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MARKETPLACE ORGANIZATION AND MARKETABILITY: NASDAQ, THE STOCK EXCHANGE, AND THE NATIONAL MARKET SYSTEM

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I. INTRODUCTION

THIS PAPER CONCERNS the effect of the National Association of Securities Dealers' Automated Quotation (NASDAQ) system on the price of marketability[1] for unlisted common stocks in the over-the-counter (OTC) marketplace.

The analysis of NASDAQ contributes some evidence on the relationship between the organization of the marketplace for stocks and the price of marketability. Tinic and West [14] have noted the paucity of empirical evidence on the relative merits of alternative marketplace organizations and have created "a stem in the direction of redressing this deficiency." Finding that prices of marketability were lower (*ceteris paribus*) in marketplaces with dealers than in those without dealers, they concluded that dealers increased the efficiency of the marketplace for stocks. Marketplaces with dealers have been organized in various ways, however. The study reported here considers some alternative organizations for dealer marketplaces. In particular, the analysis of NASDAQ revealed that changing a multidealer marketplace to incorporate a computerized market information system has increased its efficiency. This finding adds to Tinic and West's stem a branch that is of interest for several reasons.

The first is the efficiency of the OTC marketplace itself. Dealer firms provide marketability for stocks by immediately transacting on their own terms, which they announce as bid and ask price quotations.[2] Since the marketplace for a particular unlisted stock usually includes several OTC dealers, the function of NASDAQ is to display continually, through a centralized computer system, their current bid and ask quotations. Traders and brokers searching for the best transaction instantly obtain all dealer quotations from NASDAQ. As one part of the study I measured how much the introduction of NASDAQ lowered the price of marketability for unlisted stocks.

Second, by providing comprehensive trading information instantly and continuously in a centralized system, NASDAQ has imparted to the OTC marketplace some of the character of a stock exchange. On the NYSE, each listed stock has a

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1. Marketability (or liquidity) of a stock issue means that transactions of its shares are immediately available.

2. The price of marketability generally has been represented as the difference or spread between bid and ask prices.

single specialist (dealer). While comprehensive market information is more directly and immediately accessible to specialists than such information is to OTC dealers, NASDAQ would have reduced this information advantage. A second part of the study was to estimate by how much NASDAQ reduced the price of marketability in the OTC marketplace relative to the price on the exchange. A related issue is whether an automated quotation system would replace the exchange, by duplicating the advantage of centralized exchange transaction.

The Securities and Exchange Commission (SEC) has proposed that the several marketplaces[3] that transact NYSE-listed stocks be the components of a National Market System (NMS).[4] The various dealer firms in the OTC and exchange marketplaces would report their current price quotations on NYSE-listed stocks in a centralized computer system like NASDAQ. Consequently, the estimated effect of NASDAQ on marketability in the OTC marketplace (with several competing dealers) would give some indication of the likely effect of a similar system in the NMS (with several competing dealers and exchanges).

Part II of the paper contains a theoretical analysis of marketability in a multidealer marketplace. Estimates of the impact of NASDAQ on the price of marketability in the OTC marketplace are in Part III. The effect of NASDAQ on that price relative to the exchange is in Part IV, along with the implications for the economics of an exchange marketplace. A summary and conclusion constitute Part V.

II. Marketability with Several Dealers

In this section of the paper, the theoretical analysis of marketability and its pricing is summarized, and the analysis is extended to encompass the particular characteristics of a multidealer marketplace. Previous analysis has identified several determinants of the price of marketability for a stock. These determinants underlie the empirical model in section III. Since NASDAQ would not have affected any of these determinants, however, the analysis of multidealer marketplaces was necessary in order to develop a theoretical argument for why NASDAQ or the NMS would have any effect at all on the price of marketability. This analysis indicates that interaction among the several dealers is an essential characteristic of a multidealer marketplace. NASDAQ would affect the dealers and the price of marketability as it affected this interaction. Consideration of these matters comprises most of this section.

Previous theoretical analysis of the pricing of marketability has mostly concerned the NYSE specialists, which are monopoly (or near monopoly) dealer firms.[5] In this analysis, a dealer would set its bid-ask spread (S) (the price of

3. "Marketplace" is distinguished here from "market." The market is the collection of buyers and sellers, the characteristics of the product, and so on, which together are the forces shaping the market-clearing price or equilibrium price. The marketplace is the organization for assembling bids and offers and forming transactions. A market functions through one or more marketplaces.

4. On the NMS see SEC [9] and SEC [10].

5. In Section III, the assessment of NASDAQ's effect is an analysis of changes in long-run equilibrium prices of marketability. Consequently, in the following discussion statements about costs need refer only to average costs, though the statements may apply to marginal costs as well.

marketability) to cover its costs, compensate its risks, and meet its competition:[6] these would be affected by several factors.

$$S = S(P, R, T, I, C, D, K, M) \tag{1}$$

(Let S_X be the partial derivative with respect to X.) The price (P) of the stock would determine the amount of capital required for a dealer inventory of given number of shares and, accordingly, the capital cost per share transacted ($S_P > 0$). When dealers provide marketability by committing capital to inventory positions, they risk adverse changes in market price before they can dispose of those positions. Their risk would be commensurate with price volatility (R) of the stock, requiring a wider spread to compensate greater risks ($S_R > 0$).[7] A greater time rate of transaction (T) would, however, reduce the waiting time between orders, which would reduce the risk; perhaps a greater transaction rate also would reduce the average inventory and the capital cost per share ($S_T < 0$). As more financial institutions (I) owned and traded a stock, spreads would be different, because institutions are large and sophisticated buyers of marketability services, and because they often transact in blocks,[8] which require different marketability services than do smaller transactions (the sign of S_I is ambiguous). Tinic also argued that bid-ask spreads would be smaller with greater continuity of trading (C) and greater capitalization of dealers (K), while the effect of greater portfolio diversification (D) would be ambiguous:[9] C, K, and D were not observable for OTC dealers, however. Finally, the effectiveness of the competition that OTC dealers and the other stock exchanges give to specialists in a stock presumably would be greater as their number (M) was greater. For OTC dealers, competitiveness would be proportional to their number ($S_M < 0$).

