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Trading Mechanisms and the Components of the Bid-Ask Spread

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ABSTRACT

We compare the relative magnitudes of the components of the bid-ask spread for New York Stock Exchange (NYSE)/American Stock Exchange (AMEX) stocks to those of National Association of Securities Dealers Automated Quotations (NASDAQ)/National Market System (NMS) stocks. We find that the order-processing cost component is smaller, and the adverse selection component is greater on the NYSE/AMEX trading systems than on the NASDAQ/NMS system. The inventory holding component is also greater for exchange-traded stocks than for NASDAQ/NMS stocks, but this may be attributable to differences in the characteristics of the firms whose stocks trade on the respective systems.

RECENT LITERATURE ON MARKET microstructure shows that trading systems have a significant effect on the price discovery process (Amihud, Ho, and Schwartz (1985), Cohen, Maier, Schwartz, and Whitcomb (1986), Garbade and Silber (1979a, 1979b), Goldman and Beja (1979), and Schwartz (1988)). The objective of this article is to examine how differences in the organization of trading affect an important element of the pricing process, namely, the bid-ask spread. We focus on the two major systems for trading common stocks in the United States, the agency/auction market, as represented by the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX), and the competitive dealer market, as represented by the National Association of Securities Dealers Automated Quotations (NASDAQ) system.

Prior studies contrasting exchange and dealer trading have concentrated on the impact of the trading system on the supply of liquidity and the *total* bid-ask spread (for example, Hasbrouck and Schwartz (1986), Marsh and Rock (1986), Stoll (1978), Branch and Freed (1977), and Hamilton (1978, 1979, 1987)). The general consensus of these studies is that the average

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spread on the exchanges is lower than the NASDAQ spread. Using an alternative approach, Vijh (1990) compares the liquidity of Chicago Board Options Exchange (CBOE) options with NYSE stocks. He concludes that the multiplicity of dealers on the CBOE leads to greater market depth (ability of the market to absorb large orders with only a small price impact) as well as larger bid-ask spreads relative to the specialist-based NYSE system.

According to the existing literature, the quoted bid-ask spread has three components (Copeland and Galai (1983), Glosten and Milgrom (1985), Glosten (1987), Glosten and Harris (1988), Grossman and Miller (1988), Hasbrouck (1988), Ho and Stoll (1981, 1983), and Stoll (1978, 1989)). One component is due to order processing costs, which represent a fee charged by market makers for standing ready to match buy and sell orders. A second component reflects inventory holding costs, which compensate dealers for holding less diversified portfolios. Finally, an adverse selection component represents a reward to market makers for taking on the risk of dealing with traders who may possess superior information. In this article we focus on the impact of trading structure on the components of the bid-ask spread. Specifically, we argue that exchange trading lowers order processing costs relative to dealer trading on the NASDAQ/National Market System (NMS) by facilitating the matching of buy and sell orders, by increasing the competition among market participants, and by reducing the need for dealer participation. However, unlike competitive market makers who are able to share the inventory risk, the exchange specialist is often obliged to absorb a large part of the imbalance in order flow. This leads us to predict higher inventory holding costs for the exchanges. Finally, both systems have advantages and disadvantages in coping with adverse selection risk, so we are unable to predict the direction of the difference for this component.

We compare estimates of the three components of the bid-ask spread for a sample of exchange (NYSE and AMEX) stocks and a sample of NASDAQ/NMS stocks. Consistent with our hypotheses, the empirical estimates and tests show that order processing costs are significantly lower for NYSE and AMEX stocks relative to NASDAQ/NMS stocks, while inventory holding costs are higher for the exchange-listed stocks. Subsequent tests, however, indicate this latter result may be attributable to differences in the characteristics of the stocks that trade on the two market systems rather than the trading systems per se. Finally, our results indicate a higher adverse selection component on the exchanges. Together, these results suggest that both the structure of trading and the characteristics of the individual stocks being traded are important determinants of the bid-ask spread.

The rest of the article is organized as follows. The next section discusses our hypotheses concerning the impact of trading mechanisms on the components of the spread. In Section II we discuss our data and research methods. The empirical results are presented in Section III. We conclude the article in Section IV with a summary of our findings.

I. Hypotheses

Two important differences between the exchanges and the NASDAQ/NMS are the listing standards firms must satisfy in order for their securities to be eligible for trading and the way in which trading is organized. We examine the impact of trading organization on the spread components in this section and defer the discussion of listing standards to Section II.

