximately \$0.56 to \$0.40 per share.

D. The Distribution of Trade Sizes

Our final analysis of the impact of the SEC rules changes on liquidity focuses on the distribution of trade sizes. Though quote sizes are an important component of liquidity, the distribution of trade sizes provides an important alternative measure of the ability to execute small versus large trades. In particular, we study whether the reduction in the minimum quote size to 100 shares for the January 20 sample yields a shift toward smaller trade sizes.

Table VI provides the distribution of trade sizes *before* the January 20 rules change went into effect, *between* January 20 and February 10, and *after* February 10. We separate trades into size categories for each 100 share increment up to 1,000 shares, then for 1,100–5,000 shares, for 5,100–10,000 shares, and finally for more than 10,000 shares. We then calculate the proportion of all trades that fall within each size category.

[10] Our measure of the "quote" book presumes that quoted depths remain posted during the execution of the particular order size we study. For example, assume a market order to sell 1,000 shares is entered into SOES, and there are five quotes of 200 shares each at the inside bid. We assume that none of the marketmakers update their quotes before the 1,000 share order is executed. An additional complication arises when, in this example, the inside depth is only 800 shares. The execution of the 1,000 share market order would automatically advance to the next lowest price unless a marketmaker has set its quote to auto-refresh, in which case the remaining shares could be executed without a price concession.

[11] The comparison in trading costs using the "quote book" must be interpreted with caution because we are unable to properly account for the depth offered by ECNs prior to the SEC rules change. The ECNs offered real depth to the marketmakers prior to these quotes being folded back into Nasdaq. However, our data do not provide ECN depth prior to the implementation of the SEC rules.

Table V

Costs of Executing Round-Trip Trades of Various Sizes against the "Quote Book" Surrounding the Introduction of the new SEC Order-Handling Rules

The table provides the cost of executing round-trip trades ranging from 100 through 5,000 shares using data on the quoted depths at and around the inside quotes. We first construct a "quote" book using the depths quoted by the individual marketmakers at each price fraction surrounding the inside quotes, and estimate the round-trip costs of completing different size trades at 30-minute intervals. These costs are then averaged across stocks. Panel A presents the results when quotes supplied by electronic communication networks (ECNs) are excluded. Panel B includes the ECN quotes in estimating this cost.

	Stocks with 1/20 Rule Change			Stocks with 2/10 Rule Change		
Trade Size (shares)	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97
Panel A: Excluding ECNs						
100	\$0.33	\$0.24**	\$0.23	\$0.31	\$0.33	\$0.24**
200	\$0.33	\$0.25**	\$0.23	\$0.31	\$0.33	\$0.24**
300	\$0.33	\$0.25**	\$0.24	\$0.31	\$0.33	\$0.25**
400	\$0.33	\$0.25**	\$0.24	\$0.31	\$0.33	\$0.25**
500	\$0.33	\$0.26**	\$0.24	\$0.31	\$0.33	\$0.25**
1,000	\$0.33	\$0.27**	\$0.25	\$0.31	\$0.33	\$0.25**
5,000	\$0.56	\$0.46**	\$0.44	\$0.48	\$0.50	\$0.40**
Panel B: Including ECNs						
100	\$0.33	\$0.21**	\$0.20	\$0.31	\$0.33	\$0.21**
200	\$0.33	\$0.22**	\$0.20	\$0.31	\$0.33	\$0.22**
300	\$0.33	\$0.22**	\$0.21	\$0.31	\$0.33	\$0.22**
400	\$0.33	\$0.22**	\$0.21	\$0.31	\$0.33	\$0.22**
500	\$0.33	\$0.23**	\$0.21	\$0.31	\$0.33	\$0.22**
1,000	\$0.33	\$0.24**	\$0.22	\$0.31	\$0.33	\$0.23**
5,000	\$0.56	\$0.43**	\$0.41	\$0.48	\$0.50	\$0.38**

** Indicates that the value is statistically different at the 1 percent level from the preceding value in the same row, within each rule change category.