Since these determinants of spreads largely are characteristics of the traders, the items traded, and the dealers, implementing NASDAQ would not have affected spreads by changing the values of these determinants.[10] Instead, NASDAQ would have had its impact through the dealer interaction process in the multidealer OTC marketplace. The remainder of this section concerns this process. As NASDAQ

6. Demsetz [2] and Tinic [12] comprise the theoretical foundation for the analysis of marketability prices.

7. Although stocks with greater price variability might have larger beta coefficients and, therefore, larger expected rates of return, these returns would not entirely compensate dealers for the greater inventory holding risk for such stocks. First, dealers generally would not have sufficiently diversified portfolios to neutralize their losses from random price variations. Second, dealers likely would expect greater losses to insider trading for stocks with greater R. Also, larger R does not, of course, necessarily mean larger beta coefficients and expected returns. For these reasons, dealers likely would set wider spreads for stocks with greater R. See Benston and Hagerman [1], pp. 357–59.

8. What constitutes a block transaction has no conceptual definition. Empirical studies mostly have separated blocks from nonblocks at 10,000 shares (100 round lots) per transaction.

9. Tinic [12].

10. While NASDAQ would not have a direct impact on these determinants, its effect on spreads and marketability might ultimately have an indirect impact on them. Whether it would, and even if it did whether the effect would be nonnegligible, is uncertain. By assuming, however, that NASDAQ has zero impact on the determinants, the empirical estimation of NASDAQ's effect in section III might understate somewhat NASDAQ's long-run effect.

affected interactions, it could reduce dealers' spreads either by reducing their risks and costs or by increasing the competition among them.

A. *Dealer Risks and Costs*

A monopoly dealer would evaluate its risks and costs from its own transactions, which would include all market transactions. As the sole dealer, it would have immediate first-hand information about the market. Its *own* price volatility and trading volume and the price at which it transacted would be the *market* volatility, volume, and price. When several dealer firms make a market in a particular stock, however, no one dealer would have first-hand information about the entire market.

To begin, suppose dealers were myopic and set price quotations without regard to other dealers' quotations. If a dealer received an excess of buy (sell) orders, its short (long) inventory position would induce it to quote higher (lower) bid and ask prices and to widen its spread. A myopic dealer would change its quotations only in response to its own transactions and inventory position and its independent assessment of the market. Since one dealer's transactions would be only a sample of market transactions, its quotations could be quite different from the market-clearing price. As different dealers received different mixes of buy and sell orders, their price quotations would differ. By watching the several mypoic dealers' bid and ask quotations, an observer could surmise what their individual market experiences were.

In general, however, quotations would not vary widely among the dealers in a stock issue. First, if one myopic dealer did have different quotations, some traders would find them attractive, correcting the imbalance between buy and sell orders that had induced the dealer to set those quotations. Second, dealers would, in fact, observe one another closely. Even without seeing all transactions first-hand, a dealer could follow the course of market trading. Beyond some differential among quotations, even the other dealers would submit orders to that dealer. The dealer even could initiate its own transactions with other dealers.

Consequently, as one dealer among several evaluated its risks and costs as a dealer, it would not be dependent solely on the orders it received. Since dealers would watch one another, each dealer would be evaluating its risks and cost on events in the entire market, not just on its own individual trading experience. Each dealer's risk would depend on the market price and volatility and on the market time rate of transaction, and so on. As orders arrived in the marketplace at a greater time rate, and as dealers watched and transacted, each dealer would have a smaller implicit waiting time between observations on the state of the market, just as a monopolist dealer would.

One implication of this argument is that the determinants of dealer bid-ask spreads in Equation (1) would apply equally to monopoly specialists and to marketplaces with several dealers. This is a consideration for the empirical model in Section III.

Nonetheless, since all orders would come directly to a monopolist, each of several dealers would incur some cost in monitoring quotations and adjusting inventories that a monopolist would not. This is the reason NASDAQ could reduce dealer costs and marketability prices.

Compared to a monopoly dealer, however, the several dealers in a stock would

benefit from the interplay among their several independent judgments about the state of the market. A dealer, whether a monopolist or not, always would be uncertain whether an imbalance between the numbers of buy and sell orders it received was transitory (due to chance) or was due to a change in the market-clearing price. In either case, responding to an imbalance would be risky. Since each dealer could test its own judgment against other dealers' judgments, as reflected in their bid-ask quotations, no one dealer would take the full risk of making such a judgment. The likelihood of misjudgment also might be smaller. Consequently, assuming all other conditions the same, a group of dealers might bear less risk than would a monopoly dealer, because the monopolist must rely solely on its own judgement.

