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Competition on the Nasdaq and the Impact of Recent Market Reforms

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ABSTRACT

This paper examines the effect of recent market reforms on the competitive structure of the Nasdaq. Our results show that changes in inventory and information costs cannot explain the post-reform decrease in bid-ask spreads. We interpret this as evidence that the reforms have reduced Nasdaq dealers' rents. Additionally, we find that the difference between NYSE and Nasdaq spreads have been greatly diminished with the new rules. Further, the reforms have resulted in an exit, *ceteris paribus*, from the industry for market making. Overall, our results provide strong evidence that the reforms have improved competition on the Nasdaq.

ON JANUARY 20, 1997, the Securities and Exchange Commission began implementing a new set of regulations that have drastically changed the way the Nasdaq handles orders. These regulations were formulated in response to evidence of imperfect competition under the Nasdaq's previous trading rules. The avoidance of odd-eighth quotes documented by Christie and Schultz (1994) and the large difference in trading costs compared to the NYSE, reported by Huang and Stoll (1996), have led some researchers and policymakers to question the efficiency of the Nasdaq's dealer market structure. One result of this intensified scrutiny of the Nasdaq has been the imposition of a new set of trading rules aimed at reducing investors' trading costs and promoting greater competition without adversely affecting market quality. The purpose of this study is to investigate how effective these market reforms have been at improving the competitive structure of the Nasdaq.

The competitiveness of dealer and auction market systems has recently become a contentious debate in both political and academic spheres. Proponents of dealer markets such as the Nasdaq argue that competition for order flow between market makers reduces transaction costs. Moreover, the ease of entry and exit in dealer markets may also contribute to lower trading costs. Conversely, proponents of auction market systems argue that exposing limit orders to the public lowers trading costs by allowing investors to trade with each other directly. Additionally, the presence of scale economies in market making suggests that the specialist system in auction markets, such

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as the NYSE, may be more efficient in lowering trading costs. Finally, recent theoretical work by Viswanathan and Wang (1998) shows that, under certain conditions, a hybrid market structure with both multiple dealers and exposure to limit orders may be preferred over other exchange types.

Apart from the relative merits and drawbacks of both systems, there has been increasing evidence that the Nasdaq system of trading suffered severely from imperfect competition prior to the imposition of the reforms. The assertion by Christie and Schultz (1994) of tacit collusion among Nasdaq market makers and the evidence of unusually large spreads, relative to other trading systems, called into question the competitiveness of the Nasdaq market.[1] Further, evidence of practices such as payment for order flow and preferenced trading on the Nasdaq suggests that dealers may attract order flow through non-price competition, which could prevent large spreads from being competed away.[2]

The new regulations have increased competitive pressure on Nasdaq market makers in two primary ways. First, they require that public limit orders be allowed to compete with Nasdaq market makers. Second, market makers who post orders on proprietary trading systems are now obligated to make those orders available to the public as well. Prior research by Barclay et al. (1999) is the first to examine the impact of these market reforms. They find that the objectives of the new SEC rules have largely been met: Nasdaq spreads have fallen dramatically without adversely affecting market quality.[3] While Barclay et al. (1999) show that the new market reforms have resulted in lower trading costs, no study thus far has directly addressed whether the new SEC rules have been successful in their goal of promoting greater competition among providers of liquidity on the Nasdaq.

In this paper, we directly examine the effect of these market reforms on the competitive structure of the Nasdaq. We find that the reforms have reduced market frictions that previously existed on the Nasdaq and have resulted in more competitive pricing of dealer services. Specifically, we find that market-maker rents fell after the imposition of the reforms. To accomplish this, we investigate which components of the spread are affected by the new rules. Our results show that the large decline in spreads cannot be attributed to changes in adverse information or inventory costs. We interpret these results as evidence that, prior to the new rules, the Nasdaq dealer market structure afforded market makers supracompetitive profits. This analysis provides direct evidence that the market reforms have successfully promoted more competitive pricing on the Nasdaq.

[1] For example, Huang and Stoll (1996) and Bessembinder and Kaufman (1997) find that trading costs for the Nasdaq are considerably larger than on the NYSE. Similarly, Barclay (1997) and Barclay et al. (1998) find that firms realize a decrease in spreads when they switch exchange listing from the Nasdaq to the NYSE.

[2] See Easley, Kiefer, and O'Hara (1996), Bloomfield and O'Hara (1998), and Kandel and Marx (1999).

[3] Barclay et al. (1999) examine a sample of the first 100 Nasdaq stocks subject to the new regulations. They find that quoted bid-ask spreads fell by roughly one third under the new regulations. Similarly, they report large declines for other measures of trading costs.

In addition to the decrease in Nasdaq dealer rents, we provide further evidence that the reforms have forced increased competition on the Nasdaq. First, we examine how effective this increased competition has been in reducing investors' trading costs relative to other trading systems. The reforms impose new competition from public limit orders on the Nasdaq—competition that has always been present on the NYSE. If these new regulations successfully force Nasdaq dealers to compete with public limit orders, we should expect to see execution costs narrow to levels comparable with those on the NYSE. We find that this new competition has indeed reduced Nasdaq spreads to levels similar to those at the NYSE.

Further, if the reforms have been successful at promoting competitive pricing and reducing market-maker rents, we should also expect to see exit from the market for market making.[4] To test this, we examine the impact of the reforms on Nasdaq market-maker entry and exit. We find that the reforms have caused, *ceteris paribus*, a net reduction in the average number of Nasdaq market makers. Finally, we find that the market for dealer services is less concentrated after the reforms. These results are also consistent with the hypothesis that the reforms have successfully reduced market-maker rents, forcing exit from the industry, and improving competition among remaining dealers.

Overall, the results of this study show that the imposition of the new SEC order-handling rules has significantly improved the competitive structure of the Nasdaq. Further, our work provides empirical evidence that a hybrid market structure, with both multiple dealers and public limit orders, reduces trading costs relative to a strict dealer market, though spreads are no smaller than on auction markets. These findings are consistent with recent theoretical work by Viswanathan and Wang (1998).

The remainder of the paper proceeds as follows. In Section I we provide a brief description of the regulations and data. In Section II we perform a decomposition of the bid-ask spread both before and after the new rules, to test what components of the spread have changed. Section III describes the matching procedure and compares trading costs between the Nasdaq and the NYSE for the matched sample of stocks. In Section IV we model the entry and exit decisions of market makers on the Nasdaq. Section V examines how the reforms affected the market concentration of dealer services. Section VI concludes.

I. Regulations/Data

A. Description of the New Order-handling Rules

The new rules represent a set of changes that affect Nasdaq trading on a number of levels. The Nasdaq began implementing these changes in a number of phases. The first phase took effect on January 20 and affected 50

[4] This may only be true if the practice of order preferencing does not change after the reforms. Kandel and Marx (1999) find that a reduction in market maker profits could lead to less order preferencing and hence, net entry by market makers.

stocks. On February 10 a second phase of 50 stocks were brought under the new rules. The rest of the Nasdaq securities were similarly phased in over the following months. Barclay et al. (1999) provide a thorough and detailed description of the new regulations. We provide only a brief description below.

These new rules represent two major changes to the previous trading rules.[5] The first of these permits public limit orders to compete directly with dealer quotes. Previously, public limit orders inside of a dealer's posted quotes were not publicly available. Under the new rules, when a Nasdaq dealer receives a limit order it may be executed against his own inventory, posted as a new quote, or sent to another market maker. This allows limit orders that come to a dealer inside of the quoted spread to take precedence over orders outside the spread or to become a new quote for the dealer. For example, if Microsoft is quoted at \$100 by $\$100\frac{1}{2}$ and a buy order comes in at $100\frac{3}{8}$, the trade may be executed at that price or the dealer may post a new quote as $\$100\frac{3}{8}$ by $100\frac{1}{2}$, reducing the spread by $\frac{3}{8}$. Although this new rule also applies to the NYSE, this does not represent a change in NYSE trading rules, where public limit orders are already posted and take precedence over specialist trades.

The second new rule involves quotations on proprietary trading systems. These electronic communication networks (ECNs), like INSTINET, are used mostly by dealers to trade with each other anonymously. Quotes on these networks were allegedly often narrower than public quotes. The new SEC rules force greater public access to these proprietary systems. First, market-maker quotes on an ECN may be anonymously shown to the public. Alternatively, if the market maker chooses to post the ECN quote directly on Nasdaq (revealing his identity), he is not required to post a depth larger than the minimum required depth. For example, a market maker that posts a bid of Microsoft for \$100 at a depth of 5000 shares on INSTINET has two choices. He can anonymously expose that bid to the public at the full depth, or he may directly post the bid on Nasdaq (revealing his identity), but only post a depth of at least 1000 shares to the public.

B. Data

Data are obtained from the TAQ database provided by the NYSE. Out of the 50 stocks from each the first two phases, we select those Nasdaq issues for which there is data for 90 days before and after the phase-in date and for which we can match data from CRSP. Further, we require that there be no stock splits during the sample period. As a result, our sample includes 44 Nasdaq stocks from the first phase of the new rules and 44 stocks from the second phase for a total of 88 Nasdaq issues. We also select three samples of 88 NYSE firms using the matching procedure described in the Section III.

[5] In addition to these two major changes, there are three other changes imposed by the new rules. These relate to minimum quote sizes, exposure to SOES trading, and the excess spread rule. Barclay et al. (1999) provide a thorough description of all the new rules.

We select data for each of the Nasdaq and NYSE stocks for 90 trading days prior to and following the implementation of the new SEC rules. That is, for the first phase, we select data from September 16, 1996 to May 23, 1997. For the second phase data are selected from October 7, 1996 to June 16, 1997.