Panel A of Table VI provides the distribution of trade sizes for the stocks phased in on January 20, 1997. The most striking result is that trades of 1,000 shares fall from 39.0 percent of all trades before January 20, 1997, to approximately 25 percent once the rules changes take effect. Thus, the reduction in the minimum quote size from 1,000 to 100 shares is accompanied by a steep reduction in the number of 1,000 share trades. In contrast, smaller orders become a larger fraction of all trades. Specifically, the proportion of all trades that are 100 shares increases from approximately 18 percent to 23 percent, and the proportion of all trades between 200 and 900 shares rises from 30 percent to 38 percent.

Table VI

Distribution of Trade Sizes Surrounding the Introduction of the New SEC Order-Handling Rules

The table reports the distribution of trade sizes during different periods surrounding the implementation of the SEC order-handling rules. Trades are classified as entering through SOES, SelectNet, or traditional means (telephone or internalized orders). Panel A presents the results for the sample of fifty Nasdaq stocks phased in on January 20, 1997. Panel B presents the results for the sample of fifty Nasdaq stocks phased in on February 10, 1997. The chi-square statistic tests whether the distribution of proportions of different trade sizes differs between the column containing the statistic and the previous column within that trade-type category. All reported chi-square statistics are significant at the 1 percent level.

	All Trades			SOES Trades			SelectNet Trades			Traditional Trades		
Shares (100s)	11/01/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/01/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/01/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/01/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97
Panel A: Results for Stocks Phased in on January 20, 1997												
1	17.8%	23.7%	21.9%	2.9%	16.3%	10.7%	1.2%	3.7%	3.6%	24.6%	27.2%	26.8%
2–4	16.5%	20.5%	20.3%	2.8%	9.5%	8.3%	1.9%	4.2%	4.8%	22.7%	24.5%	24.9%
5	8.7%	10.7%	11.0%	4.6%	10.0%	10.1%	3.4%	5.8%	6.0%	10.7%	11.2%	11.7%
6–9	4.4%	6.5%	5.9%	0.5%	11.1%	8.8%	1.1%	3.3%	3.1%	5.9%	5.7%	5.5%
10	39.0%	24.8%	27.4%	89.3%	53.3%	62.1%	87.1%	67.7%	67.0%	16.5%	14.2%	14.0%
11–50	11.2%	11.3%	11.1%	—	—	—	5.3%	14.4%	14.2%	15.8%	13.8%	13.7%
51–100	0.7%	0.7%	0.7%	—	—	—	0.2%	0.6%	0.6%	1.0%	1.0%	0.9%
>100	1.7%	1.9%	1.9%	—	—	—	0.0%	0.4%	0.6%	2.5%	2.5%	2.5%
No. of trades	3,183,164	1,292,944	1,295,770	791,565	242,349	253,290	200,976	79,486	97,563	2,190,623	971,109	944,917
Percentage of trades	100%	100%	100%	24.9%	18.8%	19.5%	6.3%	6.1%	7.5%	68.8%	75.1%	73.0%
Chi-square		90,150	3,061		183,019	5,412		15,563	83		6,955	266
Panel B: Results for the Stocks Phased in on February 10												
1	13.8%	14.2%	13.6%	3.4%	3.8%	4.9%	1.0%	1.3%	2.6%	17.7%	18.6%	17.8%
2–4	19.1%	18.6%	18.4%	4.4%	2.6%	6.5%	1.8%	2.2%	4.0%	24.3%	24.6%	24.0%
5	8.9%	9.1%	9.9%	5.5%	6.4%	8.9%	3.2%	2.6%	4.0%	10.2%	10.6%	11.0%
6–9	4.8%	5.0%	5.5%	0.8%	2.4%	4.6%	1.2%	1.6%	2.5%	6.0%	6.2%	6.3%
10	35.1%	35.6%	34.5%	86.1%	82.8%	75.1%	84.9%	80.9%	69.6%	17.6%	16.3%	17.2%
11–50	14.4%	13.5%	13.9%	—	—	—	7.7%	10.6%	15.9%	18.7%	18.0%	17.9%
51–100	1.1%	1.0%	1.1%	—	—	—	0.3%	0.4%	0.8%	1.5%	1.3%	1.4%
>100	3.0%	3.0%	3.0%	—	—	—	0.2%	0.4%	0.6%	4.0%	4.2%	4.3%
No. of trades	1,835,275	587,993	542,233	362,605	127,561	114,322	108,145	44,142	52,570	1,364,525	416,290	375,341
Percentage of trades	100%	100%	100%	19.8%	21.7%	21.1%	5.9%	7.5%	9.7%	74.3%	70.8%	69.2%
Chi-square		494	561		2,291	2,362		554	1,670		735	237