The stock exchanges are organized predominantly as auction markets, with the specialist enjoying an exclusive franchise to make a market in a listed stock and to manage the book of public limit orders. In return, the specialist has an affirmative obligation to maintain a fair and orderly market. Thus order flow in a given stock is consolidated at the specialist's post, and floor trading allows the buy and sell orders to be worked in the "crowd." In contrast, there are several market makers in each stock traded on the NASDAQ/NMS, and the order flow in a given stock is fragmented across dealers. These structural differences have two important effects on the trading process. First, there is much greater direct interaction of public orders on the exchange floor relative to the NASDAQ/NMS. Second, floor trading increases competition among market participants as evidenced by a greater frequency of exchange trades inside the spread (Hasbrouck (1988), Lee and Ready (1991), and Vijh (1990)). Consequently, the auction-based exchange trading structure facilitates the matching of buy and sell orders without requiring as much dealer participation as the fragmented competitive market maker structure of the NASDAQ/NMS. This leads to our first hypothesis.

HYPOTHESIS 1: *By promoting greater direct interaction of public orders, auction-based exchange trading reduces the order processing cost component of the quoted spread relative to the competitive market maker structure of the NASDAQ/NMS.*

Although multiple dealer markets are characterized by higher aggregate inventory levels, which increase in proportion to the number of market makers (Ho and Macris (1985)), they nevertheless have several advantages over specialist markets with regard to the ability to manage inventory risk. First, as Ho and Macris (1985) and Vijh (1990) note, multiple dealer markets have a larger capacity to absorb imbalances in order flow than specialist markets because of the larger inventory they carry collectively. Second, Ho and Stoll (1983) suggest that the potential for interdealer trading reduced the inventory risk exposure of competitive dealers by allowing for quick reallocation of inventory imbalances across market makers. Third, Grossman and Miller (1988) argue that because dealers assume the price risk shed by traders who place market orders, the price risk borne by any single dealer can be reduced by spreading (or diversifying) this risk across several market makers. Other things equal, the larger the group of dealers, the greater the potential for diversification gains and the lower the expected cost of inventory per unit traded by a market maker. These arguments imply that it is more expensive for the specialist to absorb a given amount of order imbalance than for a group of competing market makers with heterogeneously distributed inventory positions.

The specialist's inventory control problem is exacerbated by three additional factors. First, the affirmative obligation to maintain a fair and orderly market (i.e., the exchange-mandated price smoothing) constrains the ability to revise quotes in response to new information and consequently exposes the specialist's inventory level to greater fluctuations. Second, unlike NASDAQ dealers, specialists are not allowed to diversify their trading operations by offering other financial products and services such as investment banking and retail brokerage. Third, exchange trades are, on average, larger in size than a typical trade on the NASDAQ/NMS, and there is a higher incidence of block trading on the exchanges.[1] These factors tend to aggravate the inventory imbalances faced by the specialist and floor traders and lead to our second hypothesis.

HYPOTHESIS 2: *Unlike multiple dealers on the NASDAQ/NMS who are able to share inventory risk, the specialist faces a larger cost of absorbing a given imbalance in order flow, which increases the inventory holding cost component of the quoted spread on the exchanges.*

The way trading is organized also influences the adverse selection risk confronting market makers. An examination of the way trading is organized on the two systems reveals some differences that give NASDAQ dealers both advantages and disadvantages relative to exchange specialists with respect to the adverse selection risk. Madhaven (1992) suggests that price competition between dealers on the NASDAQ system lowers the adverse selection component of the spread. The specialist, however, also faces competition from floor traders, the limit order book, and the derivative asset markets. Grossman and Miller (1988) imply that the adverse selection risk can be reduced (i.e., diversified) on the NASDAQ system by spreading it across many dealers. Multiple dealers, however, may allow informed traders to conceal their trades more easily (e.g., by dividing their trades across many dealers, see Lin and Howe (1990)).[2] Other factors favoring NASDAQ dealers include the ability to receive orders directly from customers and to maintain close contact with them, their ability to work with company officials in the merchandising of

[1] See block trade statistics in New York Stock Exchange (1988) and National Association of Securities Dealers (1988).

[2] Chang (1989) develops a theoretical model of competitive market making under asymmetric information. In his model, although informed traders want to trade in large quantities, as in Easley and O'Hara (1987), they find it advantageous to first trade small quantities with dealers at their posted quotes (see also Kyle (1985)). The dealers, however, correctly infer that many small orders are motivated by the same quality of information as large orders.

their stocks (e.g., through initial and seasoned offerings), and to advise companies on dividend policy, stock splits, etc. (National Association of Security Dealers (1988)).[3] On the other hand, the preponderance of new, small, and regional firms that trade on the NASDAQ and the tendency for the total flow of *public* information to increase with the size of an issue, increases NASDAQ dealers' exposure to adverse selection risk. In addition to the relative scarcity of information, small firms often have fewer insiders and retain more private information (see Williams (1986)). Also, specialists are better equipped to deal with adverse selection risk by averaging profits across trades because of their limited monopoly position (Glosten (1989)) and their ability to share this risk with the limit order book, floor traders, and the upstairs market for block trades. Finally, Biais (1993) and Stoll and Whaley (1990) point out that the exchange markets are more transparent, in that information about current market conditions is more readily available to floor traders and the specialists, who can monitor their competitors' quotes as well as trades. The conflicting arguments above indicate that it is an empirical issue as to which system will result in a lower adverse selection component.

