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THE PRICING OF SECURITY DEALER SERVICES:

AN EMPIRICAL STUDY OF NASDAQ STOCKS

by

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I. Introduction

An important, if not critical, element in almost every financial market is the dealer who stands ready to trade for his own account and thereby provides to the public the convenience of being able to trade immediately. The dealer incurs costs of holding an inventory of securities, certain costs of handling each order and costs due to adverse information possessed by those that trade with him. He is compensated for the costs by selling at the ask price (above the "true" price) and buying at the bid price (below the "true" price).[1] Dealers are to be distinguished from brokers who do not bear risk and who usually charge a commission. Since healthy financial markets are viewed as critical to a healthy economy and since dealers stand at the center of many financial markets, dealers have been the focus of many regulatory inquiries and some empirical studies by academicians.

Today, competitive forces (institutional trading, third market, block trading), Justice Department pressures, and technological change (the computer) are in the process of producing major changes in the structure of securities markets. As part of this restructuring a major issue is the way in which the dealer function should be provided, the degree of competition which should exist and the rules and regulations under which individual dealers should operate.[2]

Using data from the Over-the-Counter Market (OTC), this paper examines two aspects of dealer behavior that have implications for appropriate structures of securities markets:

1. What factors determine the price of dealer services? An understanding of these factors may suggest how dealer costs may be minimized.
2. What determines the number of dealers willingly making a market in a stock?

Recent academic studies have emphasized the first question. Demsetz [5] develops the useful notion that the service provided by dealers is immediacy. He postulates that the cost per share of providing immediacy (ask price minus bid price) on the New York Stock Exchange (NYSE) is a function of the price, a transaction rate variable and the number of markets (regionals and third market) on which the issue is traded. He finds the transaction rate variable to be highly significant, but he finds the competition variable to be insignificant. Tinic [14] elaborates on the Demsetz approach by entering more variables in the regression equations including an index of competition which weights markets by activity there. His most interesting finding is that spreads are lower when there is greater competition from other markets. Tinic and West [15] apply the same kind of analysis to data for the OTC in which, unlike the NYSE, multiple dealers are permitted. They find that spreads are lower in stocks with a greater number of dealers. These findings are substantiated by Benston and Hagerman [2], who also include in their analysis a superior risk measure. With respect to the second issue Tinic and West [15] have measured the responsiveness of the number of dealers to volume.

This paper differs from earlier studies in that it is based on an explicit theory of dealer costs [12]. Second, the empirical work is based on a larger body of data than previously available and includes more of the relevant variables. In particular, the study recognizes that the competition variable (number of dealers) used in other studies may simply reflect total capital availability and specifies a competition variable that cannot be viewed as a proxy for the amount of capital committed to making markets in a stock. Third, the paper develops and tests a model of the determinants of the number of dealers in a stock and includes a number of variables not considered by Tinic and West. The primary data base is closing bid and ask prices for each stock listed on the NASDAQ system in six days in July 1973 and volume of trading of each dealer in each stock. Additional data for weeks prior to that time were also analyzed. The data are described in greater detail in the Appendix.

Since the NASDAQ market is quite new, the next section of the paper describes that market and presents characteristics of stocks and dealers in the market. A theory of the cost of dealer services is summarized in Section III and an equation for determinants of bid-ask spreads is specified. The empirical evidence on the determinants of spreads is in Section IV. An equation for the equilibrium number of dealers is developed in Section V and empirical estimates are presented. The conclusions are in Section VI.

II. Characteristics of the NASDAQ System

The NASDAQ--National Association of Securities Dealers Automated Quotation--system, which became operational in February of 1971, stores the bid and ask prices quoted by each dealer in every security on NASDAQ.[3] Brokers and other users of the system have a computer terminal which provides a representative bid price, which is the median bid of all dealers in the stock, and a representative ask price, which is the median bid plus the median bid-ask spread of all dealers in the stock. The system also provides simultaneously the bid and ask price of each dealer in a particular stock when the dealer with the best quotation is sought. Dealers that are members of the system have the facility to change quotations at any time. NASDAQ is a quotation system and does not carry out, or record, transactions which are completed in the traditional manner by telephoning the dealer quoting the best price. Quotations are good for 100 shares and are subject to negotiation if larger transactions are desired.

Since November 1971, NASDAQ has also been providing statistics on the volume of trading that are compiled from reports filed by each dealer (entries into computer system) at the end of each day. Share volume for any dealer is defined as the maximum of shares purchased from or sold to the public.[4]

To be listed on the system, securities must have at least two dealers willing to make a market. Since June 1974, a fee has been charged corporations whose stock is included in the system. Dealers are members of the NASD and meet the requirement of the self regulatory body and are subject to its discipline. As of July 1973 about 2600 common stock were listed on NASDAQ plus a large number of preferred and foreign stocks and debt securities. Not all over-the-counter stocks are on NASDAQ and some NYSE stocks are on NASDAQ. These "third market" stocks (about 90) are excluded from this analysis. There were over 500 different dealers making markets in common stocks.