For each issue, we select only those trades that clear on the primary exchange for that stock. All regular way trades are collected for each day. We then filter the data for errors using the following methodology suggested by Huang and Stoll (1996):

1. Exclude quotes and prices if they are not in multiples of 1/16th.
2. Exclude observations where the bid-ask spread is greater than \$4 or less than \$0.
3. Exclude observations when the price, ask, or bid return is greater than 10 percent.

In addition, we exclude the first trade on each day for the NYSE issues since these trades result from a batch auction. These filters eliminate less than 3 percent of our sample. Section III contains a description of both the Nasdaq and NYSE samples.

Trades are matched to relevant quotes using a 10-second delay. This procedure accounts for the fact that trades are often recorded after they occur (Lee and Ready (1991)). On the Nasdaq, dealers are required to report trades within 90 seconds. Thus, to the extent that dealers take longer than 10 seconds to report trades, we introduce measurement error into estimates that rely on both trade prices and quotes (e.g., effective spreads and our trade indicator variables). Lee and Ready suggest using a five-second delay to correct for the different reporting times. Although the five-second rule is the most commonly used, Hasbrouck, Sofianos, and Sosebee (1993) report a median delay of 14 seconds. If the delay is too long, however, then we could err on the side of matching trades to stale quotes. Nevertheless, these concerns are partially mitigated by the fact that averages are computed over large numbers of transactions for all stocks and there is no reason to predict any systematic bias using the 10-second algorithm.

Unlike the data used by Barclay et al. (1999), who have individual dealer data provided by Nasdaq, the TAQ data does not include trades executed on most proprietary systems like Select Net. However, the data does include trades executed on INSTINET, though these trades are not separately identified. In addition, our data does not allow us to identify trades executed on the Small Order Execution System (SOES). To the extent that trading costs vary over these different venues, we are unable to identify how the market reforms affect trading costs in these areas. However, because all SOES trades are 1,000 shares or less, our analysis by trade size allows for some estimation of these trades.

II. Components of the Bid-Ask Spread and Dealer Rents

Given the pre-reform evidence of imperfect competition on the Nasdaq, dealers may have been able to earn supracompetitive profits under the previous set of trading rules. If this is true, then the imposition of greater competition should force dealers to reduce bid-ask spreads and lead to a decrease in any economic profits. Although Barclay et al. (1999) show that the reforms resulted in a dramatic decrease in spreads, they do not test whether this decline represents a decrease in economic profits or a real reduction in market-making costs. In this section we directly test whether the large decline in Nasdaq spreads can be attributed to a reduction in market-maker rents.

To accomplish this, we ask whether the decrease in bid-ask spreads can be attributed to a particular component of the spread or to a uniform decrease in all. According to microstructure theory, the spread typically has four parts: order-processing costs, inventory-holding costs, adverse-information costs, and market-maker rents or economic profits.

Order-processing costs arise from the simple fact that the market maker incurs a cost in clearing trades. This was the component first studied by Demsetz (1968) in his estimation of the transaction cost of exchange. Order-processing costs include the fixed cost of holding a seat on the exchange, paperwork, and administrative costs. As the new regulations do not change any of the administrative or overhead costs on the Nasdaq, it is unlikely that the reforms have affected order-processing costs.

Inventory-holding costs stem from the market maker's personal position in the stock. To clear trades smoothly, the dealer generally holds a positive inventory of shares in his portfolio. Thus, part of the spread stems from the excess return that the market maker must earn to be compensated for holding a nondiversified portfolio. To prevent this inventory from becoming unbalanced, the specialist may adjust the spread to induce orders at the bid or ask side, to return his market position to equilibrium. The imposition of the new rules could have an effect on inventory costs in a number of ways. Because market makers must now post inside orders at the market bid/ask, they may have less ability to adjust quotes for inventory purposes (although the market maker does retain the right to send the order to another dealer). Also, the new visibility of quotes posted on proprietary trading systems may increase dealers' inventory costs. If this visibility makes it more difficult for dealers to price discriminate, charging large spreads to the public while maintaining tighter spreads on interbroker systems, then the ECN rule could make it relatively more expensive to purchase inventory through interbroker systems.

Adverse-information costs have been the most frequently studied component of the spread. In theory, market makers face trades with two stylized types of agents—informed traders and liquidity traders (Kyle (1985)). Informed traders have information about the true value of the security that the market maker does not. Liquidity traders, on the other hand, do not execute trades based on any private information. As their name reveals, they buy and sell purely for liquidity purposes. When the market maker trades with informed traders, he faces an adverse-selection problem: better-informed investors buy when the market maker sets the ask price too low and sell when the bid price is set too high. Faced with this adverse-selection cost from informed traders, the market maker will widen the spread (relative to the spread in the absence of informed traders) to mitigate losses. By widening the spread, the market-maker gains profits from trading with liquidity traders, offsetting the losses to informed traders. Because this component of the spread is a function of the proportion of informed trading and the frequency of information events (like earnings or merger announcements), it is unlikely that the new regulations will affect information costs.

Market-maker rents. Since Bagehot's (1971) argument that the NYSE specialists' position as the "only game in town" may enable them to earn economic profits, the issue of imperfect competition in market making has created heated debate. Lending support to the existence of rents, Brock and Kleidon (1992) argue that large spreads near the open and close of trading may reflect the NYSE specialists' ability to peak-load price during periods of high-inelastic demand for trading. Additionally, McInish and Wood (1995) find that the bid-ask spread for a sample of NYSE issues is negatively related to competition from regional exchanges. They argue that without this competition for order flow, the specialist may quote larger spreads.

The existence of such rents has also been alleged in dealer markets like the Nasdaq. Christie and Schultz (1994) and Christie, Harris, and Schultz (1994) suggest that dealers' reluctance to post odd-eighth quotes raises the suspicion of collusion on the Nasdaq. In a similar vein, Huang and Stoll (1996) find that Nasdaq spreads are significantly larger than spreads for comparable NYSE listed firms. Further, Barclay (1997) and Barclay, Kandel, and Marx (1998) find that firms who switch exchange listing from the Nasdaq to the NYSE enjoy a large reduction in the quoted spread. As a result of this mounting evidence, the allegation of imperfect competition on the Nasdaq has been one of the driving forces behind the new SEC rules. Because these rules have been aimed directly at promoting greater competition on Nasdaq, we expect market-maker rents (to the extent they exist) to fall under the new rules.

A. Estimation

To test what components of the spread have changed since the new rules were implemented, we decompose the spread using the empirical model of Huang and Stoll (1997). They derive a simple model that allows a one-step decomposition of the information and inventory components as a percentage of the spread. The remaining spread stems from order-processing costs and market-maker rents.

The model identifies these components by measuring how the midpoint of the spread, M_t, changes as a function of the direction of the last trade. They define an indicator variable, Q_t, which takes on the values $\{-1,0,1\}$ based on the direction of the last trade. That is, define P_t as the transaction price at time t and S_t as the time t quoted spread. Q_t is then defined as follows: $Q_t = -1$ if $P_t < M_t$ (indicates a sell order); $Q_t = 0$ if $P_t = M_t$; $Q_t = 1$ if $P_t > M_t$ (indicates a buy order). ϵ_t represents the random (i.i.d.) public information shock at time t. The regression equation is then specified as:

$$\Delta M_t = \alpha\left(\frac{S_{t-1}}{2}\right)Q_{t-1} + \epsilon_t \tag{1}$$

where α measures the proportion of the half spread, $S_{t-1}/2$, that stems from inventory and information costs. The remaining proportion of the spread $(1 - \alpha)$ results from order-processing costs and market-maker rents. Note that this specification combines both inventory and information effects into one parameter, α.

To understand the intuition behind this model, consider the limiting cases. If $\alpha = 0$, then the previous trade provided no information and had no effect on the dealer's equilibrium inventory. As a result, there should be no reason for the midpoint of the spread to change. In this case, orders simply bounce between a fixed bid and ask as the true value of the security follows a martingale sequence. On the other hand, if $\alpha = 1$, then the last trade signals to the dealer that the trade was fully informative or reflected a change in desired inventory. As a result, the market maker moves the midpoint of the spread to the last transaction price. That is, the dealer moves the spread to straddle the last bid (following a sell order) or ask (following a buy order). For values of α between 0 and 1, the amount by which the dealer moves the midpoint of the spread in reaction to the last trade measures the amount of the spread attributable to these components.

The regression specified by equation (1) assumes that the adverse-selection/inventory component of the spread is uniform over all trade sizes. However, Lin, Sanger, and Booth (1995) and Huang and Stoll (1997) provide evidence that α is an increasing function of trade size. If dealers use the profits from small (less-informed) trades to offset smaller profits (or losses) from large (better-informed) trades, then we might expect the reforms to affect the components of the spread differently by trade size.

To allow α to vary with trade size, we generalize equation (1) following Huang and Stoll (1997) as:

$$\Delta M_t = \alpha^{small}\,\frac{S_{t-1}}{2}\,D_{t-1}^{small} + \alpha^{medium}\,\frac{S_{t-1}}{2}\,D_{t-1}^{medium} + \alpha^{large}\,\frac{S_{t-1}}{2}\,D_{t-1}^{large} \tag{2}$$

where

$$D^{small} = Q_{t-1} \text{ if share volume at time } t \leq 1{,}000 \text{ and 0 otherwise.}$$
$$D^{medium} = Q_{t-1} \text{ if share volume at time } t \text{ is between 1,000 and 10,000 and 0 otherwise.}$$
$$D^{large} = Q_{t-1} \text{ if share volume at time } t \geq 10{,}000 \text{ and 0 otherwise.}$$

This model allows us to estimate α separately for each trade size category both before and after the new rules.

B. Results

We estimate equations (1) and (2) using GMM with robust standard errors for all 88 Nasdaq stocks both before and after the imposition of the new rules. GMM is appropriate for a number of reasons. First, the error term may not be normally distributed given the discrete nature of tick sizes. Additionally, the error term may contain conditional heteroskedasticity of an unknown form as well as serial correlation. Hansen (1982) shows that our estimate of α will be consistent and normally distributed using GMM. We use the Newey–West procedure to obtain a robust covariance matrix for our estimate. Our only orthogonality condition is that the independent variables be orthogonal to the error term. This implies that our coefficient estimates are identical to OLS but with robust standard errors.