B. *Dealer Competition*

Improved or cheaper information might also increase competitiveness among dealers. For a given number of dealers, competition might increase as traders, brokers, and the dealers themselves had more nearly complete knowledge of dealer price quotations. Dealers either would quote the same prices as other dealers (or better prices) or would not transact: niches would disappear. Facing more knowledgeable brokers, some dealers might even try to set more favorable bid and ask prices by narrowing their bid-ask spreads, i.e., price cutting.

C. *The Effect of Automated Quotations*

This discussion of marketability in a multidealer marketplace shows why NASDAQ would affect marketability: NASDAQ would facilitate the process of dealer interaction. Prior to NASDAQ, OTC dealers followed the market by telephone and by the daily quotation sheets (the so-called "pink sheets").[11] Dealers could not follow all the other dealers continuously and instantaneously. With NASDAQ, however, they could.

If an automated quotation system like NASDAQ drew the several dealers from myopic isolation, its effect on the price of marketability likely would be very large. Since a network of interaction would preexist, however, a system like NASDAQ or the proposed NMS quotation system would only increase the scope (and perhaps the accuracy) of a dealer's information and the speed with which it received and utilized the information: the system would not create new kinds of information nor change the nature of dealer interaction. Nonetheless, to whatever extent lower dealer costs or increased competition led to narrower bid-ask spreads, traders would pay lower marketability prices.

Automated quotations might cost dealers less than did the monitoring process it displaced. If not, its benefits must, of course, be weighed against its costs. If the extra cost of automated quotations was more than offset by reduced risk from improved information, dealers' total costs still would be smaller. Furthermore, even if dealers had higher costs, the total transaction cost still might be lower, if brokers had lower search costs (and fees) or traders had lower internal costs of trading. This paper concerns only the effect of automated quotations on the dealers.

11. See West and Tinic [15], pp. 67–68.

Since the elements of Equation (1) are the fundamental determinants of dealer costs and bid-ask spreads, these elements probably would have much greater weight in determining spreads than would an automated quotation system: automated quotations would not affect these other factors. Consequently, as a result of initiating NASDAQ or a similar system in a multidealer marketplace, bid-ask spreads probably would be smaller, but perhaps not much smaller.

III. The Effect of NASDAQ: Empirical Estimation

The preceding argument predicts that with the implementation of NASDAQ, OTC dealers would have reduced their bid-ask spreads. The size of the reduction was estimated by comparing OTC dealers' bid-ask spreads before and after NASDAQ, which was inaugurated on February 8, 1971.

A. *The Model of Dealer Spread Determinants*

Dealer bid-ask spreads could have changed between 1970 and 1971 for reasons other than the initiation of NASDAQ. In section II several determinants of spreads were identified. To control for changes in the values of these factors, the following multivariate model of the determinants of dealer spreads was used.

$$S_{it} = b_{1t} + b_{2t}P_{it} + b_{3t}\ln N_{it} + b_{4t}SS_{it} + b_{5t}IN_{it} + b_{6t}\ln R_{it} + b_{7t}\ln M_{it} + e_{it}, \quad (2)$$

where S_{it} = average bid-ask spread for stock i in sample period t;
P_{it} = mean share price;
N_{it} = number of shareholders;
SS_{it} = number of shares per shareholder, net of shares closely held by corporate officers, families of the company founders, or other corporations;
IN_{it} = number of financial institutions holding shares of stock i;
R_{it} = the difference between high and low bid prices for stock i for sample period t, as a ratio with P_{it};
M_{it} = mean number of OTC dealers quoting bid and ask prices for stock i;
e_{it} = error term.

Let $t=0$ for the 1970 sample period and $t=1$ for the 1971 sample period.

The theoretical analysis underlying Equation (2), which is a particular specification of Equation (1), was discussed in section II. This specification conforms with previous studies. The price of marketability was measured both as the dealers' bid-ask spreads (S) and as relative spreads (S/P). Since the bid and ask prices that dealers quote generally are firm quotations only for several round lots, the model would not relate directly to marketability of blocks of stock. Since reliable data on trading volumes were not available for OTC stocks prior to NASDAQ, I followed Demsetz's [2] suggestion and used the number of shareholders (N) as a proxy for the long-term or "normal" volume. The number of shareholders alone, however, might not be an entirely accurate indicator of the normal volume. Shareholders with only a few shares have low turnover rates. Consequently, for a given N, greater SS or IN would mean a higher normal trading volume. However, institutions trade more in blocks than do other traders. For a given number of

shares transacted, larger *IN* might mean more block trading and a *lower* normal volume of nonblocks.

Price volatility (R) was included,[12] but data were not available to measure trading continuity, dealer portfolio diversification, or capitalization of dealers, which were specified in Equation (1).

Finally, the degree of competition among dealers in a stock was presumed to be greater as their number (M) was greater, although the marginal impact would be less as more dealers already were trading: $\ln M$ was the specification used.[13]

From Section II, $E(b_2)>0$, $E(b_3)<0$, $E(b_4)<0$, $E(b_6)>0$, $E(b_7)<0$, and $E(b_5)$ is uncertain.

