A Comparison of Trade Execution Costs for NYSE and NASDAQ-Listed Stocks

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Abstract

We compare average trade execution costs during 1994 for sets of large, medium, and small capitalization stocks listed on the New York and NASDAQ stock markets. All measures of execution costs examined, including quoted bid-ask spreads, effective spreads (which allow for executions within the quotes), and realized spreads (which measure price reversal after trades), are larger for NASDAQ-listed than for NYSE-listed stocks. The differentials in average trading costs across exchanges are greater for medium and small capitalization issues than for large capitalization stocks and are greater for small compared to large trades. These differentials cannot be attributed to cross-exchange differences in the adverse selection costs of market-making. Furthermore, we find no evidence that average execution costs on NASDAQ declined after the publicized events of May 1994.

I. Introduction

Academics and practitioners alike are interested in the optimal design of securities markets. Desirable characteristics for a security market include price discovery without excess volatility and the provision of liquidity at low cost. The New York Stock Exchange's (NYSE) specialist-auction market and the NASDAQ dealer market each provide price discovery and liquidity services for equity shares, but differ substantially in design.[1] The cost of executing trades on the NASDAQ stock market has recently been the subject of intense scrutiny. Much of this interest has been spurred by the work of Christie and Schultz (1994), who document that many NASDAQ market-makers refrain from using odd eighths of a dollar when quoting bid and ask prices. They note that the avoidance of odd eighths implies a minimum quoted bid-ask spread of a quarter dollar, and they interpret the evidence as indicative of "tacit collusion" among NASDAQ market-makers to maintain wide spreads. Their study, however, focuses exclusively on quotations. Since trades are often executed at prices inside the quotes, no link necessarily exists between quoted

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[1]See Huang and Stoll (1996) for a summary of the alternate market structures.

spreads and traders' actual execution costs. To make meaningful comparisons of the performance of alternate market structures, it is desirable to directly compare traders' actual execution costs.

In this study, we evaluate average execution costs on the NYSE and on NASDAQ. The study complements that of Huang and Stoll (1996), who compare execution costs for trades competed during 1991 for a matched sample of large capitalization NYSE and NASDAQ issues. They report that average execution costs on NASDAQ exceed those for NYSE firms by a factor of two to three times.[2] While Huang and Stoll focus exclusively on large capitalization stocks, our analysis includes matched sets of small and medium capitalization issues as well.

Examining small and medium capitalization firms along with large capitalization firms is important, since overall market-making costs and the relative significance of various cost components potentially vary across firm size groups and across exchanges. Kleidon and Willig (1996) argue that the structure of the NASDAQ market, where each dealer sees only a portion of the total order flow, leaves dealers more vulnerable to adverse selection costs arising from losses on trades with better informed agents. Easley, Kiefer, O'Hara, and Paperman (1996) report that the probability of informed trading is greater for less actively traded stocks. Since less actively traded stocks tend to be smaller firms, greater adverse selection costs may justify higher execution costs on NASDAQ, particularly for small firms. The inventory costs of market-making are also likely to be greater for small firms, due to greater return volatility and more difficulty in unwinding inventory imbalances in thin markets. The presence of multiple dealers on NASDAQ allows for inter-dealer trades and may facilitate inventory rebalancing. Chan and Lakonishok (1993) have ventured that the NASDAQ market structure may provide a comparative advantage in executing trades for smaller firms, while the NYSE has a comparative advantage in executing large firm trades. We provide direct comparisons of execution costs for trades in small and large firms on each exchange, both before and after allowing for the adverse information costs of market-making.

The extension of cross-exchange comparisons of execution costs to smaller firms is also of interest in light of the Christie and Schultz (1994) analysis, since market-maker behavior may differ across firm size groups. Tacit collusion of the type asserted by Christie and Schultz might be easier to sustain in smaller stocks, since there are typically fewer market-makers in small stocks. As we document, however, NASDAQ trading volumes are heavily concentrated in larger stocks, implying the possibility of larger dollar profits there. Comparisons of cross-exchange trading cost differentials across size categories can be useful in distinguishing among these possibilities.

This study uses data from calendar year 1994, which allows comparisons of our results to those provided by Huang and Stoll to determine whether cross-exchange differences in execution costs have diminished in relation to the large margins they report for 1991. Also, we provide comparisons of execution costs before and after the mid-1994 interval when the Christie and Schultz (1994) study received extensive publicity and when Christie, Harris, and Schultz (1994) allege

[2]In related work, Christie and Huang (1994) and Barclay (1997) compare trading costs for firms that change from NASDAQ to NYSE listings, each documenting significant decreases in execution costs following exchange listing.

that the "implicit pricing agreement" to maintain wide NASDAQ spreads broke down.

We examine three measures of (one-way) trade execution costs, including quoted bid-ask half-spreads, effective bid-ask half-spreads (which account for executions inside the quotes), and realized bid-ask half-spreads (which measure price reversals after trades). Consistent with the results reported by Huang and Stoll, we find that execution costs are generally lower on the NYSE than on NASDAQ. Importantly, the differentials in execution costs that we document are uniformly larger for small and medium capitalization firms compared to the large capitalization issues studied by Huang and Stoll. For large firms, average effective half-spreads are 8.1 basis points greater (0.320% vs. 0.239% of trade value) on NASDAQ compared to the NYSE. In comparison, average effective half-spreads are 45.7 basis points larger (1.043% vs. 0.586% of trade value) on NASDAQ for medium firm trades and are 53.9 basis points larger (1.941% vs. 1.402% of trade value) on NASDAQ for small firm trades. Although we document greater execution costs for large NASDAQ issues compared to large NYSE issues, the cross-exchange differential during 1994 is notably smaller than that reported by Huang and Stoll for their 1991 large firm sample.

The larger average trading costs on NASDAQ are apparently not attributable to a larger adverse information cost, since we find that the average price impact of NASDAQ trades, which measures information content, is generally similar to or smaller than on the NYSE. For example, measured over a one-day horizon, average price impact is about 12% greater on the NYSE. We document that returns on NASDAQ stocks are more volatile than returns on size-matched NYSE stocks, implying higher inventory costs on the NASDAQ market. However, controlling for cross-exchange variation in economic attributes, including volatility, fails to explain the higher execution costs on NASDAQ.

In contrast to results reported by Christie, Harris, and Schultz (1994) in their widely publicized study of five large NASDAQ companies, we find no evidence for our sample of 300 diverse NASDAQ companies that average quoted or effective spreads on NASDAQ narrowed after May 1994. The empirical results do support those of Christie, Harris, and Schultz, in that we document that NASDAQ market-makers use even-eighth quotes more frequently than NYSE market-makers, and that the usage of even-eighth quotes on NASDAQ decreased significantly after May 1994.

This paper is organized as follows. In the next section, we discuss the measures of trading costs employed. Section III describes the data sources and sample selection criteria, and presents some descriptive data on the sample of trades and quotes. The key empirical results are reported in Section IV. Section V presents the conclusions of the study.

II. Empirical Measures of Trading Costs

The simplest measure of trading costs is the quoted bid-ask spread: the difference between the quoted ask price and the quoted bid price. In this study, we report percentage quoted half-spreads, computed as

$$\text{Quoted Half-Spread}_{it} \quad = \quad 100\,(A_{it} - B_{it}) \,/\, (2 * M_{it}),$$

where A_{it} is the posted ask price for security i at time t, B_{it} is the posted bid price for security i at time t, and M_{it} is the quote midpoint or mean of A_{it} and B_{it}. The quoted half-spread measures the percentage trading cost incurred in a one-way trade executed at the posted quote. It should be noted that this measure of trading costs, as well as alternate measures of bid-ask spreads developed below, exclude commission costs, which may vary across exchanges and across trades. This omission implies that our estimates of transactions costs are incomplete. However, commissions are reported to traders explicitly, and can be readily compared across exchanges by them. In contrast, execution costs are paid implicitly through the prices at which trades are completed, and are not reported to traders.

It is well documented that many equity trades actually occur at prices inside the posted bid and ask quotes, implying that quoted spreads provide biased estimates of actual execution costs. (See, for example, Peterson and Fialkowski (1994) and Lee (1993)). A simple measure of trading costs that reflects trades inside the quotes is the percentage effective half-spread defined as

$$\text{Effective Half-Spread}_{it} \quad = \quad 100 D_{it}\,(P_{it} - M_{it})\,/M_{it},$$

where P_{it} is the transaction price for security i at time t, M_{it} is the midpoint of the most recently posted bid and ask quotes for security i (interpreted as a proxy for the pre-trade value of the asset), and D_{it} is a binary variable that equals one for customer buy orders and negative one for customer sell orders.[3] The effective half-spread is an estimate of the percentage execution cost actually paid by the trader, and of gross revenue to the supplier of immediacy.