First, we estimate α across all trade sizes for the 90 trading days prior to the new regulations and then again for the 90 days after. We then estimate equation (2) both before and after the new rules. Table I describes the results of our estimation for equations (1) and (2). All estimates of α are statistically significant at the 5 percent level.

B.1. Results for All Trades

On average across the 88 Nasdaq stocks, the adverse-selection/inventory components for all trades are 4.1 percent of the spread before the new rules and increase to 7 percent after. Additionally, the median, minimum, and maximum estimates of these components also increase, whereas the order-processing costs, as a percentage of the spread, decrease. We find an increase in these components of the spread for 78 out of the 88 stocks. These results suggest that, as a percentage of the spread, information and inventory costs have risen with the implementation of the new rules.

However, the information/inventory parameter is estimated as a percentage of the spread. Because the level of the spread has also changed with the imposition of the new rules, we need to compute the actual dollar costs of these components both before and after the new rules. We construct the

Table I

Components of the Bid-ask Spread

This table presents a comparison of the information and inventory components of the bid-ask spread before and after the imposition of the new-order handling rules. The information component of the spread is constructed for all trades by estimating the parameters from the regression suggested by Huang and Stoll (1997): $\Delta M_t = \alpha\,(S_t/2)Q_t + \epsilon_t$ where ΔM_t represents the time t change in the midpoint of the quoted spread (S_t), Q_t is a buy/sell indicator variable, and ϵ_t is an i.i.d. public information shock. For results by trade size, the regression includes three trade-size dummy variables that allow α to be estimated separately for each size category. The information component of the spread, α, is estimated separately for the 90 day period before and after the new rules. All estimated coefficients are significant at the 5 percent level. Order-processing costs and market-maker rents are constructed as $(1 - \alpha)$. Dollar cost of the components are constructed for each stock by multiplying the components of the spread (%) by the average effective spread over the sample for each stock. Reported statistics are equally weighted means across the 88 Nasdaq stocks. Small trades are transactions of 1,000 shares or less. Medium trades contain between 1,001 and 9,999 shares, and large trades contain all transactions of 10,000 shares or more.

	Pre-SEC Rule Change				Post-SEC Rule Change			
	Information & Inventory		Order Processing & Rents		Information & Inventory		Order Processing & Rents	
	(% of spread) (1)	($ cost) (2)	(% of spread) (3)	($ cost) (4)	(% of spread) (5)	($ cost) (6)	(% of spread) (7)	($ cost) (8)
Average								
All trades	4.10%	0.012	95.90%	0.271	6.80%	0.013	93.20%	0.171
Small	4.10%	0.012	95.90%	0.270	6.60%	0.013	93.40%	0.172
Medium	4.90%	0.014	95.10%	0.268	7.80%	0.015	92.20%	0.169
Large	4.50%	0.013	95.50%	0.269	8.70%	0.017	91.30%	0.168
Std Dev.								
All trades	0.021	0.009	0.021	0.129	0.026	0.008	0.026	0.060
Small	0.024	0.010	0.024	0.128	0.027	0.008	0.027	0.059
Medium	0.025	0.009	0.025	0.128	0.029	0.008	0.029	0.060
Large	0.020	0.011	0.020	0.126	0.028	0.009	0.028	0.059
Median								
All trades	3.80%	0.010	96.20%	0.230	6.80%	0.012	93.20%	0.147
Small	3.80%	0.010	96.20%	0.229	6.70%	0.011	93.30%	0.147
Medium	4.50%	0.012	95.50%	0.228	7.90%	0.015	92.10%	0.144
Large	4.10%	0.011	95.90%	0.228	9.30%	0.015	90.70%	0.143
Min								
All trades	0.50%	0.001	99.50%	0.126	1.40%	0.002	98.60%	0.075
Small	1.40%	0.001	98.60%	0.126	1.30%	0.002	98.70%	0.076
Medium	1.30%	0.002	98.70%	0.125	1.80%	0.002	98.20%	0.075
Large	1.80%	0.002	98.20%	0.122	2.20%	0.003	97.80%	0.073
Max								
All trades	9.80%	0.043	90.20%	0.640	15.20%	0.035	84.80%	0.392
Small	15.20%	0.047	84.80%	0.628	14.70%	0.037	85.30%	0.389
Medium	13.00%	0.041	87.00%	0.638	17.50%	0.041	82.50%	0.393
Large	11.30%	0.076	88.70%	0.597	14.00%	0.045	86.00%	0.379

dollar costs by multiplying the percent of the spread due to information/inventory effects, α, by the level of the effective spread. This statistic measures the actual cost per trade to investors of these components.[6]

As seen in Table I, this measure shows that, although the relative cost of the information/inventory components has increased considerably after the new rules, the dollar value of these components has changed by only one-tenth of a penny on average (from \$0.012 to \$0.013). Although this difference is statistically significant, it is economically insignificant. These results show that, although information/inventory costs have increased as a percentage of the spread, the actual cost of these components to investors has not changed with the imposition of the new rules.

The dollar value of order-processing costs and market-maker rents are constructed by computing the portion of the spread not explained by information and inventory effects ($1 - \alpha$). Table I shows that the dollar value of the order-processing cost and market-maker rents over all trades have fallen by 10.0 cents per trade after the new rules (from \$0.271 to \$0.171).

B.2. Results by Trade Size

Because medium- and large-sized trades are more likely to be informed than small trades, we might expect market makers to cross-subsidize over trade sizes.[7] That is, market makers could earn a higher marginal profit off small trades than off large trades, using the profits from small uninformed trades to offset smaller profits (or losses) from clearing large trades. To the extent that the new rules decrease the market makers' ability to earn economic rents, we might expect rents from small trades to decrease more than from large trades.

The results presented in Table I for all trades are remarkably consistent with the results by trade-size category. First, as previously documented, our estimate of α typically increases with trade size. After the imposition of the new rules α increases for all three trade-size categories, with the biggest increase for large trades (from 4.5 percent to 8.7 percent). Similarly, order-processing cost and market-maker rents decrease across all trade-size categories, both as a percentage of the spread and in dollar value.

After the market reforms, order-processing costs and market-maker rents fall, on average, 9.8, 9.9, and 10.1 cents for small, medium, and large trades, respectively (Table I, column 4–column 8). Similarly, the median value of

[6] The effective spread is defined as:

$$effectiveSpread = 2\left|price - \left[\frac{Ask + Bid}{2}\right]\right|$$

This measure of trading costs accounts for trades executed inside the bid-ask spread and, as such, may provide a better measure of actual execution costs.

[7] For example, Lin, Sanger, and Booth (1995) and Huang and Stoll (1997) find that information costs increase monotonically with trade size, and Barclay and Warner (1993) find that medium-sized trades contain the most information.

order-processing costs and market-maker rents fall, 8.2, 8.4, and 8.5 cents for small, medium, and large trades, respectively (Table I, columns 4–8). Although this decrease is positively related to trade size, the post-reform change in order-processing costs and market-maker rents varies by only three-tenths of a penny from small to large trades. These differences are not economically significant.

Our results show that the components of the spread attributable to order-processing costs and market-maker rents decline uniformly across trade-size categories. These results suggest that, if market makers were earning supracompetitive profits, they did so equally across trade sizes. Note that these results do not provide evidence that market makers do or do not cross-subsidize trades—only that, to the extent that market makers earned rents, these rents declined uniformly over all trade sizes.

C. Price Impact of Trades and the Realized Spread

The results in Section I.B suggest that market makers have lost economic rents through a reduction in spreads. However, the spread is not the only measure of trade quality. If market-maker profits fall, and market makers consequently become less active, then the price impact of a trade may increase. Our components of the spread analysis measures the price impact of a trade only from transaction to transaction. In this section, we consider changes in the price impact of a trade both before and after the new rules over a longer time horizon than one transaction. If the market reforms have led to an increase in the price impact of a trade, then investors, although benefiting from the decrease in spreads, suffer from a less resilient market. Investors who wish to execute a trade without a large impact on price may be willing to pay a higher spread. To compare trade execution costs in the pre- and post-reform environments, we must be sure that the market has not changed along these other dimensions of liquidity.

We define the price impact of a trade to be the percentage difference between the midpoint of the spread and the midpoint of the spread that arises after the trade is executed multiplied by our trade indicator variable:

$$\text{Price impact}_t = \left[\frac{M_t - M_{t+\tau}}{M_t}\right] Q_t$$

where τ is the time horizon after the trade is executed. We estimate the price impact using $\tau = 10$ minutes.[8]

[8] Estimates were also computed using $\tau = 5$ minutes and $\tau = 30$ minutes. Results do not vary qualitatively. Huang and Stoll (1994) also find little difference between a 5-, 10-, and 30-minute rule.

In addition to the price impact of a trade, we estimate the realized spread. The realized spread is the revenue to the market maker net of the price impact. This variable is defined as the absolute difference between the midpoint of the spread and the transaction price less the price impact or

$$\text{Realized spread} = \text{effective half spread} - \text{price impact}$$

where the effective half spread and price impact are measured as a percentage of the midpoint of the spread. Comparing the realized spread before and after the rules allows us to test whether changes in the price impact of a trade explain part of the decline in spreads after the new rules. Because we expect larger trades to have more price impact than smaller trades, we estimate the price impact of a trade and the realized spread for all trades and for the three trade-size categories described in Section I.B.