The bid-ask spread may not be an entirely accurate empirical indicator of the price of marketability.[14] For a given market equilibrium price of a stock, the price of marketability for that stock would be the difference between the average price paid by dealers for shares they buy and the average price received for shares they sell. Bid and ask prices are quotations, not actual transaction prices. The depth of the market that dealers are willing to make at those quoted prices simply is unknown. Dealers might adjust their transaction prices, thereby changing the actual price of marketability, without changing their spreads. To whatever extent (unknown) the quoted spreads are not correlated with actual prices of marketability, the differences in spreads among stocks would not accurately indicate the differences in marketability prices to traders. Furthermore, the correlation between spreads and actual marketability prices may change over time. If so, any observed differences in spreads between 1970 and 1971 might be due to differences in this correlation as well as to NASDAQ. In the absence of actual dealer transaction prices, however, the major studies of the price of marketability in both the NYSE and OTC marketplaces have used quoted bid-ask spreads.

B. *Method for Estimating the Effect of NASDAQ.*

The effect of NASDAQ on the price of marketability for OTC stocks was measured as what OTC dealer spreads would have been in 1970 had NASDAQ been operating then. Equation (2) was estimated separately for 1970 and 1971. The estimated parameters b_{j0} ($j=1,\ldots,7$) for 1970 ($t=0$) showed how dealer spreads related to the several independent variables before NASDAQ was implemented, while the estimated b_{j1} for 1971 ($t=1$) showed the relationship after NASDAQ was implemented. From the observed values of the independent variables for 1970 for stock i, Equation (2) for 1970 estimated the dealer spread (S_{i0}^{*}) for that stock in the period prior to NASDAQ. The same observed values for 1970 then were combined with the estimated b_{j1} for 1971, representing the conditions with NASDAQ operating, to impute what the dealer spread for that stock would have been in 1970 had NASDAQ been in operation then. The imputed spread for stock i was S_{i0}^{**}.

12. Measuring risk as the variance of prices for the sample period was an alternative to R. For the variance measurement, however, the estimates of b_6 were less consistent among alternative specifications, and the R^2 were lower. The specification $\ln R$ likewise was superior to R.

13. Tinic and West [13] simply used M. Tinic [12] constructed a Herfindahl index for M, which also reduced the marginal impact of added dealers.

14. See Schmidt [11] and Logue [5].

For stock i, then, $D_i(\text{OTC}) = (S_{i0}^* - S_{i0}^{**})/S_{i0}^*$ would measure the proportion by which spreads would have been smaller in 1970 had NASDAQ been operating then. The S_{i0}^{**} could properly be compared to S_{i0}^*, but not to S_{i0}, since the e_{i0} were not used in computing either S_{i0}^{**} or S_{i0}^*, while $S_{i0} = S_{i0}^* + e_{i0}$.

The mean $\overline{D}_1$ of D_i (OTC) would measure the mean effect of NASDAQ on dealer spreads for OTC stocks.

The specification of Equation (2) did not include any variable representing changes in general market conditions between 1970 and 1971, which might have affected $(S_{i0}^* - S_{i0}^{**})$. Market conditions were taken into account as follows. First, changes in general market conditions would have affected the bid-ask spreads of the NYSE specialists for NYSE-listed stocks, just as such changes would have affected OTC dealer spreads. The introduction of NASDAQ for *unlisted* stocks would not, however, have affected the specialist spreads for *listed* stocks. Second, Equation (2) also was estimated for NYSE specialists for 1970 and 1971. Then, analogous computations of S_{i0}^* and S_{i0}^{**} for NYSE specialists gave D_i (NYSE) $= (S_{i0}^* - S_{i0}^{**})/S_{i0}^*$, just as for D_i(OTC).

The mean $\overline{D}_2$ of D_i (NYSE) would be a rough approximation of the effect of general market conditions on dealers' spreads between 1970 and 1971.

Consequently, a measure of the effect of NASDAQ on OTC dealer spreads, controlling for changes in general market conditions, was computed from the means of D_i (OTC) and D_i (NYSE) as $(\overline{D}_1 - \overline{D}_2)$.[15,16]

Since Equation (2) was estimated for both OTC dealers and NYSE specialists, another test for the effect of NASDAQ was possible. Reiterating, NASDAQ would be expected to affect OTC dealers, but not NYSE specialists. The estimated b_j for OTC dealers would be expected to differ between 1970 and 1971, while for NYSE specialists the b_j would not be expected to change. These expected changes were testable hypotheses. First, for a particular set of values of the independent variables, the expected value of S_i could be different, which would appear as a difference in the intercept b_1 between the 1970 and 1971 regressions. Second, the b_j could be different. Without explaining each expected change in detail, for each independent variable the most likely structural change from implementing NASDAQ would have appeared as a reduction in b_1. The absolute value of the other b_j $(j = 2, \ldots, 7)$ might be either unchanged or reduced: no more precise prediction was made. The null hypotheses for both OTC dealers and NYSE specialists were, of

15. Specialists might adjust their bid-ask spreads to changing general market conditions differently than OTC dealers do. While there is no particular reason to suspect such a difference on the average, if specialists did change spreads more (less), then $\overline{D}_2$ would over(under)estimate the effect of general market conditions on OTC spreads, and $(\overline{D}_1 - \overline{D}_2)$ would under(over)estimate the effect of NASDAQ. As a factor diminishing this possibility, however, the measurement of $\overline{D}_2$ used only listed stocks with characteristics similar to the unlisted stocks in the sample (see the following section).

