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Marketplace Fragmentation, Competition, and the Efficiency of the Stock Exchange

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I. Introduction

MANY STOCKS LISTED ON the New York Stock Exchange (NYSE) are traded not only on the NYSE but also on the regional stock exchanges and in the over-the-counter (OTC) marketplace (the so-called "third" market in listed stocks). This paper reports empirical estimates of the effect of off-board trading (a) on the prices of marketability[1] on the NYSE for transaction of its listed stocks and (b) on the volatility of daily returns for those stocks.

Off-board trading potentially has two opposite effects. The first is a competitive effect. Greater off-board trading increases the number of marketplaces and dealers transacting the listed stocks. Increased competition from these marketplaces and dealers might stimulate the exchange to supply better or cheaper transactions. Specialists might narrow their bid-ask spreads (the prices of marketability) and trade more against price movements, damping daily stock returns fluctuations. The second is a fragmentation effect: off-board trading "fragments" the market for NYSE-listed stocks. A given group of stocks could be traded primarily on an exchange or in some other form of marketplace. If an exchange has lower prices of marketability and lower daily returns variance for those stocks than would other marketplace forms, the reason would be that the exchange centralizes transacting. Off-board trading reduces exchange trading volume, which would reduce exchange efficiency, if centralization has economies of scale. Prices of marketability might be greater. Daily stock returns might have a larger variance. The net effect of increasing off-board trading might, therefore, be to increase competition by reducing exchange efficiency. On the other hand, reducing fragmentation to protect marketplace efficiency might reduce competition.

The Special Study [16] recognized that any assessment of the social value of multiple marketplaces requires an appraisal of the trade-off between the fragmentation and competitive effects.[2] Recently, the potential trade-off between the competitive and fragmentation effects of off-board trading has affected the Congressional and the Securities and Exchange Commission (SEC) reorganization

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[1] Marketability means that a transaction in a stock always is immediately available. Dealers provide marketability by standing ready to transact immediately on their own terms. The price of marketability is what a dealer realizes as compensation from transacting on those terms. In most empirical studies the price of marketability has been measured as the dealer's bid-ask spread.

[2] S.E.C., Special Study [16], pp. 901–902, 940.

of the securities marketplace into a National Market System (NMS) for listed stocks. Some proponents of the NMS apparently believe it would reduce or eliminate this trade-off. According to its planners, while the NMS would preserve the numerous marketplaces and the competition among them, it would more centralize the transacting of listed stocks, perhaps by centralizing quotations, transacting, and reporting in a computerized system that would include all dealers in those stocks.[3]

The two previous empirical estimates of the trade-off between competition and fragmentation concerned bid-ask spreads and gave conflicting estimates. The NYSE [13] estimated that a reduction in off-board trading, as it reduces competition, tends to raise the prices of marketability on the exchange; at the same time the reduction in fragmentation, as it increases exchange efficiency, tends to lower the prices of marketability, and by even more. These estimates imply that the prices of marketability would be minimized with less fragmentation and less competition. Branch and Freed [3] reported the opposite estimated trade-off: less competition tends to raise prices of marketability considerably more than improved efficiency tends to lower them. The estimated trade-off favors preserving competition and fragmentation. Though the Special Study had no empirical estimates, it concluded that the fragmentation effect likely is minor and is outweighed by the competitive effect.[4]

In this study the fragmentation and competitive effects of off-board trading are specified more accurately than in the previous studies. For both specialist spreads and daily stock returns variance, the estimates show that the competitive effect exceeds the fragmentation effect, but that both effects are small. An attempt to estimate the separate effects of the regional exchanges and the third market was largely futile.

Bid-ask spreads and daily returns variance are considered separately. Section II of the paper concerns the method for studying specialist spreads and the specification of the competitive and fragmentation effects. The empirical estimates are in Section III. Section IV concerns the method for studying returns variance, while the empirical estimates are in section V. Section VI is a summary and conclusion.

II. Specification of the Effects of Off-Board Trading

The competitive and fragmentation effects of off-board trading on the NYSE specialists' bid-ask spreads are estimated from a multivariate regression model, which controls for several other factors that also are determinants of bid-ask spreads. This section concerns the model and the specification of the competitive and fragmentation effects in that model.

A. *Determinants of Specialist Spreads*

In a cross-section study, the determinants of specialist bid-ask spreads explain differences in specialist spreads among stocks. Spreads would differ for two

[3] On the NMS, see SEC [14 and 15].

[4] S.E.C., Special Study [16], p. 909.

principal reasons.[5] First, the specialists' costs of making markets would differ among stocks. Second, since specialists can be considered as dominant firms in the industry of making markets for listed stocks, they might have some market power in setting spreads; specialists in different stocks would face different degrees of competition.

Several factors would affect dealer costs. First, the higher the price (P) of a stock, the more capital is required for an inventory of given number of shares, and the higher would be the dealer's opportunity cost of capital per share transacted. Second, as the price variability (R) of a stock is greater, the dealers' chances of capital gains or losses on inventory transactions in that stock are greater. Since dealers presumably are risk averse, then the greater is R, the greater would be their opportunity cost per share transacted.[6] Third, portfolio diversification reduces the risk. As the number (N) of different stock issues assigned to the specialist unit for a stock is greater, its portfolio would be more diversified. Fourth, a greater market trading volume (T) reduces the waiting time between orders, which would reduce the specialists' risks of holding a given inventory position. A greater T also might reduce the average inventory and the capital cost per share transacted, especially since some orders might match in the marketplace without requiring the specialist to take an inventory position. Fifth, for a given T, as the number (I) of financial institutions owning a stock is greater, specialist costs would be different. Since financial institutions often trade in blocks, the average waiting time between orders would be greater. Block transactions also require different marketability services than do smaller transactions. Finally, since specialists would lose on transactions initiated by traders who had information not yet available to specialists, then to the extent such information trading occurred the specialists would widen their spreads to compensate for these losses.[7] Stoll [17] argued that, for a given number of shares outstanding (SO) in a stock, turnover ($TO = T/SO$) would be greater as information trading is greater.