Table II presents the results for our measures of price impact and the realized spread. Panel A shows that, for all trades, the price impact in the pre-reform period is 0.105 percent. As expected, price impact increases with trade size from 0.091 percent for small trades to 0.261 percent for large trades prior to the imposition of the new rules (Table II, Panel A, column 1). This implies that a small sell order on a $30 stock would decrease the midpoint of the spread by roughly $\frac{1}{32}$, whereas a large order would reduce the price, on average, by just over $\frac{1}{16}$.

Comparing columns 1 and 2 of Table II (Panel A), we find that the price impact of a trade has actually decreased after the imposition of the new rules across all trade-size categories. However, none of these differences are significantly different from zero (Table II, Panel A, column 3). These results suggest that there has been no change in the price impact of a trade in the Nasdaq market after the recent reforms. These results are consistent with our decomposition of the spread presented in Section III.B.

Part of the reason for this finding may be that trading volume in the post-reform market is larger than during the pre-reform period. Barclay (1997) finds that firms who switch exchange listing from the Nasdaq to the NYSE (during the pre-reform period) enjoy a large reduction in spreads and a significant increase in trading volume. In our sample, post-reform volume increased by 32 percent on average with an increase for 64 out of the 88 stocks. Additionally, the average number of trades per day increased 38 percent on average with an increase in 71 of the stocks. Perhaps the increased willingness of investors to trade after the decline in transactions costs improves the liquidity of the market to the extent that trades have less price impact. Nevertheless, our results show that the difference in trading costs between the pre- and post-reform environments cannot be explained by any change in the price impact of a trade at either the transaction level, or at longer horizons.

Given that the price impact of a trade has not increased after the market reforms, it is not surprising to find that the realized spread has decreased dramatically in the post-reform period. Panel B of Table II shows realized

Table II

Price Impact of a Trade and the Realized Bid-Ask Spread

This table presents a comparison of the average price impact of a trade and the realized spread before and after the imposition of the new order-handling rules for a sample of 88 Nasdaq stocks. Data are collected from the NYSE's TAQ files. Means for each firm are computed using all trades 90 day prior to the new rules and then the following 90 days. Reported averages are the equally weighted cross-sectional means across the 88 stocks. Trade impact is calculated as the percentage increase (decrease) for buy orders (sell orders) in the midpoint of the spread from the time of the trade to 10 minutes later. The realized spread for each observation is calculated as two times the effective half spread less the trade's price impact, where the effective half spread is defined to be the absolute value of the difference between the midpoint of the quoted spread and the transaction price divided by the midpoint of the spread. Standard errors are reported under estimates. Small trades are transactions of 1,000 shares or less. Medium trades contain between 1,001 and 9,999 shares, and large trades contain all transactions of 10,000 shares or more.

	Pre-SEC Rule Change (1)	Post-SEC Rule Change (2)	Change (3) = (2) − (1)
	Panel A: Trade Impact (%)		
All trade sizes	0.105	0.095	−0.010
	0.093	0.064	
Small	0.091	0.085	−0.006
	0.077	0.058	
Medium	0.116	0.094	−0.022
	0.115	0.059	
Large	0.261	0.235	−0.026
	0.330	0.228	
	Panel B: Realized Spread (%)		
All trade sizes	0.348	0.191	−0.085***
	0.083	0.033	
Small	0.388	0.212	−0.092***
	0.108	0.032	
Medium	0.199	0.107	−0.065***
	0.062	0.020	
Large	0.259	0.167	−0.057**
	0.081	0.055	

*** and ** denote significance at the 1 percent and 5 percent levels, respectively.

spreads declined across all trade size categories (column 3). The largest decline in realized spreads occurs in the smallest trade size category, where spreads decline by 0.09 percentage points. The decline in spreads then falls across trade size categories with the smallest decline, 0.06 percentage points, for the largest trade size category. These results are consistent with the hypothesis that market makers were earning the largest rents from small trades, to offset lower profits (or losses) to larger (better-informed) trades. Because the realized spread measures market-maker revenue net of price impacts, these results provide further evidence that changes in the informativeness of trades or price impacts cannot explain the post-reform decline in spreads.

Our results show that the reforms have not caused a decline in Nasdaq share volume, number of trades, or in the price impact of a trade. Further, Barclay et al. (1999) report that the market reforms have not caused a decrease in market depth or affected the average size of a transaction. It seems unlikely therefore that the benefit to investors through reduced spreads have been mitigated by a deterioration of liquidity in other dimensions.

Overall, we find that the amount of the spread that can be attributed to order-processing costs and market-maker rents fell dramatically for all trades as well as for all trade-size categories. These results provide direct evidence that Nasdaq dealers were able to earn supracompetitive profits prior to the recent reforms. Because it is unlikely that order-processing costs have changed so dramatically with the imposition of the new rules, these results are consistent with the hypothesis that the reduction in spreads stems from new competition on the Nasdaq which has reduced market-maker rents.

III. Comparison of Trading Costs: NYSE versus Nasdaq

Our results in Section II suggest that a large portion of Nasdaq spreads, prior to the new rules, may have stemmed from economic rents. Further, we found that the introduction of competition from limit orders caused a significant decline in these rents. Because auction markets such as the NYSE already allow for competition from the public, it seems natural to test whether the increased competition on Nasdaq has resulted in spreads that now resemble those on the NYSE. Further, this comparison is driven by pre-reform evidence of unusually large spreads on the Nasdaq relative to the NYSE (e.g., Huang and Stoll (1996), Bessembinder and Kaufman (1997), Barclay (1997) and Barclay et al. (1998)).[9] In this section we examine how successful the reforms have been by comparing trading costs between the Nasdaq and the NYSE both before and after the implementation of the new regulations.

A. Matching Procedure

To compare apples to apples, we attempt to control for factors that could affect trading costs, independent of market structure. Demsetz (1968) finds that spreads are positively related to price, firm size, and volume, and Stoll (1978) finds that spreads are positively related to volatility. Additionally, Lin et al. (1995) find that spreads are an increasing function of trade size. To control for these factors, we create three matched samples of firms from

[9] Huang and Stoll (1996) and Bessembinder and Kaufman (1997) find that pre-reform spreads are larger for matched samples of Nasdaq–NYSE firms. Barclay (1997) and Barclay et al. (1998) find that firms who switch exchange listing from the Nasdaq to the NYSE realize a sharp decline in spreads.

each exchange, that is, for each of the Nasdaq stocks included in the first two phases of the new SEC rules, we find three similar NYSE-listed issues based on three sets of different factors. Specifically, stocks are matched on the following sets of characteristics:

Sample 1: firms are matched on price, market capitalization, and volatility.

Sample 2: firms are matched on price, market capitalization, volatility, and volume.

Sample 3: firms are matched on price, volatility, trade size, and (at least) two-digit SIC code.

To construct the matching characteristics, we compute the average daily price, volume, market capitalization, and volatility based on the last trade for each day. The comparison of volume between the Nasdaq and NYSE presents some problems. In dealer markets, trades are often immediately turned around by the market maker and thus double counted, making it hard to compare with volume in auction markets. However, because volume is such an important determinant of the spread, we make an attempt to control for different volumes by comparing NYSE volume to a scaled Nasdaq volume where Nasdaq volume is divided by two.

Data for price, volume, volatility, and market capitalization are collected from the CRSP daily statistics file. Average trade size for each firm is measured across all trades in the sample. Trade-size data is collected from TAQ. In addition, we collect the four-digit primary standard industrial classification code (SIC) from CRSP. We use data from September 1, 1996 to June 30, 1997 to construct the matched sample.

We measure the equally weighted absolute percentage deviation of each $i = 1, \ldots N$, NYSE issue as:

$$statistic_i = \sum_{j=1}^{K} \left| \frac{factor_{Nasdaq} - factor_{NYSE_i}}{factor_{Nasdaq}} \right|$$

where K is equal to the number of factors included in the matching procedure detailed above. For each Nasdaq issue, we choose the NYSE stock with the smallest penalty statistic for each sample. We sample from the NYSE without replacement for each of the three samples independently. The procedure yields three samples of 88 matched Nasdaq–NYSE pairs.

Table III describes the matched samples. Average price for each stock represents the average daily closing price over the sample period. Trade size, number of trades, and volume are calculated for each firm by averaging the daily figures. The volatility of returns is calculated as the average absolute daily return over the sample period. Reported averages are the cross-sectional means over the 88 stocks in each sample. The Nasdaq stocks have a smaller mean price (by 2.1 percent) than the matched NYSE sample 1, and NYSE samples 2 and 3 have smaller prices, on average, than the matched

Table III

Summary Statistics of Matched Sample

This table presents summary statistics for the 88 Nasdaq stocks and the three samples of matched NYSE stocks. The first sample chooses matching NYSE stocks based on price, market capitalization, and volatility of returns. The second sample includes volume as an additional matching characteristic, where NYSE volume is matched to one-half Nasdaq volume. The third NYSE sample matches firms based on price, market capitalization, volatility, and average trade size, as well as requiring that matched firms have the same SIC code at (at least) the two-digit level. Trade size and number of trades are collected from the TAQ daily statistics file. Price, market capitalization, volume, and volatility are collected from CRSP. Nasdaq volume is reported as average daily volume divided by two. Reported averages are the equally weighted cross-sectional means across the 88 stocks in the sample. The sample period extends from October 1996 to June 1997. Volatility is measured as the standard deviation of daily returns over the sample period. Price, market capitalization, volume, and number of trades are based on daily averages. Trade size is computed as the average across all transactions for each firm.