16. Santomero [8] tested the null hypothesis that S/P was unchanged between the periods preceding and following the introduction of NASDAQ. His difference between means tests would not, however, control for changes in variables determining spreads, nor for changes in market conditions during the 15 months of his sample period. Another study of NASDAQ by Reilly and Slaughter [7] concerned 30 NYSE-listed stocks that were included in NASDAQ for a period. While they also used difference between means tests, their 3 month sample period may have been short enough that not controlling for other variables had little effect.

course, $b_{j0} = b_{j1}$ $(j = 1, \ldots, 7)$, while the alternative hypotheses were $|b_{j0}| > |b_{j1}|$ $(j = 1, \ldots, 7)$.

C *Measurements*

A sample of 174 unlisted OTC stocks and one of 182 NYSE-listed stocks were selected for 1970, prior to NASDAQ. Data were collected for both 1970 and 1971. Since the purpose of the analysis was not only to gauge the effect of improved information on bid-ask spreads of OTC dealers, but also to make (in section IV) an inference about the effect improved information might have on spreads for listed stocks, the sample of OTC stocks was constrained to those issues exceeding (roughly) the minimum NYSE listing requirements in 1970.[17] Also, since few OTC stocks had more than 10 million shares outstanding, both samples also were constrained to stocks with fewer than 10 million shares outstanding. By matching the two samples in this way, comparisons of the two marketplaces, and inferences from one to the other, would be more meaningful.[18]

Since quotations on a single unlisted stock differed among OTC dealers, an average spread was necessary. I used a modal concept and a market concept. For each stock, the modal spread was that most frequently quoted by the dealers. Since some dealers quoted higher bids or lower asks than other dealers, I measured market spread as the difference between the mean of the three highest bid prices and the mean of the three lowest ask prices. The OTC spreads were computed from "wholesale" quotations that were equivalent to the NYSE specialist quotations, from which spreads were computed for the listed stocks.

Bid-ask spreads, prices, and numbers of dealers were measured for April 30, June 30, and August 31 in each year.[19] Other variables were measured for the four month sample periods or for the years 1970 and 1971.[20]

D. *The Estimates*

For the sample of OTC stocks, between 1970 and 1971 the mean modal spread ($\bar{S}$) declined from .7739 (dollars) to .5450, while the mean market spread fell from .4871 to .4028. For the sample of NYSE stocks, the mean spread also declined, from .4039 to .3607. The question was whether the decrease in OTC spreads was due to changes in the several determinants of spread in Equation (2), to changes in general market conditions, or to the initiation of NASDAQ.

Table 1 presents the estimated parameters for Equation (2) for different specifi-

17. More precisely, only those stocks were included that in 1970 had 700,000 shares outstanding net of closely held shares, 2,000 shareholders, and positive average earnings for 1966–69, and positive earnings in two or more of those years.

18. For their comparison of the OTC and NYSE marketplaces, the two samples Tinic and West [14] used were not matched. While the NYSE sample contained observations for March, 1969, the OTC sample was for November, 1971, a separation of two and a half years. Since the characteristics of the stocks selected were not constrained to similar ranges, estimated values of S had to be computed out of the sample spaces in order to compare the two marketplaces. The equations estimated for the comparison included only variables equivalent to P, $\ln N$, and R.

19. OTC bid-ask quotations and the number of dealers were from The National Quotation Bureau. Specialist bid-ask quotations were from Francis Emory Fitch.

20. Standard and Poor's *Stock Guide, Stock Reports, Corporation Records, Daily OTC Stock Price Record,* and *Daily NYSE Stock Price Record* (various dates).

TABLE 1

ESTIMATED PARAMETERS OF EQUATION (2) FOR OTC AND NYSE SAMPLES

Specification	Intercept	P	$\ln N$	SS	IN	$\ln R$	$\ln M$	$\bar{R}^2$	SEE
A. Over-The-Counter Samples.									
Market Spread									
S_{it}									
1970	1.5129	.0157	−.0701	−.1846	−.0061	.0457	−.4531	.73	.2330
	(.1435)[a]	(.0017)	(.0322)	(.0601)	(.0021)	(.0344)	(.0400)		
	10.54[b]	9.13	−2.18	−3.07	−2.84	1.33	−11.33		
1971	.7162	.0156	.0222	−.1487	−.0097	.1372	−.2558	.56	.2784
	(.1682)	(.0014)	(.0389)	(.0562)	(.0024)	(.0377)	(.0416)		
	4.26	11.09	.57	−2.65	−4.01	3.64	−6.14		
S_{it}/P_{it}									
1970	.1373		−.0099	−.0209	−.0005	.0123	−.0210	.41	.0222
	(.0134)		(.0030)	(.0057)	(.0002)	(.0032)	(.0035)		
	10.25		−3.25	−3.68	−2.82	3.83	−6.01		
1971	.0838		−.0039	−.0084	−.0003	.0114	−.0129	.38	.0164
	(.0098)		(.0023)	(.0033)	(.0001)	(.0022)	(.0024)		
	8.52		−1.72	−2.59	−2.58	5.28	−5.48		
Modal Spread									
S_{it}									
1970	1.3298	.0231	−.1132	−.1102	−.0053	.1228	−.1872	.73	.2022
	(.1245)	(.0015)	(.0279)	(.0521)	(.0019)	(.0299)	(.0347)		
	10.68	15.47	−4.05	−2.11	−2.88	4.11	−5.39		