The investor trading on NASDAQ is faced with two costs: the fee charged by the broker who represents him in seeking the dealer with the best price and the compensation to the dealer (represented by the spread). To the extent that investors trade directly with dealers, the brokerage fee can be avoided. However, this is difficult for non-institutional investors.[5] This paper is concerned only with compensation of dealers.

Table 1 presents the NASDAQ composite price index and NASDAQ share volume for selected dates in 1972 and 1973 as well as median value for certain other variables. As is evident in the Table, the middle of 1973 was not a good time for the securities industry. Between April 1972 and July 1973 volume fell drastically; and primarily as a result of the decline in stock prices, percentage spreads rose quite substantially--from 5.1% to 10.5% for the typical industrial stock and from 2.7% to 4.2% for the typical financial stock. The median number of dealers listed per stock did not decline as much as one might expect. A major part of the adjustment to lower volume apparently came in less activity for each dealer. It is interesting to note that in the NASDAQ system of multiple dealers, the typical stock supports 4 to 5 dealers. This is true even though volume is much less than for NYSE stocks.

A. Stock Characteristics

Table 2 presents decile values for a number of characteristics of industrial and financial NASDAQ stocks based on the six trading days in 7/9/73 to 7/16/73. It is evident that there is considerable variability across stocks in all the characteristics. For example, ten per cent of the industrial stocks had average spreads below 3.79% or above 25.64%. Even recognizing that these spreads are based on the RBA rather than on the best bid and best ask, it is evident that trading is quite expensive for a significant fraction of NASDAQ stocks. This is undoubtedly due to the low volume and high risk of some of the NASDAQ stocks. For financial stocks where volume is greater and risk less, spreads are a good deal less. In fact, 10% of those stocks have spreads of 1.77% or less.

The table also presents deciles on the average number of dealers listed per day and the average number of dealers trading per day. The number of dealers prepared to trade is set at a minimum of two by NASDAQ rules. For 10% of the industrial stocks, it is 10 dealers or more. The willingness to trade does not always result in trading activity so that the average number of active dealers per day is considerably less than those listed.

The last column gives deciles on the average absolute daily inventory change of all dealers in a stock. This measures the daily imbalance between public purchases and sales and is necessarily less than volume per day if the public both purchases and sells a stock during the day. Both volume and inventory change appear quite small. Daily volume for the median industrial stock was only $2837 or less than 500 shares for a median priced stock of $5.9. Daily inventory change for median industrial stock was only $283. Volume is substantially higher for financial stocks. Inventory change is also higher, but not to the same degree.

B. Dealer Characteristics

Table 3 summarizes by category of stock certain characteristics of dealers who make markets on NASDAQ in OTC stocks. Item 2 of the table gives the total number of different dealers listed at least once in at least one stock during the 6 days. There were 283 different dealers willing to trade at least one NASDAQ financial stock and 527 willing to trade at least one NASDAQ industrial stock. For all NASADAQ common stocks (excluding third market stocks) there were 537 different dealers listed.

The number of different stocks traded by a single dealer varies considerably. Item 3 gives the number of stocks listed by the median dealer and by the dealer listing the most stocks. Item 4 gives the maximum and median for stocks traded at least once in the six day period. Thus, of all the dealers listing at least one financial stock, the median dealer listed 3. The number traded by the median dealer is 2. The dealer listing the most financial stocks listed 111 and the dealer trading the most financial stocks traded 110 at least once. The dealer listing the most industrial stocks (may be the same as the dealer listing the most financial stocks) listed 434 stocks. Considering all classes of stocks, one dealer listed 462 and one dealer traded 417 at least once. The median dealer listed 10 stocks and the median dealer traded 7 stocks at least once.

Items 5, 6 and 7 give an idea of the total dollar activity per dealer in all his stocks. Dealers are classified by their 6 day dollar inventory change, by their average absolute daily inventory change and by their average daily dollar trading volume. As one would expect the median dealer experienced an insignificant inventory change during the six days in all his stocks taken together. (The slight negative change is consistent with the fact that stock prices rose slightly during the six days.) Certain dealers, however, experienced significant positive or negative changes. In the category "all stocks," +$4,290,000 was the largest positive change for a dealer; and -$1,404,000, the largest negative change for a dealer. The median dealer experienced an average daily imbalance of $4,149 in all his stocks in the "all stocks" category. This is greater than the six day inventory change because dealers take actions to reverse accumulations or decumulations of inventory. The median dealer experienced an average daily volume of $9,750 in all his stocks.