Competition might be greater as the number of dealers is larger. With more dealers the specialist's position as a dominant firm is weaker. The potential also is greater that dealers would expand marketmaking capacity as the specialist set wider spreads; this threat would limit specialist's spreads further. Stoll [17] suggested, however, that with more dealers more capital also is committed to making the market for a stock; greater capital would tend to reduce spreads. The number of dealers (M) for a stock is the specialist plus the number of OTC dealers ($M3$) and regional exchanges (MR) that traded the stock. Also, since financial institutions are large and sophisticated buyers of marketability services, spreads might narrow as I is greater.

B. *Specification of Fragmentation and Competitive Effects*

The efficiency and competitive effects are specified separately by $F = (T-V)/T$ and by M, where V is trading volume on the exchange.

[5] Demsetz [6] and Tinic [19] provide the theoretical basis for the selection of variables.

[6] On the relationship between R and S, see Hamilton [10], and Benston and Hagerman [2], pp. 357–59.

[7] See Bagehot [1].

Part of specifying the fragmentation effect accurately is measuring trading volume in the model (see below) as total market trading volume (T). An accurate concept of the fragmentation effect is conveyed by this question: for given T and M, as fragmentation (F) is greater would specialist spreads be larger due to reduced efficiency? Studies of multidealer marketplaces, in particular the OTC marketplace for unlisted stocks, have found that greater trading volume in the market as a whole reduces the bid-ask spreads of each dealer in the market place.[8] The apparent reason is interdealer arbitrage. The implication is that spreads depend not just on a dealer's own trading volume, but on the trading volume in the entire market.[9] Accordingly, the spread of the specialist, as one of several dealers for a stock, would depend on the market trading volume in that stock, not just on the exchange trading volume (V).

In the NYSE and Branch-Freed studies, the fragmentation effect was measured by using V to estimate the elasticity of the bid-ask spread (S) with respect to V. For an x percent change in fragmentation, they calculated the corresponding percent change in V, and from the estimated elasticity of S with respect to V they calculated the resulting percent change in S as the fragmentation effect. This measurement did not, however, separate the effect of total trading volume (T) from the effect of its dispersion (F). The observed inverse relation between S and V does not imply increased efficiency from greater centralization, since the observed relation between S and T also is inverse.

An accurate concept of the competitive effect is conveyed by this question: for given T and F, as the number of dealers (M) is greater, would specialist spreads be smaller due to increased competition? For a given relative extent of off-board trading (F), as the number of dealers (M) is greater, not only would the specialist's dominant firm position be weaker, the potential for expansion is greater and more immediate, further limiting the specialist's spreads. If M is correlated with marketmaking capital, then the competitive effect would include the effect of more capital as well as more rivals.

Often in empirical studies the competitiveness of a market is specified as the concentration of production or, in this case, of trading volume among firms. Demsetz [7] has argued that, to the contrary, what matters for competitiveness in a market is not the concentration of trading volume in one or a few firms: what matters is the number of firms that actually bid for the business. Competition in bidding keeps prices low relative to costs, quite apart from the concentration of trading volume among firms. In marketmaking for NYSE-listed stocks, the number of marketmakers quoting prices by and large is also the number of marketmakers that actually trade in the stock (M), which is the specification of competition used here. Not only is M the proper specification, following Demsetz, but a concentration measure would be highly collinear with F, seriously reducing the efficiency of the estimates of both parameters.

[8] West and Tinic [20], Benston and Hagerman [2], and Hamilton [8].

[9] See Hamilton [8], pp. 780–83, and Hamilton [10]. This reasoning is weakened if total trading volume is greater with trading confined to the NYSE than with trading dispersed among various regional exchanges and OTC dealers. The Special Study argued, on the contrary, that dispersion of trading probably increases total trading volume. With access to off-NYSE transaction of orders, nonmember broker-dealers might in some cases suggest listed stocks to their customers, whereas they otherwise would suggest unlisted stocks. Special Study [16], pp. 902, 941.

The issue concerning off-board trading is whether or not the fragmentation effect outweighs the competitive effect. By assuming that an x percent change in F also would entail an x percent change in M, the net effect of changing off-board trading would be determined by comparing the elasticities of spreads with respect to F and M.

C. *The Model*

For each stock the price of marketability is measured by the bid-ask spread (S).[10]

Combining all of the variables, the model is[11]

$$S_i = S(P_i, R_i, N_i, TO_i, T_i, I_i, F_i, M_i, u_i). \tag{1}$$

It is estimated in two forms. The first is

$$S = a + bP^{1/2} + c \ln T + d \ln R + eI + fN + gTO + hF + jM + u. \tag{2}$$

The specification of price as $P^{1/2}$ is pragmatic. Previous studies suggested that the effect of P on S is increasing, but at a decreasing rate. Also the error terms are heteroscedastic with P, such that $\mathrm{Var}(u) = kP$ approximately. Consequently, the correction involves $P^{1/2}$, such that $\mathrm{Var}(u/P^{1/2}) = k$. With $P^{1/2}$, the equation for the adjusted data is simplified compared to alternative specifications of P. Finally, among alternative specifications of P, $P^{1/2}$ yields the highest $\bar{R}^2$.