1971	.5526	.0149	.0128	−.0932	−.0095	.0655	−.1194	.66	.1899
	(.1148)	(.0010)	(.0265)	(.0383)	(.0017)	(.0257)	(.0284)		
	4.81	15.52	.48	−2.43	−5.72	2.55	−4.20		
S_{it}/P_{it}									
1970	.1413		−.0126	−.0207	−.0008	.0228	−.0002	.41	.0256
	(.0155)		(.0035)	(.0065)	(.0002)	(.0037)	(.0040)		
	9.13		−3.58	−3.15	−4.11	6.13	−.05		
1971	.0764		−.0025	−.0082	−.0006	.0159	−.0014	.40	.0527
	(.0106)		(.0025)	(.0035)	(.0001)	(.0023)	(.0025)		
	7.19		−1.01	−2.33	−4.21	6.81	−.55		
B. New York Stock Exchange Samples.									
S_{it}									
1970	.3797	.0094	−.0228	−.0982	−.0020	−.0083	−.0352	.52	.1372
	(.0945)	(.0007)	(.0209)	(.0480)	(.0007)	(.0228)	(.0211)		
	4.02	12.65	−1.09	−2.04	−2.74	−.36	−1.67		
1971	.3005	.0080	−.0205	−.0365	−.0020	−.0219	−.0280	.62	.1349
	(.0930)	(.0005)	(.0192)	(.0417)	(.0007)	(.0252)	(.0211)		
	3.23	15.43	−1.07	−.88	−2.66	−.87	−1.32		
S_{it}/P_{it}									
1970	.0305		.0001	−.0062	−.0002	.0040	−.0002	.28	.0836
	(.0055)		(.0012)	(.0029)	(.00004)	(.0014)	(.0013)		
	5.55		.12	−2.12	−5.62	2.92	−.16		
1971	.0213		.0003	−.0005	−.0002	.0039	.00003	.28	.0604
	(.0041)		(.0008)	(.0019)	(.00003)	(.0011)	(.0009)		
	5.21		.40	−.26	−5.03	3.56	.03		

[a] Parenthetical numbers are standard errors.

[b] Below the standard errors are t-statistics.

cations for the OTC and NYSE samples for 1970 and 1971. The estimated parameters generally had the expected signs. The regression for S_i explained 50–75 percent of the variance in spreads. In general the levels of significance of the estimated parameters were similar in the regressions for S_i and S_i/P_i. If the error terms e_i in the regressions for S_i were somewhat positively heteroscedastic with P_i, however, the t-values would be somewhat overstated. While the regressions for S_i/P_i would avoid this problem, these regressions explained only 30–40 percent of the relative spread variance.

TABLE 2

F-TESTS FOR HOMOGENEITY OF PARAMETERS OF EQUATION (2) BETWEEN 1970 AND 1971 FOR OTC AND NYSE SAMPLES

Specification of Equation (2)	Residual Sum of Squares H_n	Residual Sum of Squares H_a	F
A. Over-The-Counter Samples.			
S Market Spread	26.8739	22.0088	10.55**
Modal Spread	22.2375	12.8512	243.95**
S/P Market Spread	.137698	.127729	26.07**
Modal Spread	.182062	.162954	39.40**
B. New York Stock Exchange Samples.			
S	7.25372	6.47814	41.90**
S/P	.020284	.018725	29.14**

** Statistically significant at 1 percent level. Critical value of $F(7,400)=2.69$.

Estimating the effect of NASDAQ on dealer spreads as $(S_{i0}^{*}-S_{i0}^{**})$ would be appropriate, of course, only if $b_{j0} \neq b_{j1}$ for some j. For the OTC stocks, each specification of Equation (2) was estimated from the pooled 1970 and 1971 samples for the null hypothesis (H_n) that $b_{j0}=b_{j1}$ ($j=1,\ldots,7$). For the alternative hypothesis (H_a) that $b_{j0} \neq b_{j1}$ ($j=1,\ldots,7$), the estimates of Equation (2) from the separate samples were used. An F-test was applied to the residual sums of squares for the two hypotheses.[21] The same test also was applied to the two NYSE samples. The F-tests rejected the null hypothesis for each specification of Equation (2) for both OTC and NYSE stocks, as shown in Table 2. Since the two cross-sections may

21. Rao and Miller [6], pp. 148–52; Kmenta [4], pp. 373–74. For the alternative hypothesis, the residual sums of squares of the separate 1970 and 1971 estimates were added.

have positive heteroscedasticity, while the observations on stock i for 1970 and 1971 likely would not be independent, the calculated F-statistics might be overstated.[22] Since they were very large, however, even after an appropriate discount the null hypotheses most likely would be rejected.

The computed values of $\overline{D}_1$, $\overline{D}_2$, and $(\overline{D}_1 - \overline{D}_2)$ are in Table 3. The reduction in S for OTC stocks was nearly 40 percent and that in S/P was about 20 percent; in all four cases $\overline{D}_1$ was statistically significant. Once the changes in the NYSE stocks ($\overline{D}_2$) were subtracted, however, the reduction in S and S/P that could be attributed to the introduction of NASDAQ was about 15 percent; in only one of four cases was $(\overline{D}_1 - \overline{D}_2)$ statistically significant.[23]

TABLE 3

ESTIMATED CHANGE IN BID-ASK SPREADS OF OTC DEALERS FOLLOWING INITIATION OF NASDAQ

Specification of Equation (2)	Mean ($\overline{D}_1$) of $(S^*_{i0} - S^{**}_{i0})/S^*_{i0}$ For OTC 1970	Mean ($\overline{D}_2$) of $(S^*_{i0} - S^{**}_{i0})/S^*_{i0}$ For NYSE 1970	$\overline{D}_1 - \overline{D}_2$
Market Spread			
S	.3861*	.2268**	.1593
S/P	.1903**	.0458	.1445
Modal Spread			
S	.3671**	.2268**	.1403**
S/P	.2171**	.0458	.1713

*Statistically significant at the 5 percent level.