	Average				Average Difference (%)			Standard Deviation of Difference			Median Difference (%)		
		NYSE			NYSE			NYSE			NYSE		
Variable	Nasdaq Sample (1)	Sample 1 (2)	Sample 2 (3)	Sample 3 (4)	Sample 1 (5)	Sample 2 (6)	Sample 3 (7)	Sample 1 (8)	Sample 2 (9)	Sample 3 (10)	Sample 1 (11)	Sample 2 (12)	Sample 3 (13)
Price ($)	38.75	39.20	36.14	34.95	−2.1	5.7	5.9	14.0	16.0	18.9	3.2	4.0	5.2
Market Cap. (Billions $)	6.02	5.26	5.19	2.14	2.4	2.8	30.9	11.6	15.3	176.2	2.6	1.5	28.2
Volatility (Std. dev.) * 100	2.51	2.12	1.93	1.69	12.9	19.0	26.9	14.5	18.3	25.2	10.4	17.1	29.4
Volume (thousands)	755	664	607	213	9.7	6.5	4.0	103.9	17.9	164.4	3.1	3.5	60.1
Trade size	1,592	2,267	2,290	1,706	−9.8	−11.9	−2.8	60.0	66.4	28.0	−3.0	−1.8	2.1
Number of trades per day	403	195	174	83	8.6	25.9	21.8	75.4	40.1	108.2	14.4	16.2	32.0

Nasdaq stocks. The Nasdaq sample of stocks is more volatile and has larger market capitalization and volume than all three NYSE samples. On average, the NYSE stocks have larger trade sizes than their Nasdaq matches.

Overall, samples 1 and 2 are reasonably well matched, with similar prices, volumes, market capitalization, trades size, and volatility. Sample 2 is not matched as well on price, volatility, and market capitalization as sample 1 because volume was included as an additional factor. Sample 3 is matched considerably worse on market capitalization, volatility, and volume. This is largely due to the fact that stocks in sample 3 are also constrained to have the same SIC code, greatly reducing the universe of possible NYSE matches.

In addition, the samples are not as well matched as in other studies (e.g., Huang and Stoll (1996)). One reason for this is that we are forced to choose those Nasdaq stocks to which the new rules were first applied and then match them with stocks from the smaller universe of NYSE issues, which is more restrictive than matching a sample of NYSE stocks to the much larger universe of Nasdaq stocks, as in Huang and Stoll (1996). The use of multiple matched samples should help to resolve part of this problem. In addition, Section III.D investigates the sensitivity of our results to the matching procedure.

B. Quoted Spreads

To compare quoted spreads across exchanges we compute the average daily spread for each firm by averaging the prevailing spread for all trades on each day. These data are then averaged for each stock for the 90 trading-day periods both before and after the implementation of the new rules. That is, the sample period for the first phase prior to the rule change comprises the 90 trading days between September 16 and January 19. The post-rule-change sample period for the first phase is January 20 to May 23. Similarly, the pre-rule-change sample period for the second phase of stocks is from October 7 to February 9; the postchange sample period is from February 10 to June 16.

Figure 1 presents the time series of quoted spreads for both the Nasdaq and matched NYSE (sample 1) of stocks.[10] Daily quoted spreads for each stock are constructed by averaging the prevailing spread over all transactions during the day. We then compute equally weighted average daily spreads for the 88 firms in each exchange. For stocks in the first phase-in, time 0 is January 20; time 0 is February 10 for stocks in the second phase. Figure 1 shows the dramatic decline in quoted spreads that occurred with the implementation of the new rules. We see that Nasdaq spreads decline immediately to levels comparable to spreads on the NYSE.

Table IV presents a univariate comparison of spreads between the Nasdaq and the three NYSE samples for both phases. As shown in Figure 1, quoted spreads fell dramatically on the Nasdaq under the new SEC rules. The av-

[10] The figure is qualitatively similar using matched samples 2 and 3.

Table IV

Comparison of Spreads: NYSE vs. Nasdaq

This table presents a comparison of quoted and effective spreads for 88 Nasdaq stocks phased into the new order-handling rules with three matched samples of NYSE stocks. The first sample chooses matching NYSE stocks based on price, market capitalization, and volatility of returns. The second sample includes volume as an additional matching characteristic, where NYSE volume is matched to one-half Nasdaq volume. The third NYSE sample matches firms based on price, market capitalization, volatility, and average trade size, as well as requiring that matched firms have the same SIC code at (at least) the two-digit level. Quoted spreads are taken to be the difference between the bid and ask price. The effective half spread is measured as twice the absolute value of the difference between the midpoint of the quoted spread and the transaction price. Quoted and effective spreads are calculated for each firm as the mean over all transactions in the sample period. Reported averages are the equally weighted cross-sectional means across the 88 stocks. Dollar volume quartiles are based only on the 88 Nasdaq firms in the sample and are computed over the entire 180-day sample period.

	90 Days Prior to the New Rules				90 Days After the New Rules			
		NYSE				NYSE		
	Nasdaq	Sample 1	Sample 2	Sample 3	Nasdaq	Sample 1	Sample 2	Sample 3
Quoted spread								
All firms	0.347	0.189	0.185	0.202	0.209	0.181	0.179	0.195
By dollar volume quartile								
1	0.491	0.195	0.202	0.206	0.279	0.187	0.198	0.200
2	0.434	0.208	0.199	0.194	0.246	0.193	0.188	0.184
3	0.284	0.189	0.178	0.196	0.175	0.180	0.171	0.189
4	0.172	0.163	0.161	0.212	0.131	0.163	0.161	0.206
Effective spread								
All firms	0.250	0.129	0.124	0.135	0.161	0.127	0.124	0.133
By dollar volume quartile								
1	0.349	0.132	0.137	0.133	0.212	0.131	0.138	0.135
2	0.309	0.141	0.129	0.132	0.185	0.132	0.125	0.129
3	0.204	0.127	0.119	0.131	0.135	0.125	0.119	0.129
4	0.135	0.117	0.114	0.142	0.108	0.117	0.114	0.140

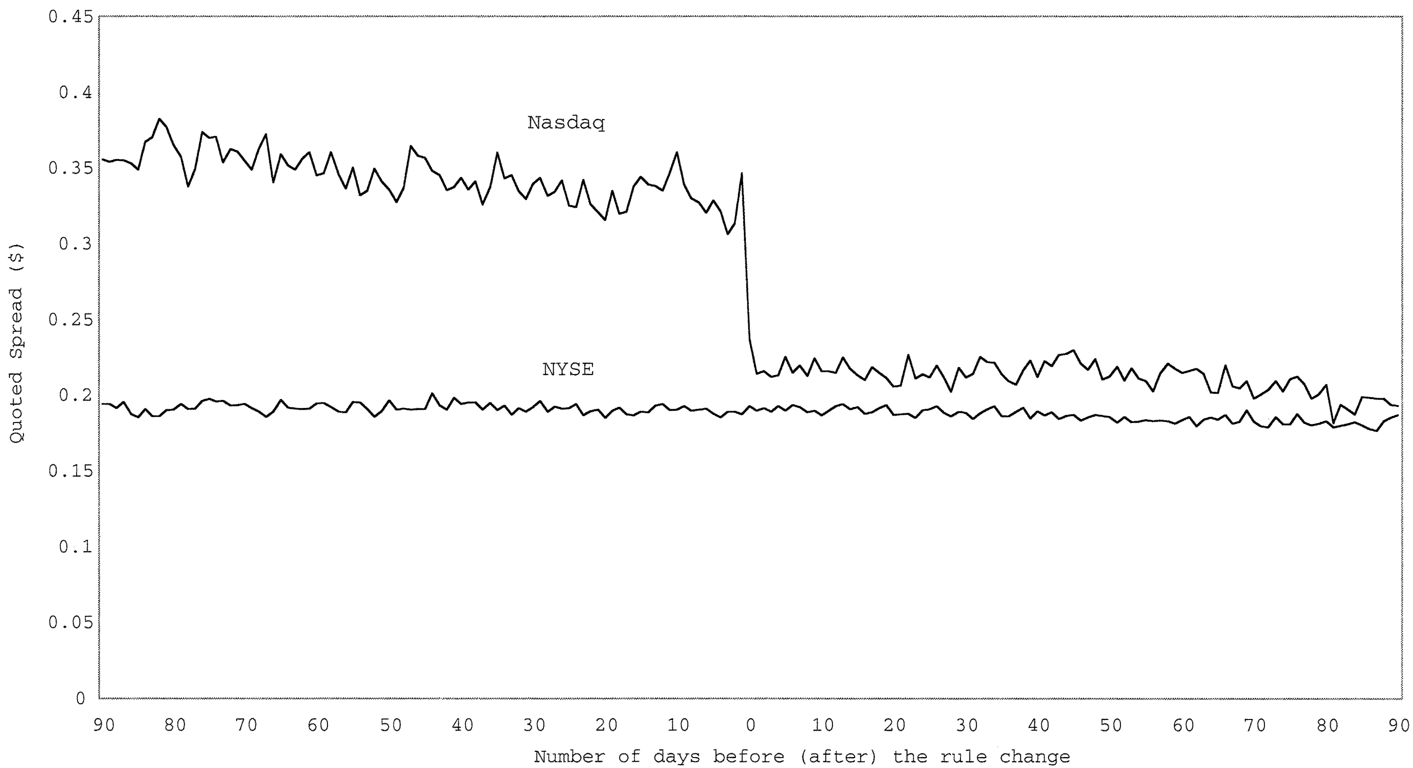

Figure 1. Comparison of Quoted Spreads: Nasdaq vs NYSE. This Figure presents a comparison of quoted bid-ask spreads for the first 88 Nasdaq Stocks to be "phased-in" under the new order handling rules from 90 days before the new rules to 90 day after. Quoted spreads for the Nasdaq are computed by averaging spreads over all transactions for each stock-day. Averages for the day are then computed as the equally weighted mean across the 88 stocks. Average quoted spreads for the NYSE are computed in a similar fashion for each of three matched NYSE samples. The results presented represent the equally weighted average across all three matched NYSE samples ($3 * 88$ stocks). Time zero represents either January 20, 1997 or February 10, 1997 depending on whether the stock was in phase 1 or 2.

erage quoted spread over the 88 Nasdaq stocks fell from roughly \$0.35 to \$0.21—a decline of about one third.[11] The comparison with the NYSE spreads shows that prior to the new rules, there was a substantial difference of 15.8 cents between the Nasdaq and the matched NYSE sample 1 (16.2 cents and 14.5 cents using NYSE samples 2 and 3, respectively). This result is slightly larger than the 11.7-cent difference reported by Huang and Stoll (1996) who used 1990 data and a different sample of stocks. After the new rules, the difference between NYSE and Nasdaq spreads fell to less than three cents for all three matched samples. Thus, the discrepancy reported by Huang and Stoll seems largely to have disappeared.