The remainder of Panel A shows the distribution of trade sizes after partitioning the trades into those entered through SOES, SelectNet, or over the phone or internalized (traditional) orders. The SEC rules have had a particularly strong impact on SOES trades, which represent 24.9 percent of all trades prior to January 20, but only 18.8 percent of all trades thereafter. We also observe a dramatic decline in the proportion of SOES trades of 1,000 shares. Before January 20, 1997, 1,000 share trades account for 89.3 percent of all SOES trades. In the first period following the rules change, the proportion falls to 53.3 percent, increasing to 62.1 percent in the period from February 10 to February 28. Thus, the decline in SOES trade size coupled with the decrease in the proportion of trades executed through SOES implies a large decrease in the proportion of volume from SOES.

The proportion of 1,000 share trades executed through SelectNet also drops dramatically after the rules changes. Prior to January 20, 1997, 87.1 percent of SelectNet trades are 1,000 shares, which is close to the 89.3 percent of SOES trades of 1,000 shares and may reflect the use of SelectNet to trade out of positions by SOES traders.[12] After the rules changes, the proportion of trades of 1,000 shares is about 67 percent, which is considerably larger than the percentage of SOES trades of 1,000 shares executed following the rules changes. The elevated proportion of 1,000 share trades on SelectNet may reflect its use by dealers to execute orders against ECN quotes. Further support for this explanation is provided by the dramatic increase in the proportion of large trades executed through SelectNet. Prior to January 20, 5.3 percent of SelectNet trades are 1,100 to 5,000 shares. Afterward, the proportion jumps to 14.4 percent.

Panel B of Table VI reports the results for the stocks phased in on February 10. A comparison of trade sizes for the two phase-in samples provides a rough estimate of the relative impact of these two rules changes, because trade sizes for the fifty stocks phased in on February 10 could only decline from the display of limit orders of fewer than than 1,000 shares. The table shows that the proportion of all trades that are 1,000 shares remains virtually constant at 35 percent throughout the sample period. It is also noteworthy that the proportion of trades executed through SOES holds steady at approximately 21 percent. However, there is a marked decline in the proportion of 1,000 share trades executed through SOES. Specifically, 86 percent of SOES trades are 1,000 shares prior to January 20, and 82.8 percent from January 20 to February 10. After the rules change, the proportion of 1,000 share trades falls further to 75.1 percent. However, this is, far less dramatic than the decline in SOES orders

[12] SOES traders often use SelectNet to unwind positions that are established against marketmaking firms. Though only marketmakers can execute trades on SelectNet, SOES traders can advertise their desire to trade specific quantities at specific prices. Marketmakers then have the option to accept those terms and complete the transaction.

observed for the January 20 rules sample. Thus, it appears that the primary cause of the decline in trade sizes among the January 20 phase-in stocks is the smaller minimum quote size rather than the display of limit orders.

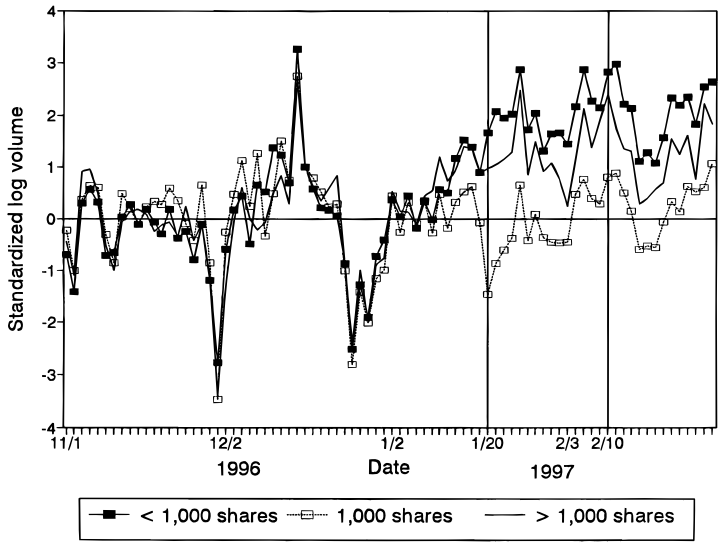
Finally, the proportion of traditional orders for 1,000 shares declines from 16.5 percent prior to January 20, 1997 to 14.2 percent in the second period. The proportion of orders of 1,100 to 4,900 shares also declines from 15.8 percent to 13.8 percent. Smaller trades again become a larger fraction of the total. However, these effects are far less pronounced than the shift in the distribution of trade sizes among SOES and SelectNet trades, implying that the distribution of trades through traditional channels is not materially affected by the SEC rules changes.