**Statistically significant at the 1 percent level.

As the theoretical analysis of dealers predicted, greater centralization of information in a multidealer marketplace reduced the bid-ask spreads that dealers take for the marketability service they provide. Also as expected, the reduction has been modest: the four estimates showed a 15 percent reduction in dealers' spreads, and only one was statistically significant.

Next, the estimated b_j for 1970 and 1971 were compared to determine whether the b_j were smaller with NASDAQ, as had been predicted.[24] By inspection of the four different specifications of Equation (1) for OTC samples (Table 1), 20 of the 24 differences in the absolute values of b_j were negative as predicted (two b_j were

22. Kmenta [4], pp. 249–56, 269–82, 508–11. The difference between $\text{Var}(e_{i0})$ and $\text{Var}(e_{i1})$ was slight for both the OTC and NYSE samples.

23. Santomero's [8] difference between means test on S/P did not reject the null hypothesis in 30 of the 56 cases, though the spread was smaller in the second period for 37 cases. This finding is consistent with the results of the present study.

24. While Table 2 reveals that the overall structure of Equation (2) had changed between 1970 and 1971 for both OTC dealers and NYSE specialists, the predicted changes in structure concerned individual b_j.

unchanged). An F-test using dummy variables in pooled samples estimates of Equation (2) tested each change in b_j for statistical significance.[25] The b_1 all were smaller by amounts statistically significant at the one percent level or higher. Of the remaining 20 changes in the estimated b_j, 11 were statistically significant at the ten percent level or higher. By contrast, for the NYSE samples the estimated b_j (Table 1) were little different between 1970 and 1971, and few changes in b_j were even close to being statistically significant: one was barely significant at the ten percent level.

As predicted, NASDAQ changed the relationships between X_j and S for OTC dealers, while for NYSE specialists in the same period the individual b_j were not changed significantly. This difference implies that $(S_{i0}^{*} - S_{i0}^{**})$ for OTC dealers was not due entirely to changes in market conditions between 1970 and 1971, while for NYSE specialists it probably was. Consequently, the measured effect $(\bar{D}_1 - \bar{D}_2)$ can be attributed to NASDAQ with greater confidence.

IV. Comparison of Exchange and Over-the-Counter Marketplaces

Alternative wholesale marketplaces, such as the exchange and the OTC marketplace, would be expected to have different marketability prices for a stock issue with particular characteristics. The exchange would be the most efficient marketplace for a stock only if it offered the lowest marketability price.

Estimating the effect of NASDAQ on the price of marketability in the OTC marketplace relative to the exchange provided two perspectives on the economics of the exchange. First, centralized exchange trading gives specialists direct and immediate access to trading information. NASDAQ, however, would partially have duplicated this aspect of the exchange. Any reduction in relative marketability prices would indicate the extent to which the economics of the exchange derived from centralized information. Second, since the economics of the exchange (or of any marketplace) depends on its marketability price relative to other marketplaces, then as alternative marketplace organizations became more efficient the exchange might no longer be the economic supplier of marketability. As it gained efficiency, an automated OTC marketplace might eventually displace the exchange. As a related issue, the proposed NMS automated quotation system for listed stocks might eliminate the economic basis for an exchange as a component of the NMS.

The most meaningful way to compare marketability prices in exchange and OTC marketplaces would be to compare the bid-ask spreads for the *same* stock in the two different marketplaces: first, with the stock traded entirely on the exchange, and then entirely over the counter. Although such an experiment could not, of course, be conducted, the carefully matched NYSE and OTC samples permitted an approximation. What the bid-ask spreads would have been for an NYSE-listed stock, had it been transacted entirely over the counter, was estimated by combining the estimated parameters of Equation (2) *for the OTC sample* with the observed

25. Rao and Miller [6], pp. 148–52. For the null hypothesis $b_{k0} = b_{k1}$ and $b_{j0} \neq b_{j1}$ $(j \neq k)$, dummy variables were added in Equation (2) for each b_j except b_k. For the alternative hypothesis $b_{j0} \neq b_{j1}$, dummy variables were added for all b_j. The F-test used the residual sums of squares from pooled samples estimates for the null and alternative hypotheses.

values of the variables *for the NYSE sample*. Then, for 1970 the OTC spread imputed to a listed stock would have been S''_{i0}.[26] The S''_{i0} were compared with the estimated specialist spreads S'_{i0}, which were computed by combining the same observed values for the NYSE stocks with the estimated parameters of Equation (2) for the NYSE stocks.

Computing the sample mean $\bar{C}_1$ of $C_{i0}=(S''_{i0}-S'_{i0})/S'_{i0}$ would measure the mean proportion by which OTC spreads for listed stocks would have exceeded the specialist spreads for 1970 ($t=0$). Similar computations using the observations and estimated parameters for 1971 ($t=1$) gave the mean $\bar{C}_2$ of $C_{i1}=(S''_{i1}-S'_{i1})/S'_{i1}$. While $\bar{C}_1$ measured the marketability price advantage of the exchange in 1970, $\bar{C}_2$ measured it for 1971. The proportion by which NASDAQ reduced the advantage was measured as $(\bar{C}_1-\bar{C}_2)/\bar{C}_1$.