The second form assumes that Equation (1) is log-linear.

$$\ln S = a + b(\ln P)^{1/2} + c \ln T + d \ln R + e \ln I + f \ln N + g \ln TO + h \ln F + j \ln M + u. \tag{3}$$

The specification of P as $(\ln P)^{1/2}$ again relates to the required heteroscedasticity correction and is a pragmatic compromise on the pure log-linear form.

From the preceding discussion the predicted signs of the parameters in Equations (2) and (3) are as follows: $b > 0$, $c < 0$, $d > 0$, $f < 0$, $g > 0$, $h > 0$, and $j < 0$. Since institutional trading may have two opposite effects on S (see above), the net effect (sign of e) is not predicted.

Although S is the magnitude the specialists set, and while P is specified as a determinant of S, some previous studies have used the relative spread $S^* = S/P$ rather than S. Equation (2) also is estimated with S^*. The only specification difference concerns P. Previous studies have found $b < 0$ for S^*, again suggesting that the effect of P on S is increasing, but at a decreasing rate. The error terms for S^* are heteroscedastic such that $\mathrm{Var}(u) = k/P$ approximately, which involves correction by $P^{1/2}$ such that $\mathrm{Var}(uP^{1/2}) = k$. For these two reasons, the pragmatic specification of P is $P^{-1/2}$; it also gave the largest $\bar{R}^2$. The predicted sign then is $b > 0$. Both the NYSE and Branch-Freed studies used S^*.

The discussion of the determinants of spreads suggests an alternative specifi-

[10] Smidt [18] and Logue [11] discuss alternative conceptual measures of the price of marketability. In the absence of the necessary transactions data, empirical studies have relied on the bid-ask spreads as the operational proxy measure of the prices of marketability. Potential biases arising from this measure are discussed in Hamilton [10].

[11] This is the specification used in Hamilton [8 and 10], where $P^{1/2}$ replaces P, as explained in the text.

cation of the effect of trading volume. Since trading volume would reduce the impact on spreads of the specialists' inventory trading positions, the parameters of P and R might be functions of T, with both approaching zero as T is larger. Differences in P or R might have a greater effect on S when T is smaller than when T is larger.

More importantly for this study, the marginal impact of fragmentation also might vary with trading volume. Increasing the proportion of total trading that occurs off-board might increase spreads less when T is larger than when it is smaller, especially if exchange efficiency increases very little beyond some V. In order to keep F and M on a comparable basis in the model, the parameter for M also is specified as a function of T.[12]

The variable parameters version of Equation (2) is

$$S = a + bP^{1/2} + b'(T\cdot P^{1/2}) + c\ln T + d\ln R + d'(T\cdot\ln R) + eI + fN + gTO + hF + h'(F\cdot T) + jM + j'(M\cdot T) + u. \tag{4}$$

The version of the log-linear model in Equation (3) is

$$\ln S = a + b(\ln P)^{1/2} + b'(T\cdot(\ln P)^{1/2}) + c\ln T + d\ln R + d'(T\cdot\ln R) + e\ln I + f\ln N + g\ln TO + h\ln F + h'(T\cdot\ln F) + j\ln M + j'(T\cdot\ln M) \tag{5}$$

The predicted signs of the added parameters in Equations (4) and (5) are as follows: $b' < 0$, $d' < 0$, $h' < 0$, and the sign of j' is not predicted.

Simultaneous equations bias is a potential problem in estimating Equations (2)–(5). Not only do fragmentation and competition affect NYSE specialist bid-ask spreads, but specialist spreads also may affect the extent of fragmentation and competition. Equations (2)–(5) can be estimated only by ordinary least squares, however, because the equations are not identified in two-stage estimation: the principal determinants of off-board trading (Hamilton, [9]) are a subset of the variables in Equations (2)–(5). Fortunately, any simultaneous equations bias makes the empirical findings reported below conservative.[13]

III. Empirical Estimates of the Effect on the Prices of Marketability

This section of the paper reports the empirical estimates of the competitive and fragmentation effects of off-board trading on specialist bid-ask spreads.

[12] For P, R, F, and M the parameters (B) are specified as $B = m + nT$. In the equations each term BX is replaced by $mX + nX\cdot T$. See Maddala [12]. Just as a test, the other parameters also were specified as functions of T, but none of the interaction terms were statistically significant. The parameters are specified as functions of T rather than $\ln T$ for the pragmatic reason that all the estimated parameters had greater statistical significance when T was used.

[13] The direction of the simultaneous equations bias in the estimated parameters h and j in Equations (2)–(5) depends on the signs of the parameters or their magnitudes. See Maddala [12], pp. 242–51. Since the interdependent relationships between S and M have opposite predicted signs, the estimated parameter j ($j < 0$) would be biased toward zero. Since the relationships between S and F are both positive, the direction of the bias in the parameter h is not known *a priori* and depends on relative magnitudes. Ordinary least squares estimation (not shown) of reasonable approximations of the equations involved indicate that the estimated parameter h ($h > 0$) is biased away from zero. Even though the biases are against finding $|j| > |h|$, the estimated competitive effect $|j|$ does exceed the estimated fragmentation effect $|h|$, as reported below.

A. *Measurements*

Equations (2)–(5) are estimated from cross-section data for a random sample of 315 NYSE-listed stock issues. Measurements of the variables are for the first quarter of 1975. Spread (S) is the mean of the four bid-ask spreads (dollars) for the last trading days in December, 1974, and January, February, and March, 1975. The mean of the eight bid and ask quotations for those four dates measures price (P). Price variability (R) is the difference between the highest and lowest daily closing prices for the quarter, expressed as a ratio with P. Trading volumes are measured as the shares transacted (millions) for the quarter, such that $T = V + TR + T3$. The number of exchanges (MR) and the number of OTC dealers ($M3$) are those that actually transacted stock i during that quarter.[14]

B. *The Estimates*

In the sample, 240 stocks (76 percent) traded off-board. For these the mean percent transacted off-board is 9.85. The maximum percentage is 53.6, while the standard deviation for the 240 stocks is 9.34 percent. The mean number of dealers for those stocks is 7.39. The maximum number is 28, while the standard deviation is 5.36. Though greater fragmentation tends to attract more dealers, considerable variation remains (between F and M the simple $r = .776$.)