Glosten and Milgrom (1985) have shown that market-makers must widen spreads to compensate for losses to better informed traders. If the NASDAQ market structure exposes dealers to greater adverse information losses, then NASDAQ spreads must be wider to compensate. This potential explanation for wider NASDAQ spreads can be investigated by decomposing the effective bid-ask spread on each trade into two components. The first is the trade's price impact, which refers to the decrease in asset value following a customer sell or the increase in asset value following a customer buy, and which reflects the market's assessment of the private information the trades convey. Such price moves comprise a market-making cost. We follow Huang and Stoll (1994) in referring to the remaining component, which

[3] In the absence of data on the orders that underlie trades, trade direction must be inferred from the trade and quote data. We categorize trades as buy or sells using the algorithm recommended by Lee and Ready (1991). They note that trades are often reported with a delay, and recommend comparing trades to quotes in effect five seconds prior to the reported trade time. Hasbrouck, Sofianos, and Sosebee (1993) report a median trade reporting delay of 14 seconds. To be conservative, we compare trade prices to quotes in effect 20 seconds prior to the reported trade time.

measures the average price reversal after trades and market-making revenue net of losses to better informed traders, as the realized spread.[4]

The decomposition of effective spreads into price impact and realized spread components requires an estimate of assets' post-trade economic value. As proxies for post-trade economic value, we use subsequent transaction prices. We report results obtained when the proxy is the first trade reported at least 30 minutes later, and when the proxy is the first trade reported at least one day later.[5]

The price impact component of the effective spread is measured in this study as

$$\text{Price Impact}_{it} = 100D_{it}\left(P_{it+n} - M_{it}\right)/M_{it},$$

where P_{it+n} denotes the first trade price observed at least 30 minutes or one day after the trade for which price impact is measured. The realized spread component of the effective spread is measured as

$$\text{Realized Spread}_{it} = 100D_{it}\left(P_{it} - P_{it+n}\right)/M_{it}.$$

Note that the realized spread can also be computed as the effective spread less the computed price impact.

The price impact and realized spread measures associated with individual trades contain measurement errors arising from errors in categorizing trades as buys or sells, due to both the arrival of additional information between times t and $t + n$, and the use of trade prices as proxies for unobservable economic value. However, the mean price impact and realized spread components computed over large numbers of trades should provide accurate estimates of trades' average price impact and net market-making revenue, respectively.

III. Issues of Research Design

A. Data Sources

This analysis relies on transaction price and quotation data obtained from the Trade and Quote (TAQ) database, made available by the NYSE. We include trades and quotes during calendar year 1994 for a set of NYSE-listed and NASDAQ National Market System-listed securities discussed below. We also obtain some descriptive information from the 1993 Center for Research in Securities Prices (CRSP) data tapes.

[4]Some authors (see, for example, Madhavan and Cheng (1997)), refer to "permanent" and "temporary" price impacts of a trade. These terms correspond roughly to the "price impact" and "realized spread" measures, respectively, that we discuss.

[5]We also investigate, but do not report, results obtained when quote midpoints are used instead of transaction prices as proxies for post-trade economic value, and when earlier transaction prices are used instead of quote midpoints as proxies for pre-trade economic value. All results are quite similar to those that we report. Huang and Stoll (1994) examine the effect of using five-minute and 30-minute horizons for estimating post-trade economic value, and report that results are quite uniform across these horizons.

B. Selection of Sample Firms

Companies listed on the NYSE and on NASDAQ differ systematically in dimensions that are known to be related to trading costs, including average market capitalization. A meaningful comparison of trading costs across NYSE and NASDAQ-listed securities requires that we control for such differences. This study uses samples of companies that are matched by firm size. The samples are, on average, also similar in terms of trading volume and price per share.

The sample is selected as follows. First, the set of common stocks (excluding closed-end investment companies or trusts) that are included on the January 1994 TAQ Master file and for which data on December 1993 market capitalization can be obtained from the CRSP tapes is identified. This set includes 1788 NYSE issues and 4317 NASDAQ issues. The 100 largest NASDAQ firms in this set are included in the large firm sample. Then, the 100 NYSE firms (out of 648 NYSE firms that are as large as these NASDAQ firms or larger) that most closely match the individual NASDAQ firms in market capitalization are identified and included in the large firm sample. Next, the 150 smallest NYSE-listed firms are identified. Of these, the 50 smallest are deleted in order to avoid including in the sample an unduly large number of financially distressed firms. The 100 NASDAQ firms (out of the set of 2,393 NASDAQ firms that are as small or smaller than these NYSE firms) that most closely match the small NYSE firms in market capitalization are identified and included in the small firm sample. Next, 100 firms are selected at random from the set of 1,824 NASDAQ issues with market capitalization greater than that of the largest member of the small firm sample and less than that of the smallest member of the large firm sample. Finally, the 100 NYSE firms whose market capitalization most closely matches these NASDAQ firms are identified and included in the medium firm sample. A listing of the 600 sample firms is available from the authors upon request.

Table 1 reports some descriptive statistics for the final sample. Mean market capitalization is nearly identical across the matched NYSE and NASDAQ samples, but varies substantially across categories, equaling $3.0 billion for the large firm sample, $220 million for the medium firm sample, and $39.7 million for the small firm sample. While the firms in the small firm sample are, in fact, very small by NYSE standards (all being drawn from the smallest decile of NYSE firms), they are fairly representative of the large number of small firms listed on NASDAQ. Mean share price is also reasonably closely matched across the NYSE and NASDAQ samples, but varies across size groups.[6]

C. The Trade and Quote Sample and Computational Issues

This study draws on quotes and trades reported in the TAQ database during 1994 for the 600 size-matched companies described above. The analysis is limited to NYSE trades and quotes for the NYSE-listed companies and NASDAQ trades and quotes for the NASDAQ-listed companies, thereby excluding regional

[6]Trading volumes are not directly comparable across exchanges due to differing market structures and differing proportions of dealer-to-dealer (as opposed to customer-to-dealer or customer-to-customer) trading. We note, though, a rough matching of volumes within size groups and substantial variation in mean volumes across groups.

TABLE 1

Mean Market Capitalization, Share Price, and Trading Volume for the 600 Size-Matched Sample Firms

	NYSE	NASDAQ
Large Firm Sample		
Market Capitalization ($000)	3,009,004	2,990,065
Trading Volume (shares per day)	241,078	612,508
Share Price ($)	36.62	38.85
Medium Firm Sample		
Market Capitalization ($000)	221,192	220,476
Trading Volume (shares per day)	50,040	79,610
Share Price ($)	18.39	19.55
Small Firm Sample		
Market Capitalization ($000)	39,695	39,727
Trading Volume (shares per day)	22,679	33,181
Share Price ($)	7.91	10.99

Reported are simple means for each indicated group. Share price is measured in dollars as of December 31, 1993. Market capitalization reflects the product of share price and the number of shares outstanding on December 31, 1993. Trading volume reflects activity during calendar year 1993.

exchange and OTC observations on NYSE companies. A small number of trades and quotes are filtered because of a high likelihood that they reflect errors, or because they differ from more common trades and quotes in dimensions that are likely to be related to trading costs.[7] We also exclude trades and quotes that are time stamped outside regular NYSE trading hours, 9:30 a.m. to 4:00 p.m.