To summarize, we hypothesize that lower order processing costs and higher inventory holding costs are associated with exchange trading than with dealer trading on the NASDAQ/NMS. However, the impact of these trading mechanisms on adverse selection costs is ambiguous and is, therefore, an empirical question.

II. Data and Methodology

A. Data

The American Stock Exchange provided data on transaction prices and bid-ask quotations for all NYSE, AMEX, and NASDAQ/NMS securities traded in the months of March and April 1985. This is the same data used by Hasbrouck and Schwartz (1986) and Vijh (1990). To be included in our sample a stock had to have an average price of at least \$3 in each of the months, and the number of shares outstanding for each stock had to be available on the Center for Research in Security Prices (CRSP) tape for the relevant period. In addition, the NASDAQ stocks had to be quoted on the NMS, and each included stock had to have at least three transactions on at least 15 of the 21 trading days in each month. This results in a final sample of 1,648 exchange stocks (1,350 NYSE and 298 AMEX) and 815 NASDAQ/NMS stocks in March and 1,646 exchange stocks (1,349 NYSE and 297 AMEX) and 810 NASDAQ/NMS stocks in April. In the remainder of the article this sample is referred to as the "Full Sample."

[3] This contrasts with specialists who are prohibited (NYSE Rule 460.1) from engaging in any corporate finance activity with a firm whose stock they trade.

Because the trading systems have different listing standards, the results using the full sample will reflect both differences in the way trading is organized and differences in the constituent stocks. The listing standards are basically of two types: quantitative and qualitative. Quantitative standards cover firm size, distribution of ownership, and earnings record, while qualitative standards are designed primarily to protect shareholders from agency problems and enforce certain business practices aimed at maintaining sound standards of corporate responsibility and accountability to shareholders. In general, these standards are substantially higher for the NYSE and somewhat comparable for the AMEX and NASDAQ/NMS. Since these listing standards influence the type of companies choosing, or eligible, to list on a trading system, any observed differences in the spread components may be attributable to listing-induced firm characteristics rather than the trading mechanisms.

To isolate differences in the spread components that are related to the trading structure, we construct a (approximately) matched sample of stocks from the two markets. Specifically, the matched sample comprises all NASDAQ/NMS stocks for which a "comparable" NYSE/AMEX counterpart could be identified, such that each matched pair differs by less than 20 percent in each of price per share, average dollar volume of trading, firm size (market capitalization), and standard deviation of daily returns. This matching is done without replacement so that each NYSE/AMEX firm appears at most once in each month in the matched sample. As shown in Panel A of Table I, this process yields a matched sample of 339 firms for March and 399 firms for April for each trading system.

Summary statistics presented in Panel B of Table I show that the mean differences in share price, trading volume, firm size, and standard deviation of returns between the exchange and NASDAQ/NMS matched stocks are not significantly different from zero. The mean percentage spreads for the matched sample are quite close, although the difference between the percentage spreads on the two systems is statistically significant.

B. Research Method

To estimate the components of the bid-ask spread, we use methods developed by Stoll (1989) and by George, Kaul, and Nimalendran (1991). The Stoll (1989) method constructs estimates of the order processing, inventory holding, and adverse selection components of the spread from slope coefficients of regressions of the serial covariance in the percentage price change series on the bid-ask spread:

$$\mathrm{cov}_T = a_0 + a_1 S^2 + u$$

$$\mathrm{cov}_Q = b_0 + b_1 S^2 + v,$$

where S denotes the quoted proportional spread (i.e., the difference between

Table I

Matched Samples of Exchange and NASDAQ / NMS Stocks

The Full Sample contains all stocks with an average price of at least \$3 in both March and April 1985, for which the number of shares outstanding is available on the CRSP tape. The matched sample includes all NASDAQ/NMS stocks that could be matched with a NYSE or AMEX firm such that the price, volume, firm size, and standard deviation of daily returns of the matched NYSE/AMEX firm is within 20 percent of each of the price, volume, firm size, and standard deviation of the NASDAQ/NMS firm. This matching is done *without* replacement, so that each NYSE/AMEX firm can only appear once in each month in the matched sample. Price (Volume) is the average closing price (number of shares traded times closing price) over the two months across all stocks in the matched sample. σ is the cross-sectional average of the standard deviation of daily closing returns for each stock. Size is the firm size at the end of the month (i.e., closing stock price at month end times number of shares outstanding). Spread is the average closing percentage spread of all stocks in the matched sample. For each stock the percentage spread is averaged for all days in the month and these averages are averaged across all stocks. No. of Transactions is the average number of transactions per day for each stock.