Table 1 reports in columns A, C, E and F the heteroscedasticity-corrected estimated parameters of Equations (2)–(5). Equations (2) and (4) also are estimated using V instead of T (columns B and D) and using S^* instead of S (columns G and H): these variations are discussed at the appropriate points below. The heteroscedasticity corrections in general reduce the standard errors of the estimated parameters.

In Equations (2)–(5) the estimated parameters for P, T, and R have the predicted signs and are statistically significant at the 5 percent level. While the estimated parameters for N and TO have the predicted signs, in general they are not statistically significant. The sign of the parameter for I is not predicted: it is negative except in Equation (4) and is statistically significant only for the log-linear Equations (3) and (5). In Equations (4) and (5) with variable parameters, the interaction terms $T \cdot P$ and $T \cdot R$ have the predicted signs; they are statistically significant only for Equation (4). (The estimated parameters for F and M are analyzed below.) The $\bar{R}^2$ are satisfactory for cross-section estimates. For Equation (4), the $\bar{R}^2$ is only slightly higher than in the corresponding Equation (2), and similarly for Equations (5) and (3). The F-statistics show that each specification is a statistically significant model.

Estimating Equations (2) and (4) using V and T alternately supports the argument in Section II that T is preferable to V as the measure of trading volume in specifying the fragmentation effect of off-board trading. The estimates with T are in columns A and C of Table 1, while the estimates with V are in columns B and D. Substituting T for V has essentially no effect on the estimated parameters in the equation or their levels of significance: the characteristics of the estimates

[14] Specialist quotations are from *Stock Quotations of the New York Stock Exchange*, Francis Emory Fitch, Inc. *TR, T3, MR*, and *M3* are from SEC reports on regional exchange and third market trading. Other data are from NYSE, *The Specialists*, and Standard and Poor's *Stock Guide* (February–April, 1975) and *Daily Stock Price Record, NYSE* (January–March, 1975).

Table 1

Estimated Parameters of Equations (2)–(5), Corrected for Heteroscedasticity

	Spread (S)				Log Spread (ln S)		Relative Spread (S*)	
	Equation (2)		Equation (4)		Equation (3)	Equation (5)	Equation (2)	Equation (4)
Variables[a]	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Intercept	.06881	.06912	.06218	.06270	−2.205	−2.1058	−.005904	−.006307
P	.04726	.04727	.05368	.05469	.7150	.7522	.08699	.08917
T · P			−.009559	−.01205		−.0493		−.002714
			(−3.65)	(−3.76)		(−1.01)		(−1.49)
T	−.01769		−.01814		−.07111	−.063555	−.001671	−.001935
	(−3.68)[b]		(−3.50)		(−2.36)	(−1.74)	(−4.60)	(−4.52)
V		−.01757		−.01744				
		(−3.67)		(−3.31)				
R	.02869	.02868	.03985	.04103	.09018	.1263	.001913	.002991
	(3.77)	(3.77)	(4.60)	(4.63)	(2.18)	(2.73)	(3.12)	(4.19)
T · R			−.01319	−.01761		−.04471		−.0006643
			(−2.09)	(−2.20)		(−1.63)		(−2.44)
I	−.0001247	−.0001253	.00008658	.00006065	−.01551	−.01529	.000004247	.000005380
	(−1.42)	(−1.43)	(.54)	(.40)	(−3.33)	(−3.23)	(2.34)	(1.64)
N	−.00003323	−.00003260	−.00003588	−.00003131	−.02624	−.02604	.00001212	.00001581
	(−.24)	(−.23)	(−.26)	(−.23)	(−.93)	(−.90)	(1.09)	(1.43)
TO	83.72	82.37	111.63	115.13	.01602	.02721	.5919	4.258
	(1.41)	(1.39)	(1.69)	(1.73)	(.53)	(.84)	(.13)	(.90)
F	.1155	.09335	.1189	.08110	.01752	.01403	.004398	−.00009337
	(1.99)	(1.61)	(1.65)	(1.14)	(1.73)	(1.26)	(1.08)	(−.02)
T · F			−.03784	−.04587		.008704		.002900
			(−1.16)	(−1.12)		(.52)		(1.11)
M	−.003236	−.003230	−.003700	−.003698	−.05811	−.05400	.00001427	.0001583
	(−2.00)	(−1.99)	(−1.94)	(−1.92)	(−1.14)	(−1.03)	(.14)	(1.29)
T · M			.001659	.002054		.01434		−.00005964
			(1.98)	(1.99)		(.80)		(−1.88)
$\bar{R}^2$	.542	.542	.558	.559	.878	.878	.403	.421
F	47.537	47.514	34.055	34.199	282.421	188.542	27.502	20.027

[a] Variables are listed generically, since the specifications differ among equations. For each equation the specification is shown in the text.

[b] Parenthetical numbers are t-statistics.

give no basis for choosing between them. But the substitution of T for V entirely eliminates the argument for measuring the fragmentation effect from the elasticity of spread with respect to exchange trading volume, as the NYSE and Branch-Freed studies did.