The impact of the minimum size rule on the proportion of 1,000 share trades relative to all other trade sizes is further developed in Figure 4. This figure plots the time series of standardized log share volume surrounding the rules changes for each of the two samples, partitioned by the size of the trade. For each sample, we partition trades into three mutually exclusive categories: (1) trades of fewer than 1,000 shares, (2) trades of 1,000 shares, and (3) trades of more than 1,000 shares. Within each category, we compute the aggregate log (share volume) for the period from November 1, 1996, to the trading day before the implementation of the SEC rules. For each trading day, we estimate the standardized log volume by subtracting the mean and dividing by the standard deviation from the preimplementation period.

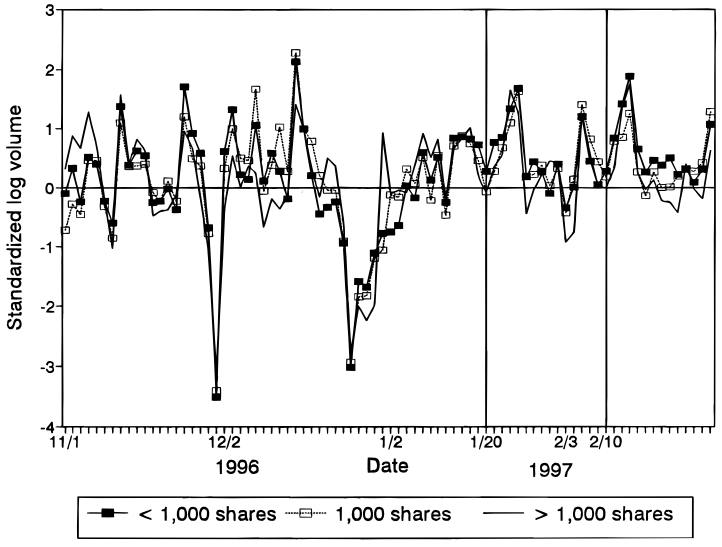
Panel A of Figure 4 presents the results for the sample of January 20 phase-in stocks. During the period prior to the new SEC rules, the three trade series track each other very closely. However, once the new SEC rules are implemented and dealers are free to post 100 share rather than 1,000 share quotes, the frequency of 1,000 share trades declines relative to the frequency of both smaller and larger trades. Panel A also displays a persistent increase in volume after January 20 for trade sizes other than 1,000 shares. Panel B plots the time series of log volume for the February 10 phase-in stocks. Without the presence of the new quote-size rule, the three trade size series do not diverge once the new SEC rules take effect, further supporting the hypothesis that the patterns observed in Panel A result from the dealers' ability to post quote sizes under 1,000 shares.

VI. Characteristics of Dealer Quotes in a Hybrid Dealer/Auction Market

The infusion of competition through the exposure of binding limit orders and the display of the "best price" has led to a significant reduction in trading costs measured using either quoted or effective spreads. However, there are other by-products that emerge from introducing auction-like characteristics into what had traditionally been a pure dealer market. This section examines how the Nasdaq market has changed along dimensions that reflect the interplay between dealers and investors.