Panel A: Sample Sizes

	March		April	
	Full Sample	Matched Sample	Full Sample	Matched Sample
NYSE	1350	276	1349	280
AMEX	298	63	297	119
Exchanges	1648	339	1646	399
NASDAQ/NMS	815	339	810	399

Panel B: Summary Statistics for the Matched Sample

	Exchanges				NASDAQ/NMS				Difference in Means
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.	(t-Statistic)
Price	17.13	10.46	3.18	68.88	17.34	10.77	3.11	63.13	−0.37
Volume	24.39	25.07	2.11	217.29	24.79	24.98	2.53	182.69	−0.31
σ	1.12	0.61	0.25	4.44	1.12	0.56	0.25	3.90	−0.06
Size	214.36	294.44	6.43	3301.03	196.86	267.60	7.12	3188.84	0.23
Spread	1.89	0.94	0.46	5.78	1.77	0.97	0.35	6.71	2.33
No. of Transactions	17.13	17.11	3.70	177.10	27.90	33.30	4.20	472.70	−7.79

the ask and bid quotes divided by the average of these quotes); cov_T is the serial covariance of transaction price changes; cov_Q is the serial covariance of changes in bid (or ask) quotes; and u and v are error terms.

Given a_1 and b_1, the Stoll method then solves for intermediate values, ∂ (the size of a price continuation as a fraction of the spread) and π (the probability of a price reversal) from two auxiliary equations:

$$a_1 = \partial^2(1\text{-}2\pi) - \pi^2(1\text{-}2\partial), \quad \text{and} \quad b_1 = \partial^2(1\text{-}2\pi).$$

Components of the bid-ask spread are then determined as follows:

$$\text{Adverse Selection Cost} = [1\text{-}2(\pi\text{-}\partial)] \tag{1}$$

$$\text{Inventory Holding Cost} = 2(\pi\text{-}0.5) \tag{2}$$

$$\text{Order Processing Cost} = (1\text{-}2\partial). \tag{3}$$

In addition to providing estimates of the proportional components of the spread, the Stoll method can also be used to obtain estimates of the amount charged in cents for each component of the spread per dollar of stock price. Estimates of the costs as well as the proportion may be important because previous studies indicate that the level of the spread differs substantially between the trading systems. These costs per dollar of price can be computed by multiplying each of the proportional components (i.e., equations (1), (2), and (3)) by the percentage spread (S).

As in Stoll (1989), two estimates of cov_T (return covariances, one based on daily closing price changes, the other on intraday price changes) and two estimates of cov_Q (quote covariances, one based on changes in the daily closing bid quote, the other on daily closing ask quotes) are obtained for each of the months, March and April. The parameters a_1 and b_1 are estimated separately for each market system, for each month, and for each covariance measure. Final estimates of a_1 and b_1 are obtained for each market system by averaging the coefficients obtained using both covariance measures and both months. These values of a_1 and b_1 are then used to obtain estimates of the three components of the spread in equations (1), (2), and (3).

George, Kaul, and Nimalendran (1991) observe that the Stoll (1989) method is likely to result in biased estimates of the spread components.[4] To overcome the bias problem, George, Kaul, and Nimalendran (1991) propose an alternative method for estimating the components of the spread. The George, Kaul, and Nimalendran method has two major advantages over the Stoll method. First, under their assumptions, it provides unbiased estimates of the order-processing cost and adverse selection components of the spread. Second, the George, Kaul, and Nimalendran method utilizes a regression framework that can be easily amended to test for differences between trading systems in a parametric framework. Unfortunately, the George, Kaul, and Nimalendran model requires the assumption of a zero inventory cost component. While they provide some evidence suggesting this may not be an unreasonable assumption, it has traditionally been assumed that inventory costs are an important component of the spread (e.g., Garman (1976)).

[4] George, Kaul, and Nimalendran (1991) argue that due to positive autocorrelation in time-varying expected returns, transaction return-based estimates of the spread and its components may be biased and inefficient under certain conditions. Although estimates of a_1 and b_1 using the Stoll method may be unbiased, the estimates of π and ∂ are nonlinear transformations of a_1 and b_1 and hence are likely to be biased. Simulations we performed indicate that the bias is small (less than 4 percent per component). Results are available from the authors on request.

We reestimate the adverse selection and order cost components of the spread using the following version of the George, Kaul, and Nimalendran model:

$$S_i = \alpha_0 + \alpha_1 S_{qi} + \alpha_2 D + \alpha_3 (D \cdot S_{qi}) + \epsilon,$$

where

$S_i \equiv 2\sqrt{-\operatorname{cov}(RD_{it}, RD_{it-1})}$;
$RD_{it} \equiv R_{iTt} - R_{iBt}$;
$R_{iTt} \equiv$ continuously compounded transaction return on security i in period t;
$R_{iBt} \equiv$ continuously compounded return computed from bid quotes following transaction prices;
$S_{qi} \equiv$ quoted spread on security i;
$D \equiv$ 1 if the stock is quoted on the NASDAQ system and 0 otherwise (i.e., listed on NYSE/AMEX).