However, the results for the full sample hide some differences when looking across volume categories. To compare these figures by different volume categories, we divide the sample of 88 Nasdaq stocks into four quartiles based on dollar volume over the entire sample (180 trading days). The results show that the difference in spreads prior to the rule change arises mostly from the low volume stocks. Stocks in the largest volume quartile had spreads that were only one cent higher than NYSE sample 1 and actually four cents lower than their NYSE sample 3 counterparts. However, the Nasdaq–NYSE difference in spreads increases as we move to smaller volume quartiles. In the three lowest-volume categories, spreads are higher on the Nasdaq both before and after the new rules over all three samples. Spread differences for the lowest volume quartile in our samples have a pre-rule change difference of over 28 cents which fell to less than 9.2 cents for all three matched samples.[12]

C. Effective Spreads

Another measure of trading costs is the effective spread. This measure of the spread accounts for trades that occur inside the quoted bid-ask spread. Because many trades take place within the quoted spread, the effective spread may reflect more accurately the actual trading cost to investors. The effective spread is defined as twice the difference between the transaction price and the midpoint of the quoted spread. That is:

$$EffectiveSpread = 2\left|price - \left[\frac{Ask + Bid}{2}\right]\right|$$

Table IV also reports the difference in effective spreads for both exchanges before and after the rule change. The average effective spreads are constructed using the same methods as for the average quoted spreads detailed

[11] This result is identical to that reported by Barclay et al. (1999), who use a different data source (individual dealer quotes provided by Nasdaq).

[12] These result differ slightly from the results of Bessembinder (1998) who examines a matched sample of 531 firms for the period June 1997 through December 1997. He finds that, on average, quoted bid-ask spreads on the Nasdaq are 1.03 percent of the share price compared to 0.78 percent on the NYSE. This implies a difference of 8.3 cents, on average, between quoted spreads on the Nasdaq and NYSE. These results are more similar to our results for low-volume stocks.

above, and the results are similar. For the full sample of firms, average effective spreads were roughly 12 cents larger on the Nasdaq prior to the rule change across the three matched samples.[13] With the imposition of the new rules, this difference dropped to less than four cents.

The results by dollar volume are again similar to those for the quoted spreads. Effective spreads on the Nasdaq are smaller than those on the NYSE for the largest quartile, whereas the lower quartiles show a positive difference (Nasdaq–NYSE) in effective spreads. These data show that the reduction in quoted spreads stemming from the rule change is translated into lower trading costs for investors. Further, the 11-cent difference in effective spreads reported by Huang and Stoll (1996) has been reduced to at most 8.1 cents with the imposition of the new rules.[14]

D. Sensitivity of Our Results to the Matching Procedure

In addition to the explanations outlined above, our results from the matched samples may stem from the fact that our firms are not perfectly matched. In this section we investigate the sensitivity of our results to the matching procedure. To test how well our stocks are matched, we regress the difference in quoted and effective spreads on the differences of the variables used in our matching procedure. If our samples are not perfectly matched, then differences in the matching factors may explain part of the difference in execution costs. Specifically, we estimate the following regression model:

$$\begin{aligned} Dspread_{i,j} &= \alpha + \beta_1\, Event\ dummy_{i,j} + \beta_2\, Dprice_{i,j} + \beta_3\, Dmarket\ cap_{i,j} \\ &\quad + \beta_4\, Dvolume_{i,j} + \beta_5\, Dvolatility_{i,j} + \beta_6\, Dtrade\ size_{i,j} + \epsilon \end{aligned} \tag{3}$$

where

$Dspread_{i,j}$ = Nasdaq spread minus matched NYSE spread for sample j,
Event dummy = An indicator variable equal to one if the observation occurs after the reforms,
$Dprice_{i,j}$ = Nasdaq price minus matched NYSE price for sample j,
$Dmarket\ cap_{i,j}$ = Nasdaq market cap minus matched NYSE market cap for sample j,

[13] This figure is consistent with Huang and Stoll (1996), who find a 10.8 cent difference in effective spreads.

[14] Again, these results differ slightly from Bessembinder (1998), who finds a persistent difference in effective spreads after the rule change. He finds that effective spreads on the Nasdaq are 0.95 percent of the average price compared to 0.64 percent for the NYSE. This difference implies a 10 cent difference in effective spreads, on average, between the NYSE and Nasdaq. These differences may be due to the stock matching procedure, or to the different sample of stocks.

$Dvolume_{i,j}$ = One half Nasdaq volume minus matched NYSE volume for sample j,
$Dvolatility_{i,j}$ = Nasdaq volatility minus matched NYSE volatility for sample j,
$Dtrade\ size_{i,j}$ = Nasdaq trade size minus matched NYSE trade size for sample j,
$j = 1,2,3,$
$i = 1,\ldots,176.$

We estimate the above regression for both quoted and effective spreads for each of the three matched samples using OLS. Each sample contains 176 observations (88×2). All 88 matched Nasdaq–NYSE pairs occur twice in the sample, once for 90 days prior to the imposition of the new order-handling rules and again for the 90 days after the new rules.

Table V presents the results of the six cross-sectional regressions. For NYSE-matched samples 1 and 2, *Dprice* and *Dvolume* are not significant determinants of the difference in spreads and *Dmarket cap* is only slightly significant. However, the larger Nasdaq volatility and smaller Nasdaq trade size do have some explanatory power. For the third sample of matched NYSE stocks, all variables except trade size are significant, which is likely due to the fact that stocks were matched on SIC code, significantly reducing the universe of possible matches.

For all three matched samples, the *constant* and *event dummy* are highly significant. The *constant* measures the pre-reform difference in spreads, controlling for differences in the matched samples. Our results are consistent with Table IV—the magnitude of the pre-reform difference in spreads is roughly 10–14 cents. The post-reform difference in spreads can be measured by subtracting the *event dummy* from the *constant* for each matched sample (Table V, columns 1 and 2). These results show that the post-reform differences in spreads have fallen to 1.8, 1.7, and −2.0 cents for the three samples respectively.

The results for the effective spread are consistent with the quoted spreads. The post-reform difference in effective spreads fell from 11.0, 10.4, and 8.5 cents to 3.2, 2.9, and 0.2 cents for the three samples, respectively. Overall, these results show that differences in the matched samples cannot explain the post-reform decline quoted and effective spreads. Further, the results from the cross-sectional regression show that the post-reform difference in spreads (*constant-event dummy*) fell, on average, to less than 1.8 cents for quoted spreads and 3.2 cents for effective spreads, controlling for differences in the matched samples.

Overall, we do find that both quoted and effective Nasdaq spreads are larger than the NYSE after the new reforms. For the regressions presented in Table V, we test whether the post-reform difference in spreads is zero. That is, we test the hypothesis that the sum of the *constant* and *event dummy* is equal to zero using a standard F-test. We reject the hypothesis

Table V
Evaluation of the Matching Procedure

This table presents cross-sectional regressions of the difference between spreads for the three matched samples of Nasdaq and NYSE firms on a constant, an event dummy variable, the difference in average trading price (*Dprice*), market value (*Dmarket Value*), volume (*Dvolume*), volatility (*Dvolatility*), and trade size (*Dtrade size*). The sample contains 176 observations (88 * 2). Each matched Nasdaq–NYSE pair occurs twice in the sample, once for 90 days prior to the imposition of the new order-handling rules and again for the 90 days after the new rules. The first sample chooses matching NYSE stocks based on price, market capitalization, and volatility of returns. The second sample includes volume as an additional matching characteristic, where NYSE volume is matched to one-half Nasdaq volume. The third NYSE sample matches firms based on price, market capitalization, volatility, and average trade size, as well as requiring that matched firms have the same SIC code at (at least) the two-digit level. The event dummy variable equals 1 if the observation represents the 90 days after the new rules. *P*-values are reported under coefficient estimates. Quoted spreads are taken to be the difference between the bid and ask price. The effective half spread is measured as twice the absolute value of the difference between the midpoint of the quoted spread and the transaction price. *Dprice* is the average transaction price for each Nasdaq stock minus the average price for the matched NYSE stock. *Dmarket value, Dvolume, Dvolatility, and Dtrade size* are constructed in the same fashion. For presentation, the *Dmarket value, Dvolume,* and *Dtrade size* coefficients are multiplied by 1,000, the *Dvolatility* coefficient is divided by 100. The *Dprice*, event dummys, and constants are unadjusted.

Dependent Variable	*Constant* (1)	*Event dummy* (2)	*Dprice* (3)	*Dmarket value* (4)	*Dvolume* (5)	*Dvolatility* (6)	*Dtrade size* (7)	Adjusted R^2 (8)
Quoted spread								
Sample 1	0.1361	−0.1179	0.0027	−0.0042	−0.0012	0.0392	−0.0017	0.25
	0.0001	0.0001	0.146	0.0600	0.4110	0.0204	0.1591	
Sample 2	0.1288	−0.1116	0.0024	−0.0032	−0.0016	0.0677	−0.0033	0.34
	0.0001	0.0001	0.168	0.0770	0.9362	0.0001	0.0001	
Sample 3	0.1001	−0.1205	0.0028	0.0008	−0.0107	0.0546	0.0019	0.42
	0.0001	0.0001	0.0480	0.406	0.0001	0.0001	0.944	
Effective spread								
Sample 1	0.1103	−0.078	0.0020	−0.0025	−0.0091	0.0238	−0.0018	0.23
	0.0001	0.0001	0.1220	0.1022	0.4190	0.0501	0.0286	
Sample 2	0.1039	−0.0746	0.016	−0.0019	−0.0014	0.0474	−0.0025	0.33
	0.0001	0.0001	0.0692	0.1524	0.9213	0.0001	0.0001	
Sample 3	0.0845	−0.0822	0.0021	0.0007	−0.0074	0.0413	−0.0006	0.40
	0.0001	0.0001	0.0300	0.2803	0.0001	0.0001	0.7270	

that the sum of the *event dummy* and *constant* term is zero for all three samples. This implies that Nasdaq spreads remain significantly higher by roughly two to three cents than spreads on the NYSE after the market reforms.