Table 2 reports the estimated elasticities of specialist spreads with respect to F and M. These elasticities depend, of course, on the estimated parameters for F and M in Equations (2)–(5) in Table 1 (columns A, C, E, and F). All the estimates have the predicted signs. For Equations (2) and (4) they are statistically significant; in the log-linear specifications, for Equation (3) only F is significant, while for Equation (5) neither is. In Equations (4) and (5) with variable parameters, only $T \cdot F$ in Equation (5) has an unpredicted sign, though only $T \cdot M$ in Equation (4) is statistically significant. The elasticities are computed for these estimated parameters for the means of the variables. Since a given percentage fragmenation might affect specialist spreads more for stocks traded in lower volumes, for Equations (4) and (5) the elasticities were computed for $\bar{T} = 1.01$, $T = .6$, and $T = .2$.

Assuming an x percent change in both fragmentation (F) and number of dealers (M), Table 2 shows that the competitive effect on specialist bid-ask spreads is about twice the fragmentation effect. But equally important, the competitive and fragmentation effects both are very small. For Equations (2) and (3) the estimated elasticities for F are only .02 to .04, while the estimated elasticities of M are $-.04$ to $-.08$. For Equations (4) and (5), at $\bar{T}$ the estimated elasticities of F are about .025, and the estimated elasticities of M are $-.04$ to $-.05$. While the variable parameter model does show a larger elasticity of F with lower trading volume, the elasticity does not exceed .04, and the elasticity with respect to M also is larger.

In Table 1, columns G and H are the estimated parameters for Equations (2) and (4) with S^*. In Equation (2) neither F nor M are statistically significant; the estimated parameter for M is not negative. In Equation (4) F, M, $T \cdot F$, and $T \cdot M$ all have unpredicted signs; only $T \cdot M$ is statistically significant. Since the estimated parameters are unsatisfactory, comparisons of the competitive and fragmentation effects are not reliable.

Table 2

Estimated Elasticities for F and M[a]

	$T = \bar{T} = 1.01$		$T = .6$		$T = .2$	
Specification	F	M	F	M	F	M
	A. Constant Parameters					
Equation (2): S	.038*	−.083*				
Equation (3): ln S	.018*	−.058				
	B. Variable Parameters					
Equation (4): S	.026*	−.052*	.032*	−.070*	.037*	−.087*
Equation (5): ln S	.023	−.039	.019	−.045	.016	−.051

* Estimated parameters in these terms were statistically significant at the five percent level.
[a] Elasticities were computed at the means of the variables.
Source: Table 1.

C. *Regional Exchange and Third Market Effects*

Trading on the regional exchanges and in the third market might affect NYSE specialist spreads differently. Since the regional exchanges trade a greater volume than does the third market, the fragmentation effect of the regional exchanges might be the greater one. On the other hand, the Special Study [16] suggested that the competitive effect of the third market might exceed that of the regional exchanges. For one thing, NYSE members are a substantial component of regional exchange membership, giving the NYSE members the potential for limiting the independence and competitive strength of these exchanges. Moreover, the third market dealers generally are well-financed and able to compete by contributing to the depth of the whole market. Regional exchanges apparently follow the NYSE more closely.[15]

The separate fragmentation effects are specified by the proportion of total trading volume transacted on the regional exchanges (FR) and in the third market ($F3$). (The NYSE study included similar variables, but said they measured competitive effects.) The separate competitive effects are specified as the number of regional exchanges (MR) and the number of OTC dealers ($M3$).

Table 3 reports the estimated elasticities for FR, $F3$, MR, and $M3$ for Equations (2)–(5). The table reports three specifications: the full specification and two partial specifications, (A) for FR with $F3$ and (B) for MR with $M3$ (see below). The disaggregation of F and M into these components has no noteworthy effect on $\bar{R}^2$ or on the estimated parameters and standard errors of the other variables. To economize, none of the estimated parameters are reported.

For the full specification, the estimated elasticities have the predicted signs except for MR in Equations (2) and (4) and $F3$ in Equation (4). The estimated elasticity for $M3$ exceeds that for MR in all four equations, but FR exceeds $F3$ in only two of the four. Only 4 of the 16 elasticities are based on statistically significant estimated parameters, however. Thus, for the full specification the results are consistent with the argument that the regional exchanges have less competitive effect than the third market, but the results are equivocal on whether the fragmentation effect is greater for the regional exchanges. Since few of the estimated parameters are statistically significant, however, little confidence can be placed in these comparisons. Also, the estimated elasticities are very small.

In the partial specifications the fragmentation and competitive effects are not separated: only the net effects of the regional exchanges and of the third market are specified. The only statistically significant elasticities are for $M3$ in (B) for Equations (2) and (4). In each of the partial specifications the effect of the regional exchanges is positive, while in six of the eight cases the effect of the third market is negative. In general, this is consistent with the full specification and with the suggested differences in the effects of the regional exchanges and the third market. Again, since the estimated elasticities are very small and not statistically significant, little confidence can be placed in the results.

An entirely plausible explanation for these poor results is that the division of off-NYSE trading between regional exchanges and the third market may have no effect on NYSE specialist spreads; perhaps only the total off-board trading matters.

[15] S.E.C., Special Study, pp. 903–904, 932, 947.

Table 3

Estimated Elasticities for FR, F3, MR, and M3[a]

	Full Specification				Partial Specifications			
					(A)		(B)	
Specification	FR	F3	MR	M3	FR	F3	MR	M3
			A. Constant Parameters					
Equation (2): S	.032*	.001	.014	−.079*	.018	−.004	.039	−.063*
Equation (3): ln S	.011	.027	−.003	−.012	.006	.005	.003	−.001
			B. Variable Parameters					
Equation (4): S	.018	−.001	.030	−.071*	.020	−.005	.044	−.068*
Equation (5): ln S	.017	.023*	−.008	−.016	.004	−.001	.005	.002

* Estimated parameters in these terms were statistically significant at the five percent level.
[a] Elasticities were computed at the means of the variables.