In this model, $\hat{\alpha}_1$ (the estimate of α_1) provides an unbiased estimate of the proportion of the spread due to order costs for exchange stocks. By assumption of zero inventory costs, $(1 - \hat{\alpha}_1)$ then provides an unbiased estimate of the proportional adverse selection component for exchange stocks. $(\hat{\alpha}_1 + \hat{\alpha}_3)$ and $(1 - \hat{\alpha}_1 - \hat{\alpha}_3)$ provide unbiased estimates of the order cost and adverse selection components, respectively, for NASDAQ/NMS stocks. Finally, the test of $\alpha_3 = 0$ is a test for differences in the order cost component (and the adverse selection component) between trading systems.

III. Empirical Results

The full and matched sample estimates of the components of the spread obtained using the Stoll method are summarized in Table II. For comparative purposes the estimates obtained in Stoll (1989) using NASDAQ/NMS stocks over the period October, November, and December 1984 are also reported in the table.

It is inappropriate to use conventional inference procedures to examine the statistical significance of the differences in the estimates between the trading systems in Table II. This follows since even if normally distributed errors are assumed in the cross-sectional regressions resulting in normally distributed estimates of a_1 and b_1, the estimates of the components of the spread have unknown distributions since they are nonlinear transformations of a_1 and b_1. Also, since cov_T may not be independent of cov_Q, a_1 and b_1 may not be independent, which further complicates the distributions of the spread components. For these reasons we employ a bootstrap method to conduct signifi-

Table II

Estimates of the Components of the Bid-Ask Spread

Components of the spread are estimated using the Stoll (1989) methodology. The full sample comprises 1,648 exchange-listed stocks and 815 NASDAQ/NMS stocks in March 1985 and 1,646 exchange-listed stocks and 810 NASDAQ/NMS stocks in April 1985. Exchange-listed stocks include both AMEX and NYSE stocks—1,350 NYSE stocks and 298 AMEX stocks in March 1985 and 1,349 NYSE and 297 AMEX stocks in April 1985. The matched sample comprises 339 and 399 stocks for each trading system in March 1985 and April 1985, respectively. Exchange-listed stocks include both AMEX and NYSE stocks—276 NYSE stocks and 63 AMEX stocks in March 1985 and 280 NYSE and 119 AMEX stocks in April 1985. Estimates obtained from Stoll (1989) are presented for comparative purposes. These are based on October, November, and December 1984 estimates for approximately 800 NASDAQ/NMS securities. p-Values are obtained from a bootstrap simulation involving 10,000 replications. They are computed as the number of negative differences divided by 10,000 where each difference is the exchange estimate minus the NASDAQ/NMS estimate for that particular bootstrap replication. The cost per dollar of price estimates (Panel B) are obtained by multiplying the corresponding proportional entry by the mean percentage spread, S. As these estimates are not given in Stoll (1989), the numbers in the first column of Panel B are computed by multiplying each individual component in the first column of Panel A by the average of the percentage spreads for October, November, and December 1984 reported in Table I of Stoll.

		Full Sample			Matched Sample		
	Stoll (1989)	Exchange	NASDAQ/NMS	Difference (p-Value)	Exchange	NASDAQ/NMS	Difference (p-Value)
			Panel A: Proportion of Percentage Spread				
Adverse selection cost	0.43	0.50	0.36	0.14(0.060)	0.59	0.35	0.24(0.032)*
Inventory holding cost	0.10	0.48	0.17	0.31(0.008)**	0.29	0.24	0.06(0.359)
Order processing cost	0.47	0.01	0.47	−0.45(0.002)**	0.12	0.41	−0.29(0.003)**
			Panel B. Cost Per Dollar of Price (Cents)				
Adverse selection cost	1.26	0.67	0.82	−0.14(0.272)	1.11	0.62	0.49(0.016)*
Inventory holding cost	0.29	0.65	0.39	0.25(0.119)	0.56	0.42	0.14(0.314)
Order processing cost	1.38	0.02	1.05	−1.03(0.000)**	0.23	0.73	−0.50(0.005)**

*,** Indicate significance at the 5 and 1 percent level, respectively (one-tail test for all but adverse selection cost).

cance tests (details provided in the Appendix).[5] The bootstrap tests indicate that significant differences in the components of the spread exist between the trading systems (see difference columns in Table II).

For the full sample, the average order processing cost is 1 percent of the quoted spread (or 0.02 cents per dollar of price) for the exchange stocks versus 47 percent (or 1.05 cents per dollar of price) for the NASDAQ/NMS stocks. The average inventory holding cost accounts for 48 percent of the spread for the exchange stocks (or 0.65 cents per dollar of price) compared to 17 percent (0.39 cents per dollar of price) for the NASDAQ/NMS stocks. These results provide statistical support for our two hypotheses. With regard to the adverse selection component, our full sample results indicate that exchange stocks have a higher proportional adverse selection component than the NASDAQ/NMS stocks (50 versus 36 percent) but a lower cost per dollar of price (0.67 cents versus 0.82 cents). This occurs because of the large difference between the average percentage spread of the exchange and NASDAQ/NMS stocks in the full sample (1.37 versus 2.26 percent) and highlights the need to compare similar stocks from the two trading systems.