Table 4 presents the computed values of $\bar{C}_1$, $\bar{C}_2$, and $(\bar{C}_1-\bar{C}_2)/\bar{C}_1$ for the four OTC specifications of Equation (2). Prior to NASDAQ the exchange had lower marketability prices than did the OTC marketplace for stocks of similar characteristics ($\bar{C}_1<0$). For three of the four estimates the exchange continued to hold this advantage even with NASDAQ in the OTC marketplace ($\bar{C}_2<0$). However, $(\bar{C}_1-\bar{C}_2)/\bar{C}_1$ shows that NASDAQ reduced the advantage by about 45–55 percent. In general, the estimates in Table 4 are statistically significant for the modal concept of bid-ask spreads and are not for the market concept. The reason is arithmetic: modal spreads simply are much larger than market spreads and much

TABLE 4

PROPORTIONATE DIFFERENCES BETWEEN ESTIMATED OVER-THE-COUNTER AND EXCHANGE BID-ASK SPREADS, 1970, 1971

Specification of Equation (2) for OTC Samples	Mean ($\bar{C}_1$) of $(S''_{i0}-S'_{i0})/S'_{i0}$	Mean ($\bar{C}_2$) of $(S''_{i1}-S'_{i1})/S'_{i1}$	$(\bar{C}_1-\bar{C}_2)/\bar{C}_1$
Market Spread			
S	.0772	.0436	.4352
S/P	.1463	−.1553**	2.0615
Modal Spread			
S	.9001**	.4790**	.4678**
S/P	1.0073**	.4534**	.5499*

*Statistically significant at the 5 percent level.

**Statistically significant at the 1 percent level.

26. Since M_{it} in Equation (2) for OTC stocks was the number of OTC dealers, I had to impute a number of OTC dealers for each listed stock in order to compute S''_{it}. For NYSE stocks, M_{it} was the number of exchanges listing the stock. Since different stocks were listed on different numbers of exchanges, I assumed that a stock listed on an above average number of exchanges likewise would attract an above average number of dealers, if it were transacted entirely in the OTC marketplace. In particular, if the NYSE stock was listed on k standard deviations more (fewer) than the mean number of exchanges, then I inputed to that stock k standard deviations more (fewer) than the mean number of OTC dealers.

larger than specialist spreads, while market spreads and specialist spreads are of similar size. With one exception, however, the orders of magnitude of $(\overline{C}_1 - \overline{C}_2)/\overline{C}_1$ are essentially the same.

Prior to NASDAQ centralization of information was unique to the exchange. About half of the marketability price advantage it held apparently was due to centralized market information that NASDAQ has duplicated.

Whether a 50 percent reduction in the marketability price advantage of the exchange has altered the economics of marketplace organization depends on the spread concept considered. While modal spreads declined sharply, the remaining difference was both economically large and statistically significant: by this measure the exchange clearly remained economic. The more appropriate concept for the comparison, however, would be the market spread, since like a specialist spread, that would be what a trader would pay to buy and then sell immediately. For the market concept, prior to NASDAQ OTC spreads were only about 8 percent larger than NYSE specialist spreads, whereas with NASDAQ they were only about 4 percent greater. Since the margin between OTC and specialist spreads was neither economically large nor statistically significant prior to NASDAQ, a 50 percent reduction would mean that the exchange then held only a thin (and perhaps non-existent) edge as the efficient organization for marketability.

V. Conclusion

The research reported here concerns alternative marketplaces. First, the empirical analysis of NASDAQ demonstrated that in a multidealer marketplace the prices of marketability are somewhat smaller when the dealers utilize an automated price quotation system. Second, the research investigated whether or not such a multidealer marketplace is as efficient as an exchange marketplace. The exchange was found to have slightly lower prices of marketability (*ceteris paribus*), but following the implementation of NASDAQ the edge was so slight that its existence may be a statistical illusion, or so small as not to be economically significant.

An automated price quotation system for listed stocks is a principal component of the plans for a National Market System. The analysis of NASDAQ suggests several observations about the likely effect of a NMS on the prices of marketability for listed stocks. First, since NASDAQ has, by the estimates reported here, reduced dealer spreads in the OTC marketplace, perhaps a NMS system would reduce specialist spreads also, and for the same reasons. Since several dealers now transact listed stocks, the proposed NMS quotation system might facilitate interaction among those dealers. Second, the effect of automated quotations on specialist spreads might be rather small. For NASDAQ the estimated reduction in spreads was about 15 percent. Since the market for listed stocks already is more concentrated in a single place (the exchange) than was the OTC market, there may be less potential for a system that facilitates dealer interaction to have any effect on spreads. As a final observation, for the exchange to remain as a component of a NMS, it would have to transact at least as cheaply as the other dealers or marketplaces in the NMS. Since the estimated advantage of the exchange over a multidealer marketplace was so small, and since the other dealers within the NMS

would comprise such a multidealer marketplace, perhaps these dealers would displace the exchange from the NMS.[27]

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27. Hamilton [3] and Benston and Hagerman [1] have evidence that specialists do not have economies of scale as dealers in individual stocks. The exchange would not retain a cost advantage or a large market share on that account.