IV. Variance of Daily Stock Returns

The daily percentage return on a stock issue is $r_t = \ln(P_t/P_{t-1})$, where P_t is the closing price of the issue on day t, adjusted for cash and stock dividends and for stock splits, and P_{t-1} is the unadjusted closing price on the preceding day. Cohen, Maier, Schwartz, and Whitcomb (CMSW) [4] developed a model of the determinants of the variance of daily stock returns. Would the variance of daily stock returns be greater as off-board trading was greater? Since $\text{Var}(r)$, the variance of r_t, would depend on several factors besides off-board trading, in order to control for them the competitive and fragmentation effects of off-board trading on $\text{Var}(r)$ are estimated from a multivariate regression model, based on CMSW. This section of the paper concerns the model: empirical estimates are reported in section *V*.

A. *Determinants of Returns Variance*

The CMSW model generates daily stock returns for a particular issue by shifts in the market demand curve to hold shares of that issue. As particular investors make idiosyncratic trades to adjust their portfolios, the market demand curve shifts. Also, if all investors reevaluate an issue, due to some widely recognized event, the market demand curve to hold shares shifts. In the model the frequency and size of these idiosyncratic and aggregate demand shifts are mutually independent compound Poisson processes.

The size of P_t/P_{t-1} depends on the frequency and size of shifts and the price elasticity of the market demand to hold. The price elasticity is $E_p = (T_s/SO)/(\Delta P/P)$, where P is price, SO is the number of shares outstanding, and T_s is the share size of the sth idiosyncratic shift during the day. CMSW assume zero transaction costs and no specialist trading. Then

$$\frac{\Delta P}{P} = \frac{T_s Z_s}{E_p SO}, \tag{6a}$$

where the variable Z_s determines whether the sth order is to buy or sell. Since CMSW let the size of the idiosyncratic shift be $Y_s = P \cdot T_s$, then

$$\frac{\Delta \mathrm{P}}{\mathrm{P}} = \frac{\mathrm{Y}_s Z_s}{E_p V}, \tag{6b}$$

where $V = P \cdot SO$ is the market value of the issue. For aggregate shifts CMSW let $\Delta P/P = U_s W_s$, where W_s is the direction of the shift and U_s is the resulting percentage change in price, rather than being the share size of the shift. Y and U are Poisson distributed random variables, while Z and W are Bernoulli random variables.

CMSW show that in their model

$$\mathrm{Var}(r) = \frac{n_i E(Y^2)}{E_p^2 V^2} + n_a E(U^2). \tag{7}$$

The number of idiosyncratic and aggregate shifts are the Poisson distributed variables N_I and N_A, where n_i is the mean rate of idiosyncratic orders per day and n_a is the mean rate of aggregate shifts per day. In Equation (7) n_i, n_a, $E(Y^2)$, $E(U^2)$, E_p, and V are assumed constant for a particular stock for all trading days. In the CMSW model, then, $\mathrm{Var}(r)$ depends on the number of shifts of both types, the mean sizes of the shifts, their variances,[16] the elasticity E_p, and the number of shares outstanding (since $V = P \cdot SO$). A reasonable modification of the CMSW model would replace Y_s with T_s, which in Equation (7) also would replace V with SO (see below).

A multivariate regression model developed from Equation (7) is reported in Cohen, Maier, Ness, Okuda, Schwartz, and Whitcomb (CMNOSW) [5]. In a cross-section sample, stocks have different $\mathrm{Var}(r)$ as they have different values of the variables in Equation (7). Except for SO and some daily measure of P, data on those variables are not available, however.

CMNOSW developed the regression model by relating each theoretical variable to one or more observable variables. The mean number of idiosyncratic orders n_i might be larger for stocks with greater V or SO and for stocks with greater ownership by financial institutions, since on average institutions trade more actively than other investors. Stocks with greater institutional activity also might have larger $E(Y^2)$, since institutions tend to trade larger blocks. To the extent institutions prefer stocks with greater SO and higher P, these also would be correlated with $E(Y^2)$. The mean number of aggregate shifts n_a would be larger for stocks with more news events. The turnover rate ($TO = T/SO$) might indicate the extent of information trading. CMNOSW suggested that higher stock prices (P) might imply higher "quality" stocks and that stocks with greater SO might be more diversified; if so, the number of news events would be larger for those stocks but each event might be less significant on average. Less significant news would mean smaller $E(U^2)$. $E(U^2)$ also might be larger with greater variability in the underlying sales or earnings of the corporations. The elasticity E_p might be larger for stocks with larger SO, CMNOSW suggested, because these stocks probably are more intensely analyzed, which likely would make investors

[16] Since $\mathrm{Var}(Y) = E(Y^2) - [E(Y)]^2$, $E(Y^2) = \mathrm{Var}(Y) + [E(Y)]^2$, and similarly for U. Thus, $\mathrm{Var}(r)$ depends on both the means and variances of Y and U.

exceptations for these securities more homogeneous, reducing the price response to any demand shift. Finally, not only would V or SO itself be related inversely to $\mathrm{Var}(r)$, CMNOSW argued that each element of Equation (7) relates to V or SO in a way that also makes V or SO inversely related to $\mathrm{Var}(r)$.