Panel A: Stocks Phased In under the New SEC Rules on January 20, 1997



Panel B: Stocks Phased In under the New SEC Rules on February 10, 1997

Figure 4. The time-series of share volume surrounding the new SEC order handling rules. For each sample of phase-in stocks, we partition trades into three mutually exclusive categories: (1) trades of fewer than 1,000 shares, (2) trades of 1,000 shares, and (3) trades of more than 1,000 shares. Within each trade category, we compute the aggregate log(share volume) from November 1, 1996, to the trading day before the implementation of the SEC order-handling rules. We then compute the average and the standard deviation of these series. For each trading day, we estimate the standardized log volume by subtracting the mean and dividing by the standard deviation from the preimplementation period. Panel A presents the results for the stocks phased in on January 20, 1997, and Panel B presents the results for the stocks phased in on February 10, 1997.

A. Impact of the New SEC Rules on the Intraday Pattern of Inside Spreads

Chan, Christie, and Schultz (1995) document that average intraday inside spreads for Nasdaq issues do not follow the U-shaped pattern observed for stocks listed on the NYSE or AMEX (McInish and Wood (1992)). The inside spread for Nasdaq issues remains relatively high after the open, narrows gradually during the day, then falls sharply during the final 30 minutes of trading. Chan et al. attribute the lack of a significant postopening decline among Nasdaq issues as evidence that the rapid narrowing of spreads for listed issues reflects the market power of the specialist at the open. They also consider the narrowing of Nasdaq spreads near the close as evidence of inventory control by dealers who post more competitive quotes to "go home flat."

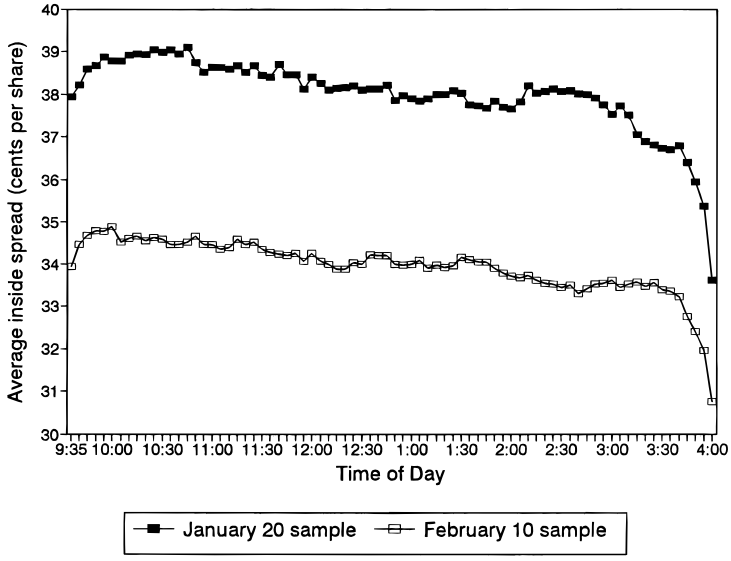
To determine whether the SEC rules changes affected the intraday pattern of inside spreads, Figure 5 plots the average inside spread at the end of each five-minute interval between 9:35 a.m. and 4:00 p.m. for the combined samples. Panel A presents the results prior to the change in the order handling rules. During this period, our sample displays the same intraday patterns as Chan et al. (1995). Spreads increase after the open and attain their intraday maximum by 10:00 a.m.. Spreads decline slightly as trading continues, though not to the same degree as documented in Chan et al. Spreads then narrow quickly during the final 30 minutes of trading. Indeed, the majority of the intraday reduction in spreads occurs during the final half-hour.

Panel B plots the average inside spreads for the two samples under the new rules. The figure indicates that the intraday pattern of spreads has changed. Inside spreads are highest immediately after the open, and drop sharply in the first half-hour of trading. Indeed, the similarity between the pattern in Panel B after the open and the pattern for listed stocks may suggest that the wider spreads on the NYSE/AMEX reflect the inherent price uncertainty after a period of market closure rather than market power. Spreads narrow as the limit order book becomes thicker and price discovery improves.