There could be a number of reasons for this remaining discrepancy. First, this may be evidence that a quote-driven system (like Nasdaq) is not as efficient in providing liquidity as the NYSE's order-driven system. That is, the remaining difference may point to economies of scale in market making. The existence of scale economies may allow the monopolistic specialist structure to have lower per-trade execution costs than the multiple dealer structure of the Nasdaq. Additionally, the practice of order preferencing on Nasdaq may contribute to higher spreads. Order preferencing involves a broker receiving a per-share payment (typically of one or two cents) to bring orders to a specific dealer. This type of non-price competition may prevent dealers from competing solely on spreads to attract order flow and impede spreads from reaching fully competitive levels. Commissions may also play some role. Nasdaq spreads are quoted net of commission for institutional investors. This implies that Nasdaq spreads may naturally be higher than similar NYSE spreads because NYSE customers must also pay a commission. Unfortunately, there are scant data on dealer commissions.

Overall, our results imply that the change in dealer market structure imposed by the new rules has created competitive forces similar to those on the NYSE. The introduction of competition from public limit orders has reduced Nasdaq spreads to levels comparable with trading costs at the NYSE. Although we have shown that Nasdaq spreads have declined, we cannot, of course, test whether both the NYSE and Nasdaq still suffer from imperfect competition. Therefore we do not argue that the new rules have exterminated economic profits in market making, rather that the new SEC rules have forced *relatively* more competitive pricing on the Nasdaq.

IV. Entry and Exit of Market Makers

The dramatic decrease in Nasdaq spreads shown above indicates that per-share market-maker profits may have dropped by almost 30 percent. Additionally, the results from Section I indicate that this decrease in spreads reflects a decline in dealer rents, rather than any real decline in market-making costs. If the new order-handling rules have successfully increased the competitiveness of Nasdaq trading then, *ceteris paribus*, we should expect to see exit from the market for market making. In fact, Wahal (1997) finds that narrower spreads lead to market-maker exit for a large sample of Nasdaq stocks. In this section, we test whether the new rules have caused a decline in the number of Nasdaq market makers.

To test the hypothesis that the reduction in spreads caused a net exit of market makers, we use daily data on the number of market makers in each of the 88 Nasdaq stocks included in the first two phases. These data are obtained from the Nasdaq and represent the total number of market makers registered to trade in each of the stocks on each day. The sample period extends from June 1996 to June 1997. However, the manner in which the market-maker data is collected presents some problems. After the reforms, the number of market makers supplied by the Nasdaq includes Electronic Communication Networks (ECNs). As a result, market-maker counts for the post-reform period are inflated, making pre- and post-reform comparisons troublesome. To control for this bias, we estimate the number of ECNs active daily in each stock from Bloomberg's market-maker activity file.[15] This file records all registered and nonregistered market makers for each stock monthly. We collect data for March through April 1997 to estimate the number of ECNs active in each stock for the post-reform period.[16] The number of ECNs is then subtracted from the post-reform data supplied by Nasdaq. This procedure assumes that, if an ECN was active in a stock during March or April 1997, then it was active on all days during that month. Although this may be a reasonable assumption, we nevertheless perform our analysis using both the ECN-adjusted and unadjusted data. Further, Section IV.B investigates how robust our results are to this potential bias.

Table VI describes the sample. The number of market makers actually increased on average from 21.3 before the new rules to 23.2 and 25.3 in the post-rule-change period for the ECN-adjusted and unadjusted data, respectively, (Table VI, Panel A, columns 1–3). Similarly, the median number of market makers increased for both the adjusted and unadjusted samples. Although these data suggest a net entry of two market makers per stock, on average, there is also considerable variation in the trading volumes and spreads over this period. Panel B of Table VI shows that the percentage change in the number of market makers is significantly correlated with changes in spreads and volume. As expected, the number of market makers increased more in stocks where volume increased as well. Interestingly, there is a strong negative correlation between the change in spreads and the change in the number of market makers. Stocks with larger declines in spreads as a result of the reforms also experienced a larger increase in the number of market makers.

Although these results may seem counterintuitive (lower profits should lead to exit), there may be some reason to expect the number of market makers to actually increase, even if profits fall. Kandel and Marx (1999) present a model of competition on the Nasdaq that includes many institutional features like preferenced trading. If the decline in spreads really does reflect a decrease in profits, this may lead to a reduction in market makers' ability to purchase order flow. Kandel and Marx (1999) show that such a reduction in payments for order flow could lead to net market-maker entry.

[15] These data were hand collected from a Bloomberg terminal using the MKAC (market-maker activity) function. This display records the total volume transacted by each market maker, including all ECN's in each stock.

[16] March 1997 was the first month that Bloomberg began recording these data.

Table VI

Description of Market-Maker Data

This table presents summary statistics on the number of dealers that make a market in the sample of 88 Nasdaq stocks. Data are obtained from the Nasdaq and Bloomberg. The number of market makers for each stock is defined as the number of registered dealers each day. The sample period extends from June 1997 to June 1998. Data for the post-reform period includes the number of electronic communication networks (ECNs). The ECN-adjusted data is constructed by subtracting the number of ECNs for each stock in the post-reform period collected from Bloomberg's market-maker activity file. Correlations are based on differences between the pre- and post-reform daily averages across the 88 stocks. Standard errors are reported under correlations.

Panel A: Number of Market Makers

		After New Rules	
	Prior to New Rules (1)	With ECN's (2)	Adjusted for ECN's (3)
Average	21.2	25.3	23.3
Median	18.8	22.8	19.8
Std. Dev.	12.9	13.1	13.1
Minimum	3.6	6.17	5.2
Maximum	50.9	59.6	57.6
N	88	88	88

Panel B: Correlation of Changes in Number of Market Makers with Changes in Spreads and Volume

	%#Δ in the Number of Market Makers	%#Δ in Quoted Spread
%#Δ in the number of market makers	1	
%#Δ in quoted spread	−0.74	1
	(0.000)	
%#Δ in average daily volume	0.35	−0.17
	(0.001)	(0.128)

However, the increase in the average number of market makers may also reflect the fact that volume on the Nasdaq has increased significantly in our sample after the reforms. In fact, we see a large and statistically significant increase in average daily volume of over 30 percent for our sample of firms. Wahal (1997) points out that the number of market makers is also an increasing function of volume. To test whether the implementation of the new SEC rules has resulted in net exit from the market for market making, *ceteris paribus*, we need to control for other factors that affect entry and exit.

As in Wahal (1997) we model the change in the number of market makers across all 88 stocks using market capitalization, volume, volatility, number of trades, and average quoted bid/ask spread. To accomplish this, we model the change in the number of market makers between the pre- and post-reform periods by collapsing the daily observations into time series means for each firm both before and after the reforms. Changes for each variable are then computed as the percentage change between the pre- and post-reform averages. If there has been net exit from the industry that cannot be explained by changes in any of the control variables, we should expect a negative sign on the *constant* term α. Although we would, ideally, control for any changes in order preferencing, data on order preferencing is, unfortunately, scant. The regression equation is:

$$\begin{aligned}\%\Delta\text{Number of Market Makers} = {} & \alpha + \beta_1\,\%\Delta(\text{Volume})_i + \beta_2\,\%\Delta(\#\ \text{Trades})_i \\ & + \beta_3\,\%\Delta(\text{Market Cap.})_i + \beta_4\,\%\Delta\text{Volatility}_i \\ & + \beta_5\,\%\Delta\text{Quoted Spread}_i + \lambda_i \qquad (4)\end{aligned}$$

where λ represents an i.i.d. error term.

Table VII presents the results of regression (4) for both the ECN-adjusted and unadjusted number of market makers. Our results are very similar in spirit to those of Wahal (1997). We find that an increase in spreads is associated with a decrease in the number of market makers, suggesting that more market makers are associated with tighter spreads. Market capitalization and volatility are also inversely related to the number of market makers. As expected, an increase in volume and the number of trades are both positively related to changes in the number of market makers.

For the unadjusted data, the *constant* term, α, is negative, but not statistically significant. This is not surprising given that the post-reform data are inflated by the number of ECNs. However, the *constant* term for the ECN-adjusted data is negative and significant. The *constant* of -0.137 implies that there are 13.7 percent fewer market makers, on average, after the new rules. Because the presample average number of market makers was 21.27, the rules caused an exit of 2.9 market makers per stock, on average.

A. Robustness Check

Because the post-reform market-maker data is contaminated by ECNs, we cannot be certain that the results presented above are not a consequence of overestimating ECN activity in the post-reform period. To test this, we collect an independent sample from later phases of the new order-handling rules for which Bloomberg market-maker activity data is available both before and after the reforms. Because Bloomberg only began collecting these data in March 1997, we use firms from phases 6 (April 30), 10 (June 1), and 13 (June 30), where there is sufficient data from both the pre- and post-reform periods.[17] Data is available for only the 82 issues from these three

[17] These phases were chosen because they fall on the first or last calendar trading day of a month. As the Bloomberg market-maker activity data is a monthly summary, this ensures that the pre- and post-reform months reflect only trading days prior to or after the reforms.