CMNOSW then argued that as specialists (or any traders) are more willing to enter limit orders in the neighborhood of equilibrium price, the elasticity E_p of demand to hold would be greater, damping the price changes from demand shifts. Not only do NYSE specialists have an affirmative obligation to trade to stabilize prices, CMSW argue that specialists also may profit from filling gaps in the limit order book and from having lower transaction costs than other traders. CMSW believe these incentives are greater for smaller issues. Furthermore, to the extent that specialists maintain their limit orders in the face of aggregate shifts, $E(U^2)$ also would be smaller. If specialists do intervene more extensively for smaller issues, their damping of returns variance would be relatively greater for stocks with smaller V or SO. CMNOSW even suggested that specialist trading could create a positive relation between $\mathrm{Var}(r)$ and V or SO.

As transaction costs are smaller, returns variance also would be smaller. The NYSE fixed brokerage commissions (which were in effect for this sample period) were a smaller percent of price for higher price stocks than for lower price stocks, implying that $\mathrm{Var}(r)$ would be lower for higher P. A transaction cost that CMNOSW did not consider is the price of marketability (the specialist bid-ask spreads). $\mathrm{Var}(r)$ would be greater for stocks with wider spreads (see below).

B. *Off-Board Trading*

The fragmentation and competitive effects of off-board trading on $\mathrm{Var}(r)$ are specified as F and M. With less centralization of transactions (larger F), if the exchange is thereby less efficient $\mathrm{Var}(r)$ would be larger. With a larger number of dealers (M) (and perhaps with more capital devoted to market making as well), the specialist might enter more limit orders around equilibrium price, increasing E_p, and it might change those orders less in response to aggregate shifts, reducing $E(U^2)$. Increased competition would reduce $\mathrm{Var}(r)$.

C. *The Model*

Adding S, F, and M to the CMNOSW regression model gives[17]

$$\mathrm{Var}(r) = e^a V^b TO^c P^d (IH/SO)^f S^g F^h M^j e^u, \tag{8}$$

where IH is the number of shares held by financial institutions and u is an error term. In some cases CMNOSW replaced V with T, which gives

$$\mathrm{Var}(r) = e^a T^{b'} TO^{c'} P^{d'} (IH/SO)^f S^g F^h M^j e^u. \tag{9}$$

Replacing V with SO was suggested above:

$$\mathrm{Var}(r) = e^a SO^{b''} TO^{c''} P^{d''} (IH/SO)^f S^g F^h M^j e^u. \tag{10}$$

In their log-linear forms, however, Equations (8)–(10) are indistinguishable:

[17] Since CMNOSW found that neither sales nor earnings variance had a significant effect on $\mathrm{Var}(r)$, no such variable is included here.

$$\ln \mathrm{Var}(r) = a + b^* \ln P + c^* \ln T + d^* \ln SO + f \ln IH + g \ln S + h \ln F + j \ln M + u. \quad (11)$$

The parameters a, f, g, h, and j are the same as in Equations (8)–(10), but b^*, c^*, and d^* are linear combinations of the other parameters in each of those equations. From the discussion above, the expected signs of the parameters in Equation (11) are as follows: $b^* < 0$, $c^* > 0$ (at least for Equations (8) and (10), $d^* < 0$, $f > 0$, $g > 0$, $h > 0$, and $j < 0$.

Since CMNOSW specified (IH/SO) as linear rather than log-linear, various specifications for the influence of financial institutions were estimated. The number (I) of institutions holding the stock was statistically significant at a higher level than any other and is used here.

Finally, the error terms are heteroscedastic with P such that $\mathrm{Var}(u) = k(\ln P)$ approximately. The correction involves $(\ln P)^{1/2}$, such that $\mathrm{Var}(u/(\ln P)^{1/2}) = k$. Substituting $(\ln P)^{1/2}$ for $\ln P$ in Equation (11) simplifies the equation for the adjusted data: compared to $\ln P$, the uncorrected equation also has larger $\bar{R}^2$ and smaller standard errors.

Equation (12) is used to estimate the effects of F and M on $\mathrm{Var}(r)$.

$$\ln \mathrm{Var}(r) = a + b^*(\ln P)^{1/2} + c^* \ln T + d^* \ln SO + fI + g \ln S + h \ln F + j \ln M + u \quad (12)$$

Simultaneous equations bias is a potential problem in estimating Equation (12). Not only do fragmentation and competition affect the extent to which the specialist would damp daily returns variance, the specialist's action also may affect the extent of fragmentation and competition. As for Equations (2)–(5), Equation (12) can be estimated only by ordinary least squares, because it is not identified in two-stage estimation. The situation for Equation (12) differs from than for Equations (2)–(5), however, since any simultaneous equations bias weakens the empirical findings reported below.[18]

V. Empirical Estimates of the Effect on Returns Variance

This section of the paper reports the empirical estimates of the fragmentation and competitive effects of off-board trading on the daily stock returns variance. $\mathrm{Var}(r)$ is computed from daily closing prices on the NYSE for the trading days in the first quarter of 1975. The other variables are measured as in section III.[19]

A. *The Estimates*

Column A in Table 4 reports the heteroscedasticity-corrected estimated parameters for Equation (12). In column B, $\ln IH$ replaces I. Columns C–E are based on three specifications that CMNOSW reported. The estimated parameters of Equa-

[18] The interdependent relationships between $\mathrm{Var}(r)$ and F have opposite predicted signs, as do the relationships between $\mathrm{Var}(r)$ and M [17]. Consequently, the estimated parameters h and j both would be biased toward zero (Maddala [12] pp. 242–51), reducing the reliability of any observed differences in their estimated values.

[19] Daily closing prices are from Standard and Poor's *Daily Stock Price Record, NYSE* (January–March, 1975). Shares outstanding and shares held by financial institutions are from Standard and Poor's *Stock Guide* (March, 1975).