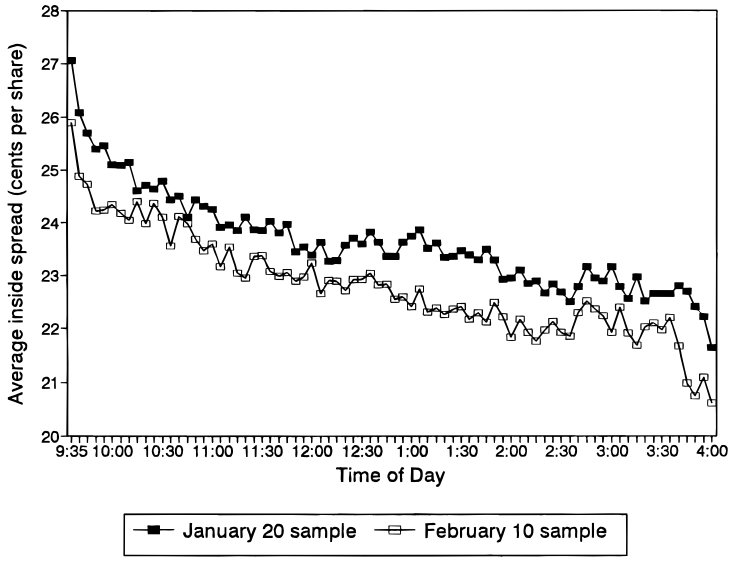
Panel B also shows that spreads narrow significantly during the 30 minutes prior to the close, although the magnitude is significantly reduced under the new SEC rules, since the majority of the intraday decline in spreads is completed prior to the last 30 minutes of trading. The continued narrowing of spreads near the close is consistent with the patterns established in Chan et al. (1995). These results indicate that under the new SEC rules, the intraday patterns for Nasdaq stocks converge to that of listed stocks near the open, but diverge near the close as the inside spreads for listed (Nasdaq) stocks widen (narrow) as the cessation of trading approaches.

B. Quotation Frequency and Location

We might expect the frequency of quote revisions to increase under the SEC order-handling rules. First, dealers that display customer limit orders will need to adjust their quotes to reflect these orders as well as to reflect



Panel A: Period Preceding Implementation of the SEC Rule Changes



Panel B: Period Subsequent to the Implementation of the SEC Rule Changes

Figure 5. The intraday pattern of average inside dollar spreads surrounding the introduction of the new SEC order handling rules. The first fifty stocks are phased in on January 20, 1997, and the second fifty stocks are phased in on February 10, 1997. For each stock, we determine the inside dollar spread nearest the end of each five-minute interval, beginning at 9:35 a.m. and ending at 4:00 p.m.. We then average the inside dollar spread across stocks within each five-minute interval. Panel A presents the intraday average drom November 1, 1997, to the last date prior to the introduction of the new order handling rules. Panel B presents the results beginning either January 20 (for the first phase-in sample) or February 10 (for the second phase-in sample).

Table VII

Quotation Revision Frequency and Participation at the Inside Spread Surrounding the Introduction of the New SEC Order-Handling Rules

This table reports measures of quotation placement activity of individual marketmakers in stocks subject to the new SEC order-handling rules. Panel A presents the daily average number of quote revisions per marketmaker per stock. Panel B presents the percentage of time that individual marketmakers post an inside quote. These figures are assembled by averaging the figures per stock for each marketmaker, then averaging across marketmakers. Electronic communications networks (ECNs) are proprietary trading systems, such as Instinet, that are used exclusively by marketmakers and large institutions.

	Stocks with 1/20 Rule Change			Stocks with 2/10 Rule Change		
	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97
Panel A: Average Number of Daily Quote Revisions						
All marketmakers, excluding ECNs	27.3	36.3**	38.3	17.3	21.6*	24.6*
Instinet	na	265.1	265.1	na	na	156.9
ECNs (excluding Instinet)	na	53.1	63.5*	na	na	43.7
Panel B: Percentage of Time that at Least One Side of the Quote is at the Inside Market						
All marketmakers, excluding ECNs	53%	41%**	42%	54%	49%**	43%**
Instinet	na	76%	77%	na	na	78%
ECNs (excluding Instinet)	na	72%	71%	na	na	70%

*, ** Indicates that the value is statistically different at the 5 percent (1 percent) level from the preceding value in the same row, within each rule change category.

their interest as principals; thus, the frequent display of limit orders inside the dealer spreads will likely result in more frequent quote revisions. Second, narrower inside spreads imply more quote revisions for a given price change; dealers will have to revise their quotes more often to ensure that the quotes are current and to manage their inventory.