The final sample includes 12.9 million trades and 3.7 million quotes. The large number of data observations creates some difficulties arising from limitations on data processing and storage capacity. We circumvent these limitations by using a two-stage computational procedure. In the first stage, we analyze trades and quotes on a calendar month basis. The output of this first stage analysis is a collection of means by month by stock for measures (quoted half-spread, effective half-spread, realized half-spread, etc.) of interest. The number of trades or quotes used to compute each mean is also recorded. The second stage analysis consists of a set of weighted least squares regressions of these monthly means on a pair of indicator variables that identify the listing exchange. Letting Y_{it} denote an average execution cost measure during month t for firm i, these regression equations can be stated as

$$(1) \qquad Y_{it} = \alpha_{\text{nys}}\text{NYSIND}_i + \alpha_{\text{nas}}\text{NASIND}_i + \epsilon_{it},$$

where NYSIND_i equals one for NYSE-listed firms and zero otherwise, NASIND_i equals one for NASDAQ-listed firms, and zero otherwise, and the weighting variable is the number of first stage observations used to compute each mean. The

[7]Trades are omitted if they are indicated in the TAQ database to be coded out of time sequence, or coded involving an error or a correction. Trades indicated to be exchange acquisitions or distributions, trades that involve nonstandard settlement, and trades that are not preceded by a valid same day quote are omitted. We also omit trades that involve price changes (since the prior trade) of 25% or more if the prior price is more than $2 per share, and trades that involve a reported fractional price that is not a round multiple of 1/64. Quotes are omitted if i) either the ask or bid price is nonpositive, ii) the differential between the ask and bid prices exceeds $4 or is nonpositive, and iii) the fractional portion of either the ask or bid price is not a round multiple of 1/64. We also omit quotes associated with trading halts or designated order imbalances, or that are non-firm.

resulting α estimates reproduce the sample means by exchange that would have been obtained if it had been possible to examine the full dataset in a single stage.

Since the hypothesis that trading costs equal zero is of little practical interest, we do not report standard errors or t-statistics for the resulting estimates. However, we do report results of testing the hypothesis that mean trading costs are equal across exchanges. Statistical inference in this application is complicated by the fact that, in contrast to classical assumptions, the regression errors in (1) are not independent. In particular, the 12 error terms corresponding to the monthly observations on each firm may contain a common, firm-specific component.

To assess statistical significance in this context, we adopt a bootstrap procedure. Equation (1) is estimated by weighted least squares, and the residuals are saved. Efron and Tibshirani (1993) emphasize that valid inference using bootstrap procedures requires the development of a bootstrap probability distribution on the parameters of interest that reflect the properties (such as nonindependence) of the actual regression errors. A bootstrap NYSE sample of 3600 (300 firms times 12 months) observations is drawn by random sampling with replacement from the set of 3600 residuals from equation (1) that pertain to NYSE firms. A bootstrap sample for the NASDAQ firms is computed analogously. Then, equation (1) is estimated using the bootstrap samples, and the resulting coefficient estimates are saved. This procedure is repeated 500 times, giving a set of 500 bootstrap coefficient estimates. The bootstrap p-value on the hypothesis that average trading costs are equal across exchanges is obtained as the proportion of the 500 bootstrap simulations in which the absolute difference between bootstrap coefficient estimates is as large or larger than the absolute difference in the actual coefficient estimates.[8]

Tables 2 and 3 report some additional detail regarding the sample. Table 2 reports the number of quotes for NYSE-listed and NASDAQ-listed companies overall, and by firm size group. Table 3 reports the number of trades occurring on each indicated exchange, overall, by firm size group, and for three trade size categories: small trades are those involving less than \$10,000, medium trades are those involving \$10,000 to \$199,999, while large trades are those involving \$200,000 or more.

The sample includes 3.2 million quotes and 2.5 million trades for the 300 NYSE-listed companies, compared to 0.6 million quotes and 10.3 million trades for the 300 NASDAQ-listed companies. NASDAQ-listed companies are traded more frequently than NYSE-listed companies, but NASDAQ quotes are updated less frequently. It is useful to note that 88.2% of NASDAQ trades are for large companies, while 74.4% of NYSE trades are for large companies. Since market-making costs tend to be smaller for large companies, this differential in trading frequencies will affect measures of average execution costs computed across all trades. We, therefore, compute average trading costs within firm size categories, which provide more meaningful comparisons. We also assess formally, in Section IV.G below, whether variation in economic attributes, including firm size, can explain cross-exchange variation in trading costs.

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[8]Earlier drafts of this paper reported p-values based on weighted least squares estimation with White (1980) corrections for heteroskedasticity. Despite the absence of corrections for the lack of independence across errors, those p-values are similar to and support the same conclusions as the bootstrap p-values reported here.

TABLE 2

Quoted Half-Spreads (%)

	Sample Size		Quoted Half-Spread (%)		
Firm Size	NYSE	NASDAQ	NYSE	NASDAQ	*p*-Value
All	3,153,298	630,983	0.575	0.820	[0.000]
Large	2,187,629	465,698	0.321	0.445	[0.000]
Medium	654,172	101,601	0.796	1.475	[0.000]
Small	311,497	63,684	1.900	2.517	[0.000]

Quoted spreads are stated in percent, and for comparability to subsequent spread measures, have been divided by two. Individual half-spreads are calculated as 100 * (Ask-Bid)/(2 * Mid), where Mid is the average of the ask and the bid. Reported spreads are simple means of all quoted spreads in the indicated category. Bootstrap *p*-values reported in brackets are for the hypothesis that the mean quoted NASDAQ spread does not differ from the mean quoted NYSE spread.

TABLE 3

Effective Half-Spreads and Improvement Rates

	Trade Size											
	All			Large			Medium			Small		
	NYSE	NASDAQ	*p*-Value	NYSE	NASDAQ	*p*-Value	NYSE	NASDAQ	*p*-Value	NYSE	NASDAQ	*p*-Value
Panel A Sample Size												
Firm Size												
All	2,549,009	10,335,292	N.A.	196,489	556,810	N.A.	1,355,816	6,487,562	N.A.	996,704	3,290,920	N.A.
Large	1,895,455	9,115,552	N.A.	180,375	533,003	N.A.	1,100,348	5,943,485	N.A.	614,732	2,639,064	N.A.
Medium	448,690	901,315	N.A.	14,673	23,060	N.A.	200,873	458,523	N.A.	233,144	419,732	N.A.
Small	204,864	318,425	N.A.	1,441	747	N.A.	54,595	85,554	N.A.	148,828	232,124	N.A.
Panel B. Improvement Rates												
Firm Size												
All	0.245	0.269	[0.002]	0.233	0.328	[0.000]	0.244	0.320	[0.000]	0.248	0.159	[0.000]
Large	0.254	0.264	[0.318]	0.236	0.319	[0.004]	0.257	0.313	[0.000]	0.256	0.143	[0.000]
Medium	0.232	0.325	[0.000]	0.208	0.547	[0.000]	0.204	0.409	[0.000]	0.258	0.221	[0.008]
Small	0.188	0.264	[0.000]	0.225	0.479	[0.000]	0.157	0.343	[0.000]	0.200	0.234	[0.012]
Panel C. Effective Half-Spread %												
Firm Size												
All	0.394	0.433	[0.000]	0.246	0.270	[0.000]	0.301	0.329	[0.000]	0.548	0.667	[0.000]
Large	0.239	0.320	[0.000]	0.229	0.253	[0.000]	0.226	0.276	[0.000]	0.266	0.433	[0.000]
Medium	0.586	1.043	[0.000]	0.419	0.634	[0.000]	0.517	0.794	[0.000]	0.657	1.338	[0.000]
Small	1.402	1.941	[0.000]	0.657	1.774	[0.000]	1.035	1.472	[0.000]	1.545	2.112	[0.000]

Sample sizes reflect the number of trades for the 600 sample firms that were time stamped between 9:30 a.m. and 4:00 p.m. Eastern time during calendar year 1994, and that passed the error filters described in the text. Improvement rates reflect the proportion of trades that are executed within the most recent bid and ask quotes. For each trade, the effective half-spread is calculated as 100 * |Price − Mid|/Mid, where Price is the transaction price and Mid is the average of the most recently posted bid and ask prices. Each entry is the simple mean of the effective spreads observed on all trades in the indicated category. Each bootstrap *p*-value reported in brackets is for the hypothesis that the mean effective spread on NASDAQ does not differ from that on the NYSE.

It should also be noted that Instinet trades are reported in the TAQ database as NASDAQ trades, and cannot be separately identified. The Wall Street Journal has estimated that as much as 20% of NASDAQ's reported volume as of late 1994 is attributable to Instinet trading, and that this percentage had doubled from a few years earlier.[9] The institutional trades completed via Instinet are likely to comprise relatively favorable executions. As a consequence, reporting Instinet trades as NASDAQ trades biases our empirical results in favor of finding lower

[9] See "Reuters' Instinet Is Biting Off Chunks of NASDAQ's Territory," The Wall Street Journal, October 4, 1994.

trade execution costs on NASDAQ. We actually document larger trade execution costs on NASDAQ, indicating that our inferences are robust to this bias.