The matched sample results, which provide a control for price, volume, firm size, and return standard deviation, also support our first hypothesis with the exchange stocks being characterized by a significantly lower order processing component than their NASDAQ/NMS counterparts.[6] While the exchange stocks are again associated with a higher inventory holding component, the difference is no longer statistically significant. With regard to the

[5] In a few instances the Stoll estimates in the bootstrap simulations resulted in negative estimates of the order cost component. Clearly this is infeasible and occurs whenever the estimate of $\partial > 1/2$. Since Stoll (1989) shows that under a pure order processing model, $\partial = 0$, and under a pure adverse selection model or pure holding cost model, $\partial = 0.5$, we restrict ∂ to the range (0; 0.5). (Note that since the realized spread is given by $2(\pi - \partial)S$, it is also clear that $\partial \leq \pi$.) Also, note that the Stoll estimates are very sensitive to the estimation of a_1 and b_1. In particular, attempts to obtain estimates of the three components for March and April separately failed due to many estimates of $\partial > 1/2$ in April for the exchange bootstrap. As a result ∂ is set equal to $1/2$ for a large number of exchange bootstraps, which, in turn, results in an estimated order cost component of zero. For this reason the a_1 and b_1 estimates are averaged over March and April. This is similar to Stoll (1989) who averages a_1 and b_1 over October, November, and December 1984.

[6] Spread comparisons between trading systems are further complicated by the presence of implicit commission costs in NASDAQ spreads. While brokerage commissions are paid on all exchange trades, Goldstein (1993) observes that when the NASD member acts as a dealer and not as a broker, institutional investors sometimes do not pay commission on their NASDAQ trades. Since NASDAQ market makers act as dealers approximately half of the time, Goldstein argues that NASDAQ spreads are overstated by some amount of the commission. We examine the effect of these implied commissions on the order-processing cost component by reestimating the spread components using the Stoll method after adjusting the NASDAQ/NMS bid quotes upward and the ask quotes downward by one-half of the estimated commissions reported in Goldstein (1993, Table 2). The reestimated proportional order processing cost components show little difference from those reported in Table II for either the full or the matched sample (49 and 47 percent of the spread, respectively, compared to the 47 and 41 percent reported in Table II). In all cases the difference in the order processing cost component across the trading systems remains significant at the 1 percent level.

adverse selection component, our matched sample results suggest that once we control for other factors, the exchange stocks are associated with a significantly higher adverse selection component than their NASDAQ/NMS counterparts (both as a proportion of the spread and as a cost per dollar of price).[7]

A comparison of the matched sample and full sample results shows that regardless of whether one controls for firm characteristics or not, spreads on exchange-listed stocks have a substantially smaller order processing component than their NASDAQ/NMS counterparts. The control for firm characteristics (or lack thereof), however, does appear to determine whether the offsetting difference (since the components must sum to one) is the adverse selection or inventory holding cost component. Specifically, for the full sample, the proportional inventory holding components are significantly different between the two trading systems but the adverse selection components are not, while for the matched sample the opposite holds (i.e., adverse selection components are significantly different, but the inventory holding components are not). This suggests that both distinctions, different trading structures and different component stocks, are important. We conclude that differences in trading structure imply differences in order processing and adverse selection costs, while differences in component stocks imply differences in inventory holding costs.

To investigate the robustness of our conclusions, we reestimate the order processing and adverse selection cost components using the George, Kaul, and Nimalendran method. These results are presented in Table III.[8] For

[7] The Stoll technique presumes transactions at the bid or the ask. Since many trades on the exchanges occur between the quotes, the autocovariances may not accurately reflect the exchange spread components. To examine the potential effect of this we reestimate the components using only data where each of the last three trades on each day occurred at the bid or ask (i.e., if any trade occurred at a price other than the bid or the ask, the observation is treated as a missing value). The results are qualitatively similar to those reported in Table II. Also, since NYSE commonly obtains closing quotes from specialists after the closing transaction, we reestimate the components using the quotes preceding the last trade of the day. Again, the resulting estimates are qualitatively similar to those reported in Table II. In addition, the specialist's affirmative obligation to maintain price continuity on the NYSE is likely to induce positive autocovariance in transaction returns and thereby affect our estimates of the spread components. Since we use daily data, however, the price-smoothing effect should be minimal for actively traded stocks. We reestimate the spread components for the exchange stocks for various activity-based subsamples such as daily dollar trading volume quartiles, daily number of transactions quartiles, and size (market value of stocks) quartiles and find little difference between the estimates for the more- and less-actively traded stocks. Further, unlike cov_I (serial covariance of intraday transaction returns), cov_c (serial covariance of daily closing transaction price changes) is likely to be less affected by price smoothing by the specialist. We reproduce the estimates using only cov_c (instead of the average of cov_c and cov_I as done in Table II) and find little difference from those reported in Table II. Tables summarizing these results are available from the authors.