Table 4

Estimated Parameters of Equation (12), Corrected for Heteroscedasticity

Variables[a]	(A)	(B)	(C)	(D)	(E)
Intercept	1.1408	.9918	.7614	.5037	−2.5448
P	−2.4902	−2.5086	−2.3748	−2.3518	−2.4866
T	.4232	.4220	.4160	.4162	.3071
	(12.94)	(12.86)	(12.65)	(12.63)	(8.89)
SO	−.4058	−.3890	−.4162	−.3944	
	(−8.98)	(−9.01)	(−9.17)	(−9.11)	
I	.0005546	.005187	.0006066		
	(1.44)	(.97)	(1.57)		
S	.2083	.2316			
	(2.55)	(2.77)			
F	.001367	−.006070	.005202	−.0008133	.009871
	(.09)	(−.41)	(.34)	(−.06)	(.59)
M	−.009653	.01095	−.02676	−.006484	−.2299
	(−.13)	(.15)	(−.35)	(−.09)	(−2.89)
$\bar{R}^2$	.890	.889	.888	.887	.857
F	362.208	360.691	414.093	494.090	471.992

[a] Variables are listed generically, since the specifications differ among equations. For each equation the specification is shown in the text.

[b] Parenthetical numbers are t-statistics.

tion (12) all have the predicted signs; those for *T*, *SO*, and *S* are statistically significant.[20] The $\bar{R}^2$ is quite high for cross-section data. The *F*-statistic shows that the model is highly significant. The estimated standard errors are smaller for the corrected equation than for the uncorrected (not shown).

Is the fragmentation effect or the competitive effect the larger one? In column A the estimated parameters (which also are the estimated elasticities) of *F* and *M* are very small, and neither is statistically significant. The competitive effect exceeds the fragmentation effect by a factor of seven. The modifications of Equation (12) reported in columns B–E affect somewhat the estimated parameters for *F* and *M*. In column B, where ln *IH* replaces *I*, *F* and *M* have unpredicted signs, but neither is significant. CMNOSW did not include *S*; in Column A it is statistically significant and has a reasonably large elasticity (over .20). Nonetheless, without *S* (and with *I*), in column C the estimated parameters for *F* and *M* have the predicted signs and are larger than in column A, but they still are not significant and are quite small (the larger was only −.026 for *M*). The competitive effect again exceeds the fragmentation effect. CMNOSW omitted *I*: in column D, F has an unpredicted sign, but neither *F* nor *M* are significant. The competitive and fragmentation effects essentially are zero. Finally, CMNOSW omitted *TO* and substituted *T* for *V*. Only in column E is an estimated parameter for either *F* or *M* statistically significant. The estimated elasticity for *M* is reasonably large (−.23) and is statistically significant. The competitive effect is much larger than the fragmentation effect.

[20] The computer regression package available to me unfortunately did not provide estimated standard errors for the intercept, which was the estimated parameter of *P* in the corrected equation. Since the significance levels were quite similar for corrected and uncorrected estimates, the estimated parameter for *P* likely was statistically significant at the .01 level, since the uncorrected estimate was.

The answer to the question must be qualified by the possibility that simultaneous equations bias has underestimated the parameters (absolute values). Nonetheless, the estimates show that the competitive effect exceeds the fragmentation effect of off-board trading, and by a substantial margin. More important, however, is the magnitude of the effects. Only in a severely abbreviated specification of Equation (12) is the competitive effect statistically significant and reasonably large. In the other equations both estimated effects are tiny. Even if these estimates are biased toward zero by a factor of 5 (or even 10), the unbiased parameters still are small.

In sum, the estimated fragmentation and competitive effects of off-board trading on Var(r) are not inconsistent with the estimated effects on bid-ask spreads.

B. *Regional and Third Market Effects.*

The equations in Table 4 also were estimated with F and M disaggregated into FR, $F3$, MR, and $M3$ in order to estimate the separate competitive and fragmentation effects of the regional exchanges and the third market on Var(r). The heteroscedasticity-corrected estimated parameters all had unpredicted signs, however. Alternatively, the equations were estimated pairing FR with $F3$ and MR with $M3$ in order to estimate just the separate net effects. The regional exchanges are expected to have the larger fragmentation effect and the third market the larger competitive effect, suggesting a positive regional exchange effect and a negative third market effect (see section III.C). In every case, however, the estimated effect of the regional exchanges was negative and, except in one case, the estimated effect of the third market was positive. Thus, the estimates contradict those for bid-ask spreads. None of the estimated parameters are reported here.

VI. Conclusion

Off-board trading of NYSE-listed stocks on the regional exchanges and in the third market might have two opposite effects on the NYSE specialist bid-ask spreads (the prices of marketability) and the daily returns variance of those stocks. Dispersion of trading might increase competition for the specialists, but prevent full realization of any economies of centralized trading on the exchange.

The question is whether the competitive effect or the fragmentation effect is the larger. The estimates reported in this paper are that, within the range of off-board trading exisitng, the competitive effect tends to reduce both the NYSE specialist spreads and the daily stock variances by more than the fragmentation effect tends to increase them. Equally important, however, neither effect is large. The estimated net effect of off-trading trading is, then, to narrow spreads and reduce returns variance, but by only a few percent at most.

Another question is whether off-board trading on the regional exchanges and in the third market have different effects. The estimates are poor, however. No reliable information is obtained about their relative effects. The reason for the poor estimates may be that, for a given amount of off-board trading, its division between the regional exchanges and the third market simply has no effect.

Since the fragmentation and competitive effects of somewhat more or less off-board trading are both quite small, off-board trading seems to have limited policy importance. Nonetheless, policy that promotes competition for the exchange, even though it somewhat increases fragmentation from its present level, apparently would give small net reductions in specialist spreads and daily returns variance. For the present level of off-board trading, such a policy would seem to have precedence over a policy that protects exchange efficiency by restricting off-board trading.

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