IV. Average Trade Execution Costs for NYSE and NASDAQ Issues

A. Quoted Bid-Ask Spreads

Table 2 reports mean quoted half-spreads for NYSE-listed and NASDAQ-listed sample companies. Quoted spreads are larger on NASDAQ. For the full sample, quoted half-spreads average 0.575% on the NYSE compared to 0.820% on NASDAQ.[10] For the large firm sample, quoted NASDAQ half-spreads are, on average, only 12.4 basis points wider (0.445% vs. 0.321%). For medium and small sized firms, the cross-exchange differentials in average quoted half-spreads widen to 67.9 and 61.7 basis points, respectively. Each of these differentials is statistically significant. The observation that the cross-exchange differential in quoted half-spreads is greater for small and medium firms than for large firms calls into question the reasoning that NASDAQ has a comparative advantage in making markets for smaller firms. However, since some trades are executed inside the quoted bid and ask prices, differentials in quoted spreads may not accurately reflect differentials in traders' actual execution costs.

B. The Frequency of Price Improvement

Table 3 reports on the frequency with which trades are executed within the bid and ask quotes in effect on the exchange at the time of the trade. For the full sample, 24.8% of NYSE trades occur within the NYSE quotes, while 26.9% of NASDAQ trades occur within the inside NASDAQ quotes. However, as documented in Table 2, NASDAQ quotes are typically wider than NYSE quotes, leaving more room for improvement. Though overall rates of price improvement are similar across exchanges, there are some cross-sectional differences. NYSE and NASDAQ improvement rates are most similar for large firms. NASDAQ improvement rates are higher for medium and small firms, perhaps reflecting the wider quoted spreads in these categories.

Improvement rates on NASDAQ are systematically related to trade size, while improvement rates on the NYSE are largely independent of trade size. Within each NASDAQ firm size group, small trades receive the lowest rate of price improvement, while large trades receive the highest rate of price improvement. Averaged across all firm size categories, 24.8% of small NYSE trades receive price improvement, compared to 15.9% of small NASDAQ trades. This regularity likely reflects that small NASDAQ trades tend to represent retail orders that are subject to order preferencing agreements or that are entered into NASDAQ's SOES system, and are automatically executed at the standing quote, while larger NASDAQ trades are more likely to reflect institutional or market-maker orders for which prices inside the quote can be negotiated. This differential in small trade improvement rates

[10]These NASDAQ spreads reflect the difference between lowest ask and the highest bid currently quoted by any NASDAQ market-maker, rather than the difference between individual bids and asks.

raises particular concerns regarding the quality of NASDAQ trade executions for individual investors.

C. Effective Bid-Ask Spreads

Since some trades are executed at prices superior to the posted bid and ask quotes, effective bid-ask spreads provide a more accurate measure of actual execution costs than quoted spreads.[11] Table 3 also reports average effective half-spreads by listing venue, overall and by firm size and trade size groups. Averaged across all trades, effective half-spreads on NASDAQ are only 3.9 basis points larger (0.433% vs. 0.394%) than on the NYSE. This relatively small differential in average execution costs reflects that a larger proportion of NASDAQ trades are for large companies, where market-making costs are typically smaller. Differentials in average effective spreads within firm size groups are greater. For large companies, effective half-spreads are 8.1 basis points (0.320% vs. 0.239%) wider on NASDAQ. This differential is substantially smaller than that reported by Huang and Stoll (1996) for their 1991 large firm sample, and may, for some institutional traders who negotiate trades without commissions, be small enough to be offset by differences in commission costs. The differentials in average effective spreads for small and medium firms are larger: for medium companies, the differential is 45.7 basis points (1.043% vs. 0.586%), while for small companies effective half-spreads are 53.9 basis points (1.941% vs. 1.402%) larger on NASDAQ. The fact that effective spreads for trades in small and medium sized NASDAQ firms are substantially greater than for trades in size-matched NYSE firms is evidence against the reasoning that the NASDAQ market structure is relatively efficient for market-making in smaller firms.

Effective half-spreads are most similar across the NYSE and NASDAQ for large trades in large companies, averaging 0.229% on the NYSE vs. 0.253% on NASDAQ. NASDAQ's relative competitiveness in executing large trades for large companies, and the improvement in this competitiveness relative to that documented by Huang and Stoll (1996), may reflect increased interdealer competition for large institutional trades. It may also reflect the presence and growth of Instinet trades, which, as noted above, are reported as NASDAQ trades in the TAQ database.

At each exchange, effective spreads increase as firm size declines. This reflects larger market-making costs in small firms, including greater inventory costs due to higher risk and more difficulty laying off unwanted inventory in thinner markets, as well as the potential for greater losses to privately informed traders. Within firm size categories, effective spreads tend to increase as trade size declines,

[11]Effective spreads that are estimated without data on underlying order flow still provide upward biased estimates of average execution costs, since these estimates fail to accommodate the possibility that trades may be executed at the "opposite quotes," i.e., sell orders may be executed at the ask price or buy orders may be executed at the bid price. Such trades will be miscategorized when the Lee and Ready (1991) algorithm is used to infer trade direction. The magnitude of the bias for a particular exchange depends on the frequency with which trades at that exchange are executed at the opposite quote. Knez and Ready (1996) using the TORQ (Trades, Orders, Reports, and Quotes) database, which covers 144 NYSE-listed firms during a three-month period in 1991, report that 12% of trades completed when there is a one-eighth spread are executed at the opposite quote. Cross-exchange comparisons cannot be made because order data for the NASDAQ market has not been publicly available.

which may reflect the existence of a fixed order processing cost component that comprises a larger proportion of the value of small trades. However, there are differences across exchanges in the margin by which effective bid-ask spreads for small trades exceed those for large trades. For small trades in large firms (a category that comprises 25.5% of the total NASDAQ sample), effective half-spreads on NASDAQ are 16.7 basis points wider than on the NYSE, compared to a differential between NASDAQ and the NYSE of 2.4 basis points for large trades in large firms. For small trades in medium sized firms, effective half-spreads on NASDAQ are 68.1 basis points wider than on the NYSE, compared to a differential of 21.5 basis points for large trades.

The NYSE trading structure focuses on the specialist, but allows for competition from floor traders and from the public in the form of limit orders. The NASDAQ market relies on competition among dealers, while allowing for "preferencing" agreements. Under these agreements, retail brokers agree to deliver order flow to specific market-makers in exchange for cash payments and an agreement by the market-maker to execute the trade at the best quote. (See NASD (1991)). The fact that the NYSE advantage in terms of average effective bid-ask spreads is greatest for small trades, where such preferencing agreements are concentrated, is suggestive that preferencing agreements hinder competition on the NASDAQ market by reducing dealers' incentives to either improve on the posted quotes or to execute trades at prices within the quotes. Also, since preferencing agreements typically target retail order flow, these findings raise particular concerns regarding NASDAQ execution of individual investor trades.

D. Measures of Price Impact

Some (e.g., Kleidon and Willig (1996)) have argued that the structure of the NASDAQ market leaves dealers more vulnerable to losses incurred in trades with better informed investors. If so, quoted and effective spreads could be greater on the NASDAQ market to allow dealers to recover this larger economic cost of market-making. This possibility can be evaluated by decomposing effective half-spreads into two components: price impact and realized half-spreads. Price impact measures trades' average information content, which comprises a market-making cost in the form of losses to better informed traders. Realized spreads measure average price reversals after trades and market-making revenue net of information costs.

Table 4 reports measures of the average price impact of trades executed on each exchange. Results reported on Panel A are based on a one-day horizon, where price impact is computed by comparing the price for the first transaction at least 24 hours subsequent to the trade to the bid-ask midpoint in effect prior to the trade. Results reported on Panel B use a 30-minute horizon instead. For the full sample, the results indicate slightly larger average price impact at the NYSE as compared to NASDAQ. At a 24-hour horizon, the differential in average price impact is 3.1 basis points (0.297% on the NYSE vs. 0.266% on NASDAQ). Measured price impact is somewhat smaller at a 30-minute horizon when compared to the 24-hour horizon, particularly for NASDAQ trades. This leads to a larger cross-exchange differential in average price impact of 8.5 basis points (0.269% on the

NYSE vs. 0.184% on NASDAQ).[12] Measured price impacts for small firms are uniformly larger on the NYSE as compared to NASDAQ. For medium and large firms, measured price impacts are larger on the NYSE at a 30-minute horizon, but results are mixed at a 24-hour horizon. The absence of systematically larger price impacts for NASDAQ trades indicates a lack of support for the reasoning that the wider quoted and effective spreads on NASDAQ represent compensation for greater losses to informed traders.