[8] There is evidence of significant heteroskedasticity across the D variable (i.e., the indicator variable differentiating the two trading systems). However, while using maximum likelihood estimation and allowing different error variances for each trading system does confirm the presence of significant heteroskedasticity, the estimates of α_1 and α_3 are virtually unchanged. Consequently, we only report the ordinary least squares results in Table III.

Table III

Estimates of the Components of the Bid-Ask Spread Using the George, Kaul, and Nimalendran (1991) Method

The following version of the George, Kaul, and Nimalendran model is estimated:

$$S_i = \alpha_0 + \alpha_1 S_{qi} + \alpha_2 D + \alpha_3 (D \cdot S_{qi}) + \epsilon$$

where $S_i \equiv 2\sqrt{-\operatorname{cov}(RD_{it}, RD_{it-1})}$; $RD_{it} \equiv$ the difference in continuously compounded transaction return and the continuously compounded transaction return from bid quotes; $S_{qi} \equiv$ quoted spread on stock i; and $D \equiv 1$ if NASDAQ/NMS stock; 0 otherwise. The adverse information component is given by $(1 - \alpha_1)$ for exchange stocks and $(1 - \alpha_1 - \alpha_3)$ for NASDAQ/NMS stocks. The order processing cost is given by α_1 for exchange stocks and $(\alpha_1 + \alpha_3)$ for NASDAQ/NMS stocks. The inventory cost component is zero by assumption. Estimates in George, Kaul, and Nimalendran (1991) for a sample of NASDAQ stocks over the period 1983 to 1987 are presented for comparative purposes. F-values are given in parentheses for tests $\alpha_1 = 0$ (exchange order cost component), $\alpha_1 = 1$ (exchange adverse information component), $\alpha_1 + \alpha_3 = 0$ (NASDAQ/NMS order cost component), and $\alpha_1 + \alpha_3 = 1$ (NASDAQ/NMS adverse information component). The full sample consists of 1648 and 1646 exchange-listed stocks in March and April 1985, respectively, and 810 and 815 NASDAQ/NMS stocks in March and April 1985, respectively. The matched sample consists of 339 and 399 stocks for each trading system in March and April 1985, respectively. This sample is chosen so that each matched pair differs by less than 20 percent in each of average price, volume traded, standard deviation of returns, and size.

	George, Kaul, and Nimalendran (1991)	Exchanges (F-value)	NASDAQ/NMS (F-value)	Difference (t-value)
Panel A: Full Sample				
Adverse selection component	0.085	0.294**	0.097**	0.197**
		(515)	(65)	(11.19)
Order cost component	0.915	0.706**	0.903**	−0.197**
		(2960)	(5684)	(−11.19)
Panel B: Matched Sample				
Adverse selection component		0.258**	0.072**	0.186**
		(103)	(9.0)	(5.29)
Order cost component		0.742**	0.928**	−0.186**
		(846)	(1473)	(−5.29)

** Indicates significance at the 1 percent level.

comparative purposes we also provide the George, Kaul, and Nimalendran results for a sample of NASDAQ stocks over the period 1983 to 1987. For both our full and matched samples, the exchange stocks are associated with a significantly lower order cost component than NASDAQ/NMS stocks. Because the George, Kaul, and Nimalendran method assumes a zero inventory cost component, this result also implies that exchange stocks have a significantly higher adverse selection component than NASDAQ/NMS stocks. This is similar to the result obtained using the Stoll method on the matched sample and is in the same direction as the result using the Stoll method on the full sample. We therefore conclude that the George, Kaul, and Nimalendran method confirms our earlier results.

Finally, it is interesting to compare our results with those of Neal (1992), who finds that when trading volume is low, the specialist system on the AMEX is associated with lower bid-ask spreads on equity options than the competitive dealer system on the CBOE, but that the difference tends to diminish as volume increases. Our results, which examine differences in the spread components between the two market structures in common stocks are consistent with his findings. In addition, we show that the primary advantage of the specialist structure is its significantly lower order processing costs. However, this is offset by the higher proportional adverse selection costs associated with the specialist system relative to the competitive market maker structure.

IV. Summary and Conclusions

In this article we advance two hypotheses regarding the impact of two predominant trading mechanisms—agency/auction and competitive dealer—on the components of the bid-ask spread. Specifically, because exchanges promote greater interaction of public orders, we hypothesize that the exchange trading system lowers order processing costs. However, exchange trading is characterized by higher inventory holding costs because the specialist faces a larger cost of absorbing a given order imbalance. We use the Stoll (1989) framework, as well as the George, Kaul, and Nimalendran method, to infer the order processing, inventory holding, and adverse selection components of the quoted bid-ask spread for both full samples and matched samples of exchange-listed and NASDAQ/NMS stocks in March and April of 1985. Results of tests comparing these components indicate that significant differences exist between the two trading structures for all three components of the spread.