Panel A of Table VII reports the average daily number of quote revisions surrounding the implementation of the new SEC rules. The results are computed using all quote revisions, independent of their location relative to the inside spread. We observe a significant increase of roughly 40 percent in the number of quote revisions for each of the two samples of marketmakers (excluding ECNs). A review of the results for the stocks phased in on February 10 indicates that a portion of the increase appears to be attributable to changes in the ESR. The marketmakers in these issues increase their frequency of quote revisions approximately 25 percent between January 20 and February 10, 1997. The remaining increase is likely the result of the display of limit orders. Support for the importance of limit orders in the frequency of quote revisions is provided by Christie and Huang (1994), who report an increase in the number of inside quote revisions of close to

20 percent among issues that list on the NYSE after having traded on Nasdaq. Thus, both the ESR and the display of limit orders appear to have contributed significantly to the increase in the frequency of quote revisions. The table also shows that Instinet quotes are revised six to seven times more often than quotes posted by individual marketmakers, while the other ECNs update their quotes about twice as frequently as individual dealers.

Panel B explores whether the increased frequency of quote revisions translates into an increased participation at the inside market. The panel reports the percentage of time a dealer is on at least one side of the inside market. The table shows that the proportion of time on the inside declines significantly. Again, the period between January 20 and February 10 for the second sample of phase-in stocks shows that a portion of this decline is due to the ESR change. The incremental decline once the new SEC rules apply on February 10 might arise from increased competition from the ECNs and limit orders. Instinet has the highest proportion of time on the inside (more than 70 percent); the other ECNs are much less active. Thus, the SEC's decision to force the display of ECN quotes was a nontrivial change to the structure of the Nasdaq market in light of the participation of ECNs at the inside market.

C. The Width and Variability of Individual Dealer Quotes

The display of limit orders might be expected to narrow individual dealer spreads. However, relaxation of the Excess Spread Rule gave marketmakers much greater freedom to manage their individual quotes. This section studies the net impact of these effects by exploring the average width and variability of individual dealer quotes surrounding the new SEC rules changes.

Panel A of Table VIII reports the average time-weighted dealer spreads for each of the phase-in samples. For stocks phased in on January 20, dealer spreads narrow once the new SEC rules are introduced, and continue to narrow throughout February. Average dealer spreads fall from \$0.87 prior to January 20 to \$0.81 after February 10. This narrowing is even more impressive for inside quotes, where average spreads fall from \$0.86 to \$0.75 over the comparable period. Interestingly, for stocks phased in on February 10, the average time-weighted dealer spread *increases* significantly once the ESR is relaxed, but before the limit order or ECN rules take effect. Thus, the change in the ESR increases dealer spreads by removing a binding constraint. The marginal effect of the ECN and limit order display rules significantly reduces the dealer spreads in both samples.

Comparison of Tables I and VIII indicates that inside spreads narrow approximately 30 percent under the new SEC order-handling rules, yet the width of individual dealer quotes narrows by only 10 percent. These results likely stem from the interplay of two factors. First, because marketmakers typically are only active on one side of the spread (see Chan et al. (1995)), dealer spreads might narrow when the dealer quote reflects a limit order that would not have been previously displayed. This would be particularly

Table VIII

Width and Variability of Dealer Quotes Surrounding the Introduction of the New SEC Order-Handling Rules

This table reports the width of the individual marketmaker quotes, along with the variability of this measure for stocks subject to the new SEC order-handling rules. Panel A presents the average time-weighted dealer spread. Panel B presents the daily time-weighted standard deviation of individual dealer spreads. These numbers are assembled by averaging the figures per stock for each market maker, then averaging across marketmakers and across stocks. Electronic communications networks (ECNs) are proprietary trading systems, such as Instinet, that are used exclusively by marketmakers and large institutions.