TABLE 4

Price Impact

	Trade Size											
	All			Large			Medium			Small		
	NYSE	NASDAQ	*p*-Value	NYSE	NASDAQ	*p*-Value	NYSE	NASDAQ	*p*-Value	NYSE	NASDAQ	*p*-Value
Panel A. Measured at One-Day Horizon												
Firm Size												
All	0.297	0.266	[0.000]	0.259	0.089	[0.000]	0.277	0.283	[0.320]	0.333	0.261	[0.000]
Large	0.185	0.221	[0.000]	0.238	0.086	[0.000]	0.197	0.254	[0.000]	0.147	0.175	[0.256]
Medium	0.486	0.551	[0.004]	0.501	0.153	[0.000]	0.529	0.583	[0.036]	0.449	0.537	[0.032]
Small	0.928	0.721	[0.000]	0.561	−0.049	[0.044]	0.964	0.706	[0.000]	0.918	0.729	[0.000]
Panel B. Measured at 30-Minute Horizon												
Firm Size												
All	0.269	0.184	[0.000]	0.229	0.054	[0.000]	0.247	0.208	[0.000]	0.308	0.158	[0.000]
Large	0.164	0.153	[0.326]	0.213	0.052	[0.000]	0.175	0.190	[0.000]	0.132	0.090	[0.114]
Medium	0.425	0.354	[0.026]	0.403	0.112	[0.000]	0.457	0.381	[0.000]	0.399	0.339	[0.074]
Small	0.892	0.570	[0.000]	0.566	−0.114	[0.038]	0.895	0.479	[0.000]	0.895	0.605	[0.000]

Reported are trades' average price impacts, measured at one-day (Panel A) and 30-minute (Panel B) horizons. For individual trades, price impact is measured as 100 * indicator * (next price − mid)/mid, where indicator is a binary variable that equals one for customer initiated buy orders and negative one for customer initiated sell orders, mid is the midpoint of the bid and ask prices prevailing at the time of the trade, and next price is the first transaction price observed at least 24 hours (Panel A) or 30 minutes (Panel B) subsequent to the trade. Each entry is the simple mean computed across all trades in the indicated category. Each bootstrap *p*-value reported in brackets is for the hypothesis that the mean price impact for NASDAQ-listed and traded firms does not differ from that for NYSE-listed and traded firms.

E. Realized Half-Spreads

Table 5 reports average realized bid-ask spreads, which are measures of price reversals after trades and of market-making revenue net of losses to better informed traders. Panels A and B of Table 5 report average realized half-spreads measured at one-day and 30-minute horizons, respectively.

Realized bid-ask spreads are consistently and significantly lower on the NYSE than on NASDAQ. This observation holds true for the full sample whether spreads are measured at the 30-minute or the one-day horizon, and, with a lone (statistically insignificant) exception, for each firm size and trade size subgroup, at both

[12]The slightly larger price impact of NYSE trades may be attributable to selection biases in the subset of trades in NYSE issues actually executed at the NYSE. Bessembinder and Kaufman (1997) demonstrate that price impact is considerably smaller when trades in NYSE issues are executed at the regional exchanges or at NASDAQ compared to NYSE executions, which they attribute to the ability of regional and NASDAQ market makers to "cream skim" uninformed trades, which are less costly to process. Thus, the subset of trades in NYSE issues that are executed at the NYSE appears to include a high proportion of informed trades. The divergence between measures of trades' price impact based on 30-minute and 24-hour horizons indicate that NASDAQ prices, on average, adjust more slowly to the information conveyed in trades, and that the adjustment is not yet complete at the 30-minute horizon. This may reflect differences across dealer and auction markets in the diffusion rate of information contained in trades.

TABLE 5

Realized Half-Spreads

	Trade Size											
	All			Large			Medium			Small		
	NYSE	NASDAQ	p-Value	NYSE	NASDAQ	p-Value	NYSE	NASDAQ	p-Value	NYSE	NASDAQ	p-Value
Panel A. Measured at One-Day Horizon												
Firm Size												
All	0.096	0.168	[0.000]	−0.013	0.181	[0.000]	0.025	0.045	[0.002]	0.216	0.406	[0.000]
Large	0.055	0.099	[0.000]	−0.009	0.166	[0.000]	0.029	0.022	[0.492]	0.119	0.257	[0.000]
Medium	0.100	0.492	[0.000]	−0.083	0.477	[0.000]	−0.012	0.210	[0.000]	0.208	0.801	[0.000]
Small	0.475	1.220	[0 000]	0.075	1.706	[0.000]	0 070	0.764	[0.000]	0.627	1.383	[0.000]
Panel B. Measured at 30-Minute Horizon												
Firm Size												
All	0.125	0.249	[0.000]	0.017	0.216	[0.000]	0.055	0.121	[0.000]	0.240	0.508	[0.000]
Large	0.075	0.167	[0.000]	0.016	0.201	[0.000]	0.051	0.086	[0.000]	0.135	0.343	[0.000]
Medium	0.161	0.688	[0.000]	0.016	0.519	[0.000]	0.060	0.413	[0.000]	0.258	0.999	[0.000]
Small	0.510	1.371	[0.000]	0.079	1.733	[0.000]	0.139	0.992	[0.000]	0.650	1.507	[0.000]

Reported are realized bid-ask (half) spreads measured at one-day (Panel A) and 30-minute (Panel B) horizons. For each trade, the realized spread is computed as 100 * indicator * (price − next price)/mid, where indicator is a binary variable that equals one for customer initiated buy orders and negative one for customer initiated sell orders, mid is the midpoint of the bid and ask prices prevailing at the time of the trade, price is the transaction price, and next price is the first transaction price observed at least 24 hours (Panel A) or 30 minutes (Panel B) subsequent to the trade. Note that the realized spread can also be computed as the effective spread less measured price impact. Each bootstrap p-value reported in brackets is for the hypothesis that the mean realized spread for NASDAQ-listed and traded firms does not differ from that for NYSE-listed and traded firms.

the 30-minute or one-day horizon. These results confirm that the wider quoted and effective spreads on NASDAQ cannot be attributed to greater adverse information costs on NASDAQ. In fact, price reversals after trades, which measure market-making revenue net of such information costs, are substantially greater on NASDAQ for all firm size categories.

F. Comparisons of Return Volatility across Exchanges

As noted above, our sample is selected by matching on the basis of market capitalization. A determinant of market-making costs that has not been controlled for is the risk associated with holding inventory positions. We compare return volatility across the size-matched sample of NYSE and NASDAQ-listed companies to determine whether risk differentials have potential to explain differences in average execution costs.

We compute standard deviations of daily returns for each firm based on closing (last) prices.[13] Daily returns are computed from both transaction prices and from quote midpoints. Since a portion of the volatility in returns based on transaction prices is attributable to bid-ask bounce and NASDAQ spreads are shown here and in earlier studies to be wider than NYSE spreads, a finding of higher NASDAQ return volatility could simply reflect the wider NASDAQ bid-ask spreads. Re-

[13]Since the close need not be representative of conditions at other times, we also compute standard deviations of daily returns based on prices observed at 11:00 a.m. and 2:00 p.m. Our empirical results are essentially identical to those reported. We measure closing NYSE prices as the last price posted on the NYSE before 4:15 p.m. This allows for the late posting of prices for trades executed just before the 4:00 p.m. NYSE close. For closing NASDAQ prices, we use the last price posted before 5:00 p.m. The 11:00 a.m. and 2:00 p.m. prices are the last observed prior to the indicated time. For those few occasions where a security has not traded by the indicated time, we use the midpoint of the most recently posted quotes in lieu of a transaction price.

turns computed from quote midpoints allow for a direct comparison of volatilities without the confounding effect of cross-exchange differences in bid-ask spreads.