Table VII

Market Maker Entry/Exit

This table presents the results for two OLS regressions on the change in the number of market makers from 90 days prior to the new regulations to 90 days following. Market-maker data are obtained from the Nasdaq. The daily number of market makers for each stock is defined as the number of registered dealers each day (including electronic communication networks (ECNs) for the post-reform period only). The first specification (column 1) includes ECNs in the post-reform period. The second specification excludes ECNs where the number of ECNs for each stock is estimated from Bloomberg's market-maker activity file. The pre-rule change period extends from June 1996 to January 19th 1997 for stocks in the first phase-in and from June 1996 to February 9, 1997 for the second phase-in of stocks. Quoted spread represents the average daily difference between the posted bid and ask price over all transactions. Volume, number of trades, and market capitalization for each firm-day are taken from the TAQ daily statistics file. Daily volatility is the standard deviation of daily returns for each firm over all transactions. Changes are computed as the difference in the daily averages over all days in the pre- and postevent periods. *P*-values are reported under coefficient estimates.

	Stocks in Phases 1 & 2	
Dependent Variable	%Δ (# Market Makers) (Not Adjusted for ECN's) (1)	%Δ (# Market Makers) (Adjusted for ECN's) (2)
Observations	88	88
R^2	0.617	0.623
Constant	−0.042	−0.137
	(0.529)	(0.040)
%Δ (Quoted Spread)	−0.519	−0.487
	(0.000)	(0.000)
%Δ ln (Volume)	0.158	0.184
	(0.090)	(0.149)
%Δ (Number of Trades)	0.083	0.087
	(0.592)	(0.689)
%Δ Volatility	−15.036	−17.157
	(0.814)	(0.814)
%Δ (Market Capitalization)	−0.132	−0.115
	(0.061)	(0.088)

phases that are still actively trading on Nasdaq. For each firm, we collect data for the two months preceding and following the date of the reform. The data includes a monthly summary of the total volume cleared by each market maker (including all ECNs) in each stock. For this sample, we estimate equation (4). Similar to the ECN-adjusted results presented above, we find a statistically significant exit of 1.9 market makers per stock, on average. Although these data do imply a smaller, *ceteris paribus*, net exit of market makers than for the 88 firms in the first two phases, they nevertheless support the hypothesis that the reforms resulted in significant exit from the industry.

To the extent that market makers were earning positive economic rents from their position, a net reduction in the average number of market makers should be interpreted as a welfare gain. If competition from public limit orders reduces the trading costs on Nasdaq without adversely affecting market quality (as found by Barclay et al. (1999)), then the conditional exit of market makers reflects not only an efficiency gain through the reduction of overhead and processing costs to support these market makers, but also a potentially more efficient allocation of human capital. These results provide further evidence that the recent market reforms have enhanced the competitiveness of the Nasdaq's trading system.

V. Market Concentration

If there has been, *ceteris paribus*, net exit from the market for market making, then there is the potential for an anticompetitive effect. That is, if the decline in profits drives out all but a few firms from the market, then the potential benefit of the reforms may be offset by an increase in the market power of the remaining firms. On the other hand, if the reforms have successfully improved competition among the remaining firms, then we should see a decline in market concentration. In this section, we investigate how the reforms have affected the market concentration of dealer services for our sample of 82 stocks from phases 6, 10, and 13.

Because the Bloomberg data include total volumes cleared by each dealer (for both block and non-block trades separately), we are able to compare the market concentration of dealer services for each stock both before and after the reforms.[18] To accomplish this, we compute for each firm, both prior to and after the reforms, the Hirshman-Herfindahl index (HHI), defined as the sum of the squared market shares over all dealers:

$$HHI_i = 10{,}000 * \sum_{m=1}^{M} \left[\frac{\text{Volume cleared by market maker } m \text{ in stock } i}{\text{Total volume in stock } i} \right]^2$$

The HHI is commonly used to gauge the competitiveness of an industry's structure. For example, a monopolistic industry would have an HHI of 10,000 while a perfectly competitive industry would have an HHI close to zero; the higher the index, the more concentrated the market is. This index is constructed for all trades as well as for block and non-block trades separately.

Table VIII provides an overview of the market concentration for the 82 stocks in phases 6, 10, and 13. For all trades, the average HHI prior to the reforms is 1,781, which would be considered a moderately concentrated market by the Department of Justice Merger Guidelines.[19] Not surprisingly, the market for non-block trades is significantly less concentrated than the market for block trades. However, what may be surprising is the concentration

[18] Block trades are defined as any trade of 10,000 shares or more.

[19] The Department of Justice Merger Guidelines defines a market with a post-merger HHI of 1,000 or less to be unconcentrated, an HHI between 1,000 and 1,800 to be moderately concentrated and an HHI of 1,800 or greater to be highly concentrated. While these cut-offs are, admittedly, *ad hoc* they do provide a useful benchmark.

Table VIII

Market Concentration

This table presents a pre- and post-reform comparison of market concentration for a sample of 82 stocks selected from phases 6, 10, and 13 of the new order-handling rules. Herfindahl indices for each stock are computed as the sum of the squared market shares over all dealers for each issue. Reported averages are the equally weighted cross-sectional means over the 82 firms. The sample period extends from two months prior to the market reforms (for the pre-reform period) to two months following the reforms (for the post-reform period). Data are collected from Bloomberg's monthly summary of market-maker activity. Block trades are defined as any transaction of 10,000 shares or greater. Definitions for concentration ranges (e.g., moderately concentrated) are taken from the Department of Justice Merger Guidelines.

	All Trades			Non-block Trades			Block Trades		
	Prior to New Rules (1)	After New Rules (2)	% Change (3)	Prior to New Rules (4)	After New Rules (5)	% Change (6)	Prior to New Rules (7)	After New Rules (8)	% Change (9)
Herfindahl Index									
Average	1,781	1,550	−12.9***	1,291	1,157	−10.3***	3,400	3,107	−8.6***
Median	1,441	1,346	−6.6***	1,119	1,045	−6.6**	3,158	2,559	−18.9***
Min	581	463		446	394		963	0	
Max	6,734	6,212		3,777	3,099		10,000	8,752	
Number of firms									
Unconcentrated 0 < HHI < 1000	16	28	75%	33	40	18%	2	2	0%
Moderately concentrated 1000 < HHI < 1800	32	31	−3%	34	34	0%	11	17	55%
Highly concentrated 1800 < HHI	34	23	−32%	15	8	−47%	69	63	−8.7%

*** and ** denote significance at the 1 percent and 5 percent levels, respectively. Significance for differences in medians is based on a rank-sum test.

of the market for block trades, with an average and median HHI of 3,300 and 3,158, respectively. This magnitude is roughly similar to a market with three firms each controlling one-third of the market, which would be considered highly concentrated by the Department of Justice.

Consistent with the analysis presented above, the market reforms have improved the competitive structure of the Nasdaq. For 60 out of the 82 stocks, the HHI for non-block trades decreased after the market reforms. Similarly, there was a decline of 8.6 percent in market concentration for block trading as well. Overall, the market experienced a decline in market concentration of 12.9 percent (Table VIII, columns 9 and 3).

Prior to the reforms, 34 of the 82 firms would have been considered highly concentrated. After the reforms, however, this number fell to 23. This pattern is similar for both block and non-block trades as well. Thus, while there may have been, *ceteris paribus*, net exit from the industry, the market has not become more concentrated. Rather, there was a significant economic and statistical decline in market concentration. These results lend additional support to the hypothesis that the reforms have improved the competitive structure of the Nasdaq.

VI. Conclusion

Our results shed light on the impact of recent market reforms and on the competitive structure of dealer markets like the Nasdaq. By comparing the components of the spread before and after the new rules, we find that the decline in spreads cannot be simply attributed to changes in the information or inventory components of the spread. Instead, the decrease in spreads must come from a decline in either order-processing costs or economic profit. As it is implausible that the new rules have changed processing costs so dramatically, we interpret this result as consistent with the hypothesis that new competition from limit orders has reduced Nasdaq market-maker rents.

Additionally, we find supporting evidence that the new reforms have created competitive forces similar to those on the NYSE. This is evidenced by the fact that spreads on the Nasdaq now resemble those on the NYSE for three comparable samples of firms. Although Nasdaq spreads are still slightly larger than spreads for three comparable NYSE issues, the remaining difference can be explained by economic factors such as commissions. Consistent with these results, we find that the imposition of new competition has led to a net exit from the market for market making. Further, this increased competition among dealers has resulted in a less concentrated market.

Overall, our results support the hypothesis that Nasdaq dealers were able to earn economic profits under the previous set of trading rules. We find that the creation of a hybrid trading system, with both multiple market makers and public exposure to limit orders, reduces execution costs, lowers market-maker rents, and forces market-maker exit. Additionally, these findings provide some empirical evidence for recent theoretical work by Viswanathan and Wang (1998), who study the relative merits of auction and dealer markets. Our results are consistent with their hypothesis that, under certain conditions, investors prefer a hybrid market structure to a strict dealer market. However, we cannot say whether the movement to a hybrid market structure was the best, or most efficient, means to improve Nasdaq. Other changes such as a reduction in tick size may also benefit investors.

Our paper discusses only a small sample of stocks to be phased in under the new rules (though it does include the top 10 Nasdaq volume stocks). As a result, our analysis here is somewhat limited. Further research is warranted regarding how trading costs are affected by the competition from limit orders across a wide array of securities. Also, our analysis does not extend to the reduction in the minimum tick size that applied to all Nasdaq issues in June 1997, which could also serve to reduce trading costs. Finally, we are unable to observe changes in order-preferencing arrangements and payments for order flow. These features of the Nasdaq have, undoubtedly, been altered by the market reforms. Nevertheless, we find that the introduction of competition from limit orders has significantly improved the competitiveness of the Nasdaq market. This finding has strong policy implications, not only for the regulation of U.S. markets, but also for the optimal design and operation of new securities markets.

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