Table 4 classifies stocks by the number of active dealers in the stock. An active dealer is one who carried out at least one trade in the stock in the six day period. The Table shows that among the industrial stocks there were 283 stocks with one active dealer, 464, with two active dealers; 450 with three active dealers, etc.. The principal purpose of the Table is to show how volume and concentration of volume change as the number of active dealers in a stock increases. Column 3 gives the average daily volume for the median stock in each dealer category and column 4 gives, for the median stock, the percentage of six day volume carried out by the dealer with the greatest volume in the stock. Thus, $188 represents the average daily volume for the median stock among the 283 with only one active dealer. Since there is only one dealer the concentration ratio in column 4 is 100%. As the number of active dealers increases, median volume increases, and the median concentration ratio decreases. When there are two active dealers, one half of the 464 stocks have concentration of trading in the top dealer of more than 75%; one half have lesser concentration of trading. When there are ten active dealers, the median concentration of trading is about 30% for both industrial and financial stocks. The tendency toward increasing volume and decreasing concentration ratios is less clear-cut after about ten dealers because the number of stocks in each dealer category becomes small and random factors become important.

III. Theory of the Cost of Dealer Services

A dealer provides the service of standing ready to trade when other investors are not available. In doing so he incurs three types of costs which may be termed holding costs, order costs and information costs. An expression for holding costs can be derived by treating dealers like other investors who desire to diversify and have preferences with regard to the risk-return characteristics of their portfolios. Requests by the public to trade cause the dealer to assume a portfolio which is nonoptimal in terms of his preferences and the proper diversification, and this is the source of the holding costs for which he must be compensated. It is shown elsewhere that the proportional holding cost in stock i (the dollar cost as a fraction of the dollar transaction, Q_i) can be given by[6]

$$c_i = \frac{z}{W_0} \tau_i \sigma_{ip} Q_p + \frac{1}{2} \frac{z}{W_0} \tau_i \sigma_i^2 Q_i. \quad (1)$$

Because Q_i is the incremental transaction this can be viewed as a marginal cost function.

The holding cost depends on :

(1) Dealer characteristics--relative risk aversion z, and dealer equity, W_0. Of two dealers in the same stock, the one with larger z and/or smaller W_0 charges a higher fee for taking a position of given size; or, at the same fee, would take smaller positions.

(2) Size of the transaction in stock i, Q_i. Proportional cost rises linearly with Q_i.

(3) Characteristics of the stock--variance of return per time period, σ_i^2; the holding period, τ_i; and the covariance between the return on stock i and the return on the initial trading account portfolio, σ_{ip}. Thus differences across stocks in the cost of immediacy depend primarily on the fundamental per period variability of the stock's price and the number of periods the stock is expected to be held. The holding period in turn depends on volume of trading since it is more likely that the dealer can reverse a position when there is active trading.

(4) Dollar size of the initial position in the trading account, Q_p, which is the current value of the sum of the positions previously acquired in the process of market making. If Q_p is positive (and $\sigma_{ip} > 0$), the cost of buying stock i is larger than if there were no initial position. Conversely the cost of selling stock i is smaller than if there were no initial position.

Order costs and information costs are related to the transaction and do not depend on initial inventory levels. It is assumed that order costs are a fixed amount per transaction, M, which reflects communications and handling costs. The per dollar cost is thus a declining function of the size of the transaction. Information costs arise when some investors trade because they have information not available to the dealer and can make profits at the dealer's quote.[7] Since the dealer is unable to determine which traders have information, he must charge an amount on each transaction that reflects the expected value of the adverse information possessed by those that trade with him. This is assumed to be a percentage amount γa, when $\gamma = 1$ if dealer purchases shares and $\gamma = -1$ if dealer sells shares. In other words, the dealer expects the stock to have an abnormal negative return of $-a$ after he purchases shares and an abnormal positive return of a after he sells shares.

The final cost function for an individual dealer who trades Q_i is then given as

$$c_i = \frac{z}{W_0} \tau_i \sigma_{ip} Q_p + \frac{1}{2} \frac{z}{W_0} \tau_i \sigma_i^2 Q_i + \gamma a_i + \frac{M}{Q_i} \qquad (2)$$

The first two terms represent holding costs; the second, information costs; the third, order costs. The function is illustrated in Figure 1. Since short positions are taken to be negative, the convention of permitting negative costs (when the dealer sells) is adopted. The upper segment of the function in Figure 1 refers to the cost of buying shares; the lower segment to the (negative) cost of selling shares. The discontinuity reflects the order costs and information costs associated with carrying out a transaction. The cost function is "u" shaped because falling order costs are offset by rising holding costs. The location of c_i depends on the dealer's initial position, Q_p. In Figure 1, the dealer is assumed to have an initial long position $(Q_p > 0)$ so that the "long" and "short" segments of the function are not centered around the abscissa, and the dealer incurs a greater cost in buying shares than in selling shares. Over time the function c_i shifts as $Q_i \neq 0$ causes Q_p to change. For example, if the dealer purchases additional shares in period t, initial inventory at the beginning of $t + 1$ would be even larger. As a result both the "buy" and "sell" segment of the function would shift upward so that the cost of additional purchases by the dealer would be raised and the cost of sales by the dealer would be lowered.[8]