Panel A of Table 6 reports cross-sectional mean and median return standard deviations for each exchange. These indicate substantially larger average return volatilities for NASDAQ issues compared to size-matched NYSE issues. For the full sample, the mean standard deviation of daily returns measured from closing trade prices is 3.88% for NASDAQ issues vs. 2.70% for NYSE issues. Corresponding medians are 3.51% for NASDAQ issues and 2.10% for NYSE issues. Using closing quotation midpoints instead of trade prices, the mean standard deviation of daily returns is 2.94% for NASDAQ issues vs. 2.49% for NYSE issues, while corresponding medians are 2.50% for NASDAQ issues and 2.04% for NYSE issues. With the lone exception of volatility measured from quotation midpoints in the small firm sample, mean and median volatility measures for firm size subsamples indicate higher NASDAQ volatility in each subgroup as well. To assess whether these differences in average volatility are statistically significant, we use the Wilcoxon rank-sum test to evaluate the hypothesis that median volatility is equal across exchanges. The resulting test statistics indicate that the observed differences in median volatility are significant in all cases, except for small firms when volatility is measured from quotation midpoint returns.[14]

TABLE 6

Comparisons of Daily Return Volatility across NYSE and NASDAQ Issues

		Returns Measured from Trade Prices				Returns Measured from Quote Midpoints			
Firm Group		All	Large	Medium	Small	All	Large	Medium	Small
Panel A. Cross-Sectional Average Return Standard Deviations									
NYSE	Mean	2.70	2.08	2.35	3.69	2.49	2.04	2.24	3.21
NASDAQ	Mean	3.88	2.90	3.98	4.78	2.94	2.76	3.06	2.99
NYSE	Median	2.19	1.78	2.09	2.98	2.04	1.68	1.97	2.71
NASDAQ	Median	3.51	2.48	3.61	4.16	2.50	2.36	2.64	2.63
Wilcoxon p-Value		[0.000]	[0.000]	[0.000]	[0.000]	[0.009]	[0.001]	[0.007]	[0.291]
Panel B. Pairwise Comparisons of Return Variances									
Percent of Observation Pairs where NASDAQ Variance Exceeds NYSE Variance		72.3	69.0	81.0	67.0	55.7	63.0	61.0	43.0
Fisher p-Value		[0.000]	[0.001]	[0.000]	[0.001]	[0.022]	[0.003]	[0.011]	[0.903]
Percent of Observation Pairs where NASDAQ Variance Significantly ($\alpha < 0.01$) Exceeds NYSE Variance		64.0	57.0	74.0	61.0	42.0	55.0	52.0	19.0

Panel A reports cross-sectional averages (means and medians) by exchange of daily return standard deviations for 300 NASDAQ-listed and 300 NYSE-listed firms. The Wilcoxon p-value pertains to a Wilcoxon rank-sum test of the hypothesis that median standard deviations are equal across exchanges. Panel B reports results of pairwise comparisons of return variances for size-matched NYSE and NASDAQ firms. The Fisher p-value pertains to a sign test of the hypothesis that NASDAQ return variances exceed NYSE variances for 50% of all pairs.

[14]We also examined return volatilities over 10-day intervals, and find that average 10-day return volatilities for NASDAQ companies also significantly exceed those for matched NYSE companies, whether returns are computed from closing prices or from quote midpoints.

To examine the robustness of the conclusion that average return volatility is greater on the NASDAQ exchange, we also conduct a pairwise comparison in which we compute the ratio of each NASDAQ firm's return variance to that of its size-matched NYSE counterpart. Under the null hypothesis of equal variances, each such ratio follows an F-distribution. On Panel B of Table 6, we report the percentage of firm-pairs where the hypothesis of equal variances is rejected in favor of greater NASDAQ variance with a significance level of 0.01 or less. Under the null hypothesis of equal variances, rejections should not exceed 1% of observations. In actuality, the null hypothesis is rejected for 64% of all observations when returns are measured from trade prices and 42% of all observations when returns are measured from quotation midpoints.

Finally, we record and report in Panel B of Table 6 the percentage of firm-pairs where the NASDAQ variance exceeds the NYSE variance, and conduct a Fisher sign test of the hypothesis that this percentage equals 50. This hypothesis is rejected for the full sample, with the actual percentage equal to 72.3 when returns are measured from trade prices and 55.7 when returns are measured from quotation midpoints. The hypothesis is rejected for each subsample as well, with the lone exception of the small firm quotation midpoint returns.

In summary, our tests indicate greater return volatility on NASDAQ than on the NYSE. We next assess whether controlling for volatility and other economic characteristics can affect conclusions regarding trading costs on each exchange.

G. Assessing Whether Heterogeneity in Economic Attributes Can Explain Cross-Sectional Variation in Average Bid-Ask Spreads

We note in Section II that our sample is constructed so that firm sizes, trading volume, and share price are comparable across listing venues. However, these sample selection criteria do not provide a complete control for all cross-sectional variation in economic characteristics that affect market-making costs. In particular, as documented in Section IV.F above, the riskiness of holding securities in inventory differs across exchanges. Also, the trades that actually occur at the NYSE are not random draws from the pool of all trades in NYSE issues. For example, Bessembinder and Kaufman (1997) document that the NYSE executes a relatively small proportion of small trades in large NYSE companies where the regional exchanges hold a large market share. Variation in average trading costs across the NYSE and NASDAQ might reflect selection biases in the subset of trades executed on the NYSE.

To address this issue, we assess whether average trading costs vary across exchanges after controlling for variation in economic characteristics. To do so, we expand the second stage regression discussed in Section III.D above to include several economic variables, while using indicator variables to allow the slope coefficient on each economic variable to differ across listing venues. The economic variables we employ include the market capitalization of the traded firm as of the beginning of the sample, the inverse of the average transaction price for each firm by month, the standard deviation of the daily returns for each firm by month, average daily trading volume for each firm during 1993, and the average trade size in dollars for each firm by month. We transform each of the economic variables by deducting the variable's sample mean (computed across both the NYSE and NASDAQ subsamples), and estimate the regression using the transformed variables.[15]

The results of estimating this augmented regression provide information on two interrelated issues. First, since separate slope coefficients are estimated by listing venue, comparisons can be made of the degree of similarity or disparity in relations between trading costs and economic variables across listing venues. However, to interpret the estimated slope coefficients, it is important to recognize that the coefficients are estimated in a multiple regression. Each slope coefficient, therefore, estimates relations between trading costs and the associated economic variable, while holding fixed each of the other economic variables. Second, by examining the estimated intercepts, it is possible to assess whether average trading costs vary across exchanges after adjusting for heterogeneity in economic attributes. Regression intercepts estimate the mean of the regression's dependent variable, conditional on each explanatory variable equaling zero. Since we use demeaned economic variables, the intercept coefficients reveal the estimated trading cost on each exchange for an "average" trade, i.e., a trade of average size in a firm with market capitalization, share price, return volatility, and trading volume equal to the means observed in the pooled NYSE-NASDAQ sample. The resulting slope coefficients are reported in Table 7, while intercepts are reported in Panel B of Table 8. Panel A of Table 8 reproduces for comparison sample means on each variable of interest.

TABLE 7

Relations between Economic Variables and Spread Measures

Economic Variable.	Firm Size		Inverse Share		Return S.D		1993 Trade Vol.		Trade Size	
	NYSE	NASDAQ	NYSE	NASDAQ	NYSE	NASDAQ	NYSE	NASDAQ	NYSE	NASDAQ
Dependent Variable.										
Quoted Half-Spread (%)	−0.079	0.261	10.050	3.350	0.585	0.853	−0.271	−0.380	*	*
		[0.000]		[0.000]		[0.000]		[0.046]		*
Effective Half-Spread (%)	−0.056	0.065	3.716	2.684	0.199	0.335	−0.079	−0.139	−0.005	−0.023
		[0.000]		[0.000]		[0.000]		[0.002]		[0.000]
Price Impact at One-Day Horizon (%)	−0.031	0.052	1.578	0.280	0.319	0.388	−0.085	−0.084	0.006	−0.018
		[0.000]		[0.000]		[0.000]		[0.918]		[0.000]
Realized Half-Spread (%)	−0.025	0.013	2.136	2.403	−0.120	−0.053	0.007	−0.055		−0.005
		[0.400]		[0.004]		[0.028]		[0.054]		[0.112]

Reported are coefficients obtained in pooled time-series cross-sectional multiple regressions of monthly means of the indicated dependent variables on economic variables. The firm size variable is market capitalization (in $billions) at the end of 1993. Inverse Share Price is the inverse of the average transaction price for the month. Return S.D. is the standard deviation of returns computed from daily closing prices for the month. Trading Volume reflects 1993 trading volume, in millions of shares per day. Trade Size is the mean monthly transaction size in units of $100,000. Separate coefficients are estimated for NYSE-listed and NASDAQ-listed firms. Bootstrap p-values reported in brackets are for the hypothesis that coefficients do not differ across NYSE and NASDAQ-listed firms.