For the full sample, our estimates indicate that the order processing component of the spread is substantially lower for the exchange-listed stocks than for the NASDAQ/NMS stocks. The inventory cost component, measured as a percentage of the quoted spread, is significantly higher for the exchange trading system, but the difference is no longer significant at conventional levels when this component is measured as a fraction of stock price. The full sample results show no significant difference in the adverse selection component between the two trading mechanisms.

The results obtained from the matched sample abstract from differences in firm characteristics and allow us to isolate the impact of trading structures on the spread components. The persistence of the substantially lower order processing cost component for the exchange-traded stocks provides strong empirical support for our first hypothesis. However, while the inventory cost component continues to be higher for the exchange-listed stocks, the difference is no longer statistically significant. Consequently, we conclude that the observed differences in the inventory cost component in the full sample are primarily due to differences in the characteristics of firms choosing to trade on each system rather than to the trading structure per se. Finally, the matched sample results indicate a significantly higher adverse selection component for the exchange-listed stocks than for NASDAQ/NMS stocks. This suggests that the lack of significance of the observed differences in the full sample is largely due to our failure to control for differences in firm characteristics.

In conclusion, we find that both the trading structure and the characteristics of the individual stocks being traded are important determinants of the components of the quoted bid-ask spread. Trading structures have a significant effect on the order processing as well as the adverse selection components. Observed differences in the inventory cost component, however, may be attributable to differences in the characteristics of firms that choose to list on a trading system.

Appendix

In order to generate a bootstrap distribution under the null hypothesis of no difference between the trading structures, we combine the 1,648 exchange-listed stocks and 815 NASDAQ/NMS stocks in our samples for March 1985 into a single March sample of 2,463 stocks. We then randomly sample 1,648 stocks (with replacement) from this combined sample and designate them "exchange" stocks. We similarly draw a second random sample of 815 stocks (again with replacement) and designate them "NASDAQ" stocks. Similarly we draw a bootstrap sample of 1,646 April "exchange" stocks and 810 April "NASDAQ" stocks from the combined April samples. The entire procedure used to obtain the estimates in Table II is then repeated using these bootstrap samples. In addition, the differences in ∂, π, and each component of the spread between the two trading systems (i.e., exchanges minus the NASDAQ/NMS) are computed. This bootstrap procedure is repeated 10,000 times resulting in 10,000 estimates of the spread components for each system and 10,000 differences across trading mechanisms for each component of the spread. Because the two "samples" in each bootstrap simulation are drawn from identical populations (i.e., the combined sample), the distribution of the 10,000 differences for each component provide bootstrap distributions under the null hypothesis of no difference between trading structures. By observing where in the bootstrap distribution the observed difference using the trading structure dichotomy in Table II falls, we can compute an approximate p-value for the null hypothesis of no difference in the component across market systems. Our test on the difference in adverse selection components is two-sided and the rest are one-sided.

The bootstrap results are summarized in Table AI, which provides some descriptive statistics illustrating the distributions of the individual components on the different trading systems. As can be seen, the distributions of the three components of spread appear to differ substantially from normality, confirming that traditional parametric hypothesis testing would be inappropriate.

Table AI

Bootstrap Summary Statistics

The proportional components of the spread are estimated using the Stoll (1989) methodology. The cost per dollar of price estimates are obtained by multiplying the corresponding proportional entry by the mean percentage spread. The sample comprises 1,648 exchange-listed stocks and 815 NASDAQ/NMS stocks in March 1985 and 1,646 exchange-listed stocks and 810 NASDAQ/NMS stocks in April 1985. The bootstrap simulation involved 10,000 replications.

	Exchanges						NASDAQ/NMS					
	Mean	Std. Dev.	Skew	Kurt	Min.	Max.	Mean	Std. Dev.	Skew	Kurt	Min.	Max.
Panel A: Proportion of Percentage Spread												
Adverse selection cost	0.49	0.07	0.26	0.27	0.18	0.72	0.35	0.05	−0.31	0.12	0.11	0.52
Inventory holding cost	0.48	0.08	0.09	−0.02	0.21	0.00	0.16	0.10	−0.18	−1.04	0.00	0.42
Order processing cost	0.03	0.03	1.08	0.60	0.83	0.19	0.49	0.13	0.37	−0.82	0.11	0.90
Panel B. Cost Per Dollar of Price (Cents)												
Adverse selection cost	0.66	0.09	−0.26	0.16	0.22	0.98	0.80	0.12	−0.32	0.10	0.25	1.16
Inventory holding cost	0.64	0.11	0.09	−0.02	0.28	1.12	0.36	0.23	0.18	−1.04	0.00	0.96
Order processing cost	0.03	0.04	1.08	0.58	0.00	0.25	1.11	0.31	0.38	−0.81	0.26	2.05

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