		Stocks with 1/20 Rule Change			Stocks with 2/10 Rule Change		
	Quote Type	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97	11/1/96–1/19/97	1/20/97–2/09/97	2/10/97–2/28/97
Panel A: Average Time-Weighted Dealer Spread							
All marketmakers, exluding ECNs	All	\$0.87	\$0.83**	\$0.81**	\$0.79	\$0.87**	\$0.77**
	Inside	\$0.86	\$0.77**	\$0.75**	\$0.78	\$0.84**	\$0.72**
	Outside	\$0.87	\$0.86	\$0.84*	\$0.79	\$0.90**	\$0.79**
Panel B: Time-Weighted Standard Deviation of Dealer Spreads							
All marketmakers, excluding ECNs	All	\$0.017	\$0.167**	\$0.137	\$0.020	\$0.138**	\$0.133
	Inside	\$0.016	\$0.147**	\$0.119	\$0.020	\$0.113**	\$0.122
	Outside	\$0.016	\$0.159**	\$0.127	\$0.019	\$0.143**	\$0.122

*, ** Indicates that the difference between the value in the given cell and the value in the adjacent cell to the left is statistically significant at the 5 percent (1 percent) level, within rule-change categories.

true if a dealer reflects trading interests on both the inside bid and ask. Second, dealers begin using the newly awarded option to increase their quoted spreads due to the relaxation of the ESR. Indeed, the increase in dealer spreads once the ESR is relaxed for the February 10 phase-in sample indicates that dealers take advantage of their new freedom to post wider spreads. Finally, the results in Table VIII are time-weighted, implying that dealers move to the inside and remain there for relatively short intervals.

One implication of the tendency for dealer quotes to narrow through the display of limit orders and to widen after the ESR rule is relaxed is that the variability of each marketmaker's spread-width would increase. Panel B of Table VIII provides evidence on the degree of uniformity of spread-widths across marketmakers by reporting the average, across all dealers and stocks, of the time-weighted standard deviation of dealer spreads. The combination of rules changes narrows average dealer spreads by approximately 10 percent for the sample of stocks phased-in on January 20, and it produces a dramatic increase in the variation of individual dealer spreads as the average variability across dealers increases almost tenfold. The same general pattern emerges for the second group of phase-in stocks between the time the ESR and the remainder of the new SEC rules apply, although the in-

crease in variability is not as large. Thus, the new SEC order-handling rules increase the number of marketmaker quote updates and the dispersion of marketmaker quote sizes, in large part due to the exposure of limit orders and the ability of individual dealers to manage their spread widths.

VI. Conclusions

In the most sweeping reform of a major U.S. equity market in more than 50 years, the SEC began phasing in new trading rules on January 20, 1997, rules that are intended to provide investors with greater opportunities to trade at lower costs. The rules apply to all equity markets, but are specifically targeted at the trading structure of the Nasdaq Stock Market. The most significant of these rules are the requirements that limit orders be executed or exposed to the market, and that superior prices placed in proprietary trading systems by Nasdaq marketmakers be made available to all public market orders. The ability of investors to compete directly with marketmakers and the mandatory display of the best available quote alleviates the fragmentation of price discovery across trading venues and market participants. This paper provides empirical evidence that the reforms succeeded in lowering trading costs among Nasdaq issues phased in under the new rules.

We find that quoted and effective spreads decline approximately 30 percent, providing the tangible benefit to investors that the SEC intended. The reduction in trading costs is most pronounced for stocks whose spreads are relatively wide prior to the new SEC rules and among smaller trades. The incorporation of limit orders and the consolidation of ECN quotes into Nasdaq appear to have significantly narrowed the historical differences in trading costs for Nasdaq and New York Stock Exchange stocks. These results highlight the desirability of incorporating a limit order book in a market structure's design.

We also find that the Nasdaq market remains liquid despite the reduction in trading costs to investors. The average trade size has fallen under the new SEC rules, but we continue to find sufficient depth at the posted quotes to suggest that an investor's round-trip transactions cost has unambiguously fallen under the new rules. The market also appears resilient, with no observed decline in the number of dealers participating in the phase-in stocks. This resiliency also surfaced on October 27, 1997, when prices in the U.S. equity market declined more than seven percent. The trading structure was able to accommodate more than one billion shares, with only limited delays in execution. These results are similar to those reported by Christie and Schultz (1998) in their study of the market break of November 15, 1991.

The restructuring of the Nasdaq market represents a milestone in the evolution of one of the worlds foremost capital markets. Our findings suggest that these reforms have produced a more competitive and efficient trading system. The NASD, the Nasdaq stock market, and particularly the SEC can take pride in the smooth and successful transition to a radically different trading environment.

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