One interesting regularity observable in Table 7 concerns the relationship between trading costs and firm size. For NYSE-listed companies, all measures of trading costs, including quoted spreads, effective spreads, and realized spreads,

[15] Inference is again based on a bootstrap procedure, where the modified regression is estimated using bootstrap samples drawn from the residuals of the actual estimation. Reported p-values reflect the proportion of outcomes in 500 bootstrap simulations where the absolute difference in the bootstrap coefficient estimates exceeds the absolute difference in the actual coefficient estimates.

TABLE 8

Mean Trading Costs Before and After Controlling for Variation in Economic Attributes

	NYSE	NASDAQ	*p*-Value
Panel A. Observed Means			
Quoted Half-Spread (%)	0.575	0.820	[0.000]
Effective Half-Spread (%)	0.394	0.433	[0.000]
Price Impact at One-Day Horizon (%)	0.297	0.266	[0.000]
Realized Half-Spread (%)	0.096	0.168	[0.000]
Panel B. Intercepts from WLS Regressions on Demeaned Economic Variables			
Quoted Half-Spread (%)	0.478	0.803	[0.000]
Effective Half-Spread (%)	0.327	0.458	[0.000]
Price Impact at One-Day Horizon (%)	0.262	0.266	[0.120]
Realized Half-Spread (%)	0.064	0.192	[0.000]

Panel A reports means of the indicated variables computed across all quotes or trades in the indicated group. The variables are defined on Tables 2, 3, 4, and 5, respectively. Panel B reports intercepts obtained in WLS regressions of the indicated variables on demeaned economic variables. (Corresponding slope coefficients are reported in Table 7). Each bootstrap *p*-value is for the hypothesis that NYSE and NASDAQ estimates are equal.

decline with market capitalization. In contrast, for NASDAQ-listed companies, each measure of trading costs increases with firm size, ceteris paribus. One possible explanation for this difference is that implicit collusion of the type asserted by Christie and Schultz occurs and is focused on the heavily traded large NASDAQ stocks. More than 88% of sample period NASDAQ trading volume is concentrated in these large stocks.

Trading costs vary inversely with share price for companies listed on each exchange. In part, this reflects the effect of minimum allowable price variations or "tick sizes," which are binding for bid-ask spreads on lower priced stocks. Quoted and effective spreads on each exchange decline as average trading volume increases, which likely reflects economies of scale in market-making. Trades' average price impact also decreases with increases in average trading volume, which is consistent with the Easley, Kiefer, O'Hara, and Paperman (1996) finding that a higher proportion of trades in less actively traded stocks originates with informed traders. On each exchange, quoted and effective spreads increase with the standard deviation of daily returns. Further, the estimated slope coefficient on risk is larger for NASDAQ firms, implying that the greater risk may contribute to the larger quoted and effective spreads on NASDAQ.

We assess whether cross-sectional variation in economic characteristics explains variation in average trading costs by comparing sample mean trading costs, reproduced on Panel A of Table 8, to intercepts from estimating the augmented second stage regression, reported on Panel B of Table 8. After controlling for variation in economic factors, quoted half-spreads are lower on the NYSE, by a large margin. The estimated intercept for NYSE quotes is 0.478%, compared to 0.803% for NASDAQ-listed companies. After controlling for variation in economic attributes, average effective half-spreads are 0.327% for NYSE-listed companies, compared to 0.458% for NASDAQ-listed issues. This differential in effective spreads is larger than the full sample differential observed in the unadjusted data (as reported in Panel A), but still smaller than the differentials reported by Huang and Stoll (1996). As in the raw data, price impact adjusted for the effects of cross-sectional variation in trades' economic attributes is greater for trades executed on the NYSE. As a consequence, realized spreads adjusted for variation across exchanges in economic attributes are smaller on the NYSE. The NYSE advantage in realized spreads is substantial: intercepts from the regression that includes demeaned economic variables are 0.064% for NYSE companies compared to 0.192% for NASDAQ companies. Collectively, these results indicate that the effect of controlling for variation in economic characteristics is to accentuate rather than explain the observed differences in average execution costs for NASDAQ vs. NYSE listings.

It remains a possibility that differences in average execution costs across exchanges are attributable to variation in economic characteristics other than those included in our analysis. For example, NASDAQ issues may, on average, represent younger companies or may reflect a higher concentration of firms in specific industries such as computer networking or biotechnology. We note, however, that to explain the higher NASDAQ intercepts reported in Table 8, the omitted variables must not only be determinants of the economic costs of market-making, but (since coefficients on included variables will reflect the effects of correlated-omitted variables) must also be uncorrelated with the economic variables such as return volatility and firm size that are included in the analysis.

Another possibility is that the differences in intercepts reported in Table 8 are attributable to differences in the nature of trading volume across exchanges. On the NYSE, the crossing of two market orders is recorded as a single trade, while on NASDAQ, the execution of two market orders always involves two trades. The multidealer system may also give rise to more interdealer trades for purposes of inventory rebalancing. There is no simple or unambiguous adjustment that would render volumes comparable across exchanges. Our analysis partially accomodates the differing nature of trading volume across exchanges by allowing separate slope coefficients by listing venue.

To investigate whether overstatement of NASDAQ volume potentially explains the larger NASDAQ intercepts reported in Table 8, we assess the sensitivity of the empirical estimates to a simple adjustment where reported volume for each NASDAQ firm is divided by a constant scaling factor. The effect of deflating reported NASDAQ trading volume in this manner is to increase the estimated NYSE intercept and to decrease the estimated NASDAQ intercept.[16] However, we find that to fully explain the observed differentials in quoted and effective bid-ask spreads requires that reported NASDAQ volume must be scaled by a factor of between six and eight. This would indicate that NASDAQ volume must be overstated by between 500% and 700% to alter our conclusions, which seems implausible. Simply adjusting NASDAQ volume by a scaler is no doubt a highly imperfect correction. However, this analysis is suggestive that the mismeasurement of volume must be severe to potentially explain cross-exchange differentials in trading costs.

[16]Mechanically, the adjustment to reported NASDAQ volume has two effects. First, the estimated NASDAQ slope coefficient on volume increases. Second, since the pooled NYSE-NASDAQ sample mean trading volume declines, the estimated intercepts for each exchange evaluate average trading costs conditional on a lower level of trading volume.

H. Quote Rounding Frequencies

Christie and Schultz (1994) document that market-makers in several large NASDAQ issues tend to round the fractional portion of price quotations to even eighths of a dollar. We extend their analysis to our broader set of 300 NASDAQ companies, and compare quote rounding frequencies across the NYSE and NASDAQ samples. Panel A of Table 9 reports the proportion of quotes in our sample that are rounded to even eighths (0/8, 2/8, 4/8, or 6/8) of a dollar, on each exchange. If the minimum allowable price variation is always 1/8 of a dollar, and the numerator in the fractional portion of each price is a random draw from the set of available integers, then the observed proportion of quotations rounded to even eighths should not differ significantly from 0.5.[17]

For the set of 300 NYSE companies, 52.1% of NYSE quotes are rounded to even eighths. In contrast, 71% of the quotes for the sample of 300 NASDAQ issues are rounded to even eighths. This result is consistent with the findings of Christie and Schultz (1994) in that NASDAQ market-makers display a notable preference for even fractions.

I. Did May 1994 Mark a Structural Shift in Bid-Ask Spreads or Quotation Strategies?

Christie, Harris, and Schultz (1994) assert that quotation strategies and trading costs in NASDAQ securities changed abruptly at the end of May 1994. They attribute the shift to the collapse of an implicit agreement among NASDAQ market-makers to round quotes and maintain wide bid-ask spreads, occasioned by publicity surrounding the Christie and Schultz (1994) paper.

The empirical evidence they report is limited to five large NASDAQ companies, and is based on data through the end of July 1994. We examine quoted spreads, effective spreads, and rates of quote rounding for our sample of 300 NASDAQ companies of varying market capitalization, and extend the analysis to the end of 1994. Results for the sample of 300 NYSE-listed companies are also reported as a point of comparison. Panel B of Table 9 reports average trading costs and quote rounding frequencies by exchange separately for the January to May and July to December subperiods.

In contrast to the results that Christie, Harris, and Schultz report for their sample of five companies, average quoted half-spreads for our broad set of 300 NASDAQ issues did not decline subsequent to May 1994. Rather, average quoted half-spreads on NASDAQ rose by a small (and statistically insignificant) margin subsequent to May 1994. Quoted half-spreads for NYSE-listed companies were also little altered after May.

With respect to quote rounding frequencies, the results for our sample of 300 diverse NASDAQ companies are consistent with those reported by Christie, Harris,

[17]NASDAQ securities priced below $10 and NYSE securities priced below $1 are eligible for quotations at a minimum tick of 1/16 of a dollar or finer. For these securities, we should expect to observe a smaller fraction of quotes at even eighths, if the numerator of each fractional price is drawn at random. The presence of such securities strengthens the interpretation of an empirical observation of a quote rounding frequency in excess of 50% as indicative of market maker preference for round quotes.

TABLE 9

Quote Rounding Frequencies and Tests for Shifts around May 1994

Panel A. Proportion of Quotes at Even Eighths

	NYSE	NASDAQ	*p*-Value
Firm Size			
All	0.521	0.711	[0.000]
Large	0.518	0.724	[0.000]
Medium	0.533	0.783	[0.000]
Small	0.518	0.499	[0.116]

Panel B. Pre and Post May Comparisons

	NYSE		NASDAQ	
	Pre	Post	Pre	Post
Quoted Half-Spreads (%)				
All Firms	0.575	0.575 [0.998]	0.804	0.832 [0.440]
Large Firms	0.323	0.319 [0.716]	0.447	0.444 [0.864]
Medium Firms	0.780	0.807 [0.620]	1.365	1.576 [0.004]
Small Firms	1.850	1.938 [0.372]	2.305	2.692 [0.028]
Proportion of Quotes at Even Eighths				
All Firms	0.526	0.518 [0.000]	0.762	0.671 [0.000]
Large Firms	0.523	0.515 [0.000]	0.786	0.678 [0.000]
Medium Firms	0.537	0.530 [0.016]	0.808	0.759 [0.048]
Small Firms	0.522	0.514 [0.088]	0.515	0.486 [0.288]
Effective Half-Spread (%)				
All Firms	0.387	0.399 [0.316]	0.444	0.426 [0.264]
Large Firms	0.238	0.240 [0.790]	0.329	0.314 [0.174]
Medium Firms	0.572	0.598 [0.260]	0.984	1.095 [0.020]
Small Firms	1.316	1.476 [0.014]	1.855	2.010 [0.082]

Panel A reports the proportion of quotes originating at each exchange that use a fractional price that is an even eighth of a dollar. Bootstrap *p*-values reported in Panel A are for the hypothesis that rounding frequencies are equal across exchanges. Panel B reports average quoted half-spreads, rounding frequencies, and effective half-spreads for January to May (Pre) and June to December (Post) 1994 subsamples. Each bootstrap *p*-value reported in brackets in Panel B is for the hypothesis that the associated parameter is unchanged across the pre and post subsamples.

and Schultz, in that the frequency with which quotes for NASDAQ companies were rounded to even eighths declined significantly from 76.2% to 67.1% after May. In contrast, quote rounding frequencies for NYSE-listed companies were little altered.

Average effective half-spreads for large NASDAQ issues declined from 0.329% to 0.314% after May 1994. This decrease is economically small (equating to $9.34 for an average large firm trade of $62,309) and is not statistically significant (*p*-value = 0.264). Further, the post May reduction in effective spreads on NASDAQ is limited to large capitalization issues. Average effective half-spreads for trades in medium and small NASDAQ companies rose after May 1994 by 0.111% and 0.155%, respectively.

To summarize, the empirical results for this sample of 300 diverse NASDAQ companies are consistent with the results that Christie, Harris, and Schultz obtain for their sample of five large NASDAQ companies only in the finding that the frequency with which quotes are rounded to even eighths declined significantly subsequent to May.[18] We find no evidence that average quoted or effective spreads on NASDAQ narrowed after May 1994.

V. Conclusions

This paper presents the results of a comprehensive analysis of execution costs for 300 companies listed on the NYSE's specialist-auction market and 300 size-matched companies listed on the NASDAQ multiple dealer market. These comparisons are of interest for traders evaluating portfolio strategies, companies choosing among listing venues, regulators and exchanges considering the design or modification of trading structures, and researchers examining market structure.

This analysis confirms that execution costs are, on average, greater for trades in NASDAQ issues compared to matched NYSE issues. The empirical results reported here are consistent with those of Huang and Stoll (1996). However, while the Huang and Stoll study focused exclusively on large capitalization issues, we also include sets of small and medium capitalization firms. We find that NYSE execution costs are lower for these groups as well, and that the differentials in average execution costs are generally greater for the smaller firms. These findings are at odds with the reasoning that NASDAQ has a comparative advantage in making markets for smaller firms when compared to the NYSE. We also document that cross-exchange differentials in average execution costs tend to be largest for small trades, a finding that raises particular concerns regarding NASDAQ trade executions for individual investors.

While we do not identify the reason for the larger NASDAQ spreads, we do dismiss some explanations. We examine the possibility that NASDAQ trades convey more private information, which would imply that NASDAQ market-makers require wider spreads to recover greater adverse information costs. We fail to find evidence of systematically larger trade price impacts on NASDAQ, implying a lack of empirical support for this reasoning. Further, the variation in average trading costs across exchanges cannot be attributed to variation in observable characteristics such as firm size, average trade size, trading volume, return volatility, or share price.

Having ruled out these explanations, the remaining explanations for larger execution costs on the NASDAQ market are limited to i) NASDAQ market-makers are subject to larger inventory or order processing costs, for which the economic variables we employ are not adequate proxies, or ii) NASDAQ market-makers earn larger economic profits than suppliers of liquidity on the New York market. There are several potential explanations for higher rates of economic profit on the

[18]We are, however, able to closely replicate their results for the five firms in their sample.

NASDAQ exchange. Tacit collusion, as suggested by Christie and Schultz (1994), is one. Kandel and Marx (1997) focus on the role of the minimum tick, showing that Bertrand competition in quotes need not decrease the bid-ask spread beyond the marginal cost of processing trades plus two ticks. Godek (1996) and Dutta and Madhavan (1997) focus on the role of "preferencing" agreements, by which retail brokers agree to deliver order flow to specific market-makers, in exchange for cash payments and a commitment by the market-maker to execute trades at the inside quote. Huang and Stoll (1996) observe that incentives to post competitive quotes are greatly reduced if a substantial portion of order flow is subject to preferencing agreements, while Dutta and Madhavan note that preferencing agreements may effectively create barriers to entry to NASDAQ market-making. Our finding that differentials in execution costs are, on average, greatest for small trades, which preferencing agreements typically target, is consistent with the reasoning that these agreements hinder competition.

The differential across exchanges in average execution costs that we document for our 1994 large firm subsample is substantially smaller than that found by Huang and Stoll (1996) for their 1991 large firm sample. Our analysis, like Huang and Stoll's, excludes commission costs. It is possible that large institutional traders, who are sometimes able to trade on NASDAQ net of explicit commissions, may face lower total trading costs when executing large firm trades at NASDAQ. Individual traders are likely to face higher average execution costs on NASDAQ even in large firm trades. Differentials across exchanges in average trade execution costs for smaller trades and for trades in smaller firms are particularly large, and are unlikely to be reduced meaningfully by the inclusion of commissions.

Our results confirm those of Christie and Schultz (1994) in that we document that NASDAQ market-makers display a notable preference for even fractions when quoting for NASDAQ issues. For the full sample, 71.1% of quotes for NASDAQ issues are rounded to even eighths. However, our results contrast with those reported by Christie, Harris, and Schultz (1994) in their widely publicized study of five large NASDAQ companies, in that we find no reliable evidence for our sample of 300 diverse NASDAQ companies that average quoted or effective spreads on NASDAQ narrowed after May 1994.

The NASDAQ market has recently agreed to a series of market reforms (see SEC (1996)). Among these is an obligation to begin displaying customer limit orders as quotes when the limit order improves on the best dealer quote. Also, the Chicago Stock Exchange has recently begun to execute trades in NASDAQ-listed firms. Determining whether these reforms reduce NASDAQ trading costs and eliminate the differential in average trading costs across the NYSE and NASDAQ comprises an interesting subject for future research.

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