The dealer is compensated by purchasing shares at the bid price, P^b, usually below the "true" price, P^*, and by selling shares at the ask price, P^a, usually above the "true" price. Under marginal cost pricing, the bid price on a dealer purchase of $Q_i^b > 0$ is set according to (2) so that

$$\frac{P_i^* - P_i^b}{P_i^*} = c_i(Q_i^b) \quad .$$

Similarly the ask price on a sale of $Q_i^a < 0$ is set according to (2) so that

$$\frac{P_i^* - P_i^a}{P_i^*} = c_i(Q_i^a) \quad .$$

Since the NASDAQ system only provides bid-ask quotations and not transactions prices, (2) must be converted to a spread function which is simply

$$s_i = \frac{P_i^a - P_i^b}{P_i^*} = c_i(Q_i^b) - c_i(Q_i^a) \quad . \tag{3}$$

By assuming that dealer price quotations refer to purchases or sales of equal size $(Q_i^b = Q_i^a)$, and that information costs (a) for purchases or sales are the same, one can from (2) write the spread as

$$s_i = \frac{z\tau_i \sigma_i^2}{W_0} |Q_i| + 2a_i + \frac{2M}{|Q_i|} \quad . \tag{4}$$

It is interesting to note that this is independent of the dealer's initial inventory, Q_p. This is due to the fact that the slope of the cost function is not changed by shifts in the function. As a result, for any $|Q_i|$, the vertical distance between the "buy" segment and "sell" segment of c_i does not depend on initial inventory or characteristics of the inventory, such as its degree of diversification. Dealers shift quotes relative to the underlying "true" value of the stock as their inventory position change, but the spread remains unaltered for a transaction of given size. Spreads increase with size of transaction, of course, as well as with the risk of the stock, risk aversion of the dealer, adverse information expected, and order costs; and they decline with dealer wealth. So long as the dealer trades one stock at a time, the relevant measure of risk in the spread function is the stock's variance of return, not its so-called systematic risk. Diversification does not affect the spread although it does affect the degree to which bid and ask prices change after a transaction.[9]

In the empirical work, (4) is treated as an industry supply function which requires that variables such as W_0 and z are those that correspond to the "representative" dealer in the stock. Because (4) relates to price quotations, not to market transactions prices, there is not a simultaneity problem; and there is no need to consider the demand for dealer services. On NASDAQ, quotations are based on trades of 100 shares. Therefore, $|Q_i|$ is given by the value of the round lot for which the quotation is good:

$$|Q_i| = P_i \cdot 100$$

where $P_i = (P^a + P^b)/2$.

In a competitive world, the market spread is given by (4). However, the competitive assumption is undoubtedly not correct for every stock. To test the effect of competition, past studies have used the number of dealers listed in a stock to represent competition, and a negative relation between spread and the number of dealers has typically be found. The difficulty with this procedure is that the number of dealers may be a proxy for the aggregate wealth devoted to making markets. Without a better measure of competition or a direct measure of wealth it is difficult to distinguish between the following two hypotheses: 1) competition among dealers reduces spreads; 2) greater wealth, whether held by one dealer of many dealers, reduces spreads. The distinction between the two hypotheses is important since those in favor of a monopoly dealer system (as has existed on the NYSE) argue that what is needed is a way to insure sufficient wealth for the monopoly dealer in a stock, and that is is the existence of sufficient capital, not competition,that reduces spreads. A finding that increases in number of dealers reduce spreads may simply reflect the fact that more wealth is devoted to making markets when there are more dealers. The empirical results below report on an attempt to hold constant the importance of wealth by entering a proxy for W_0 in (4). Secondly, an alternative measure of monopoly is used which is not subject to the same criticism as is the number of dealers.

IV. Empirical Evidence on Determinants of Spreads

A. Specification of Variables

Since the most interesting variables in (4) appear multiplicatively and since the others $\left(a_i, \frac{M}{|Q_i|} \right)$ are somewhat ad hoc, the entire relation is set up in the following form which is log-linear:

$$s_i = \frac{2z}{W_0} \sigma_i^2 \tau_i F_i G_i (P_i \cdot 100) X_i \qquad (5)$$

where F_i and G_i correspond to a_i and $\frac{M}{|Q_i|}$ respectively, $|Q_i| = P_i \cdot 100$, and X_i is a variable that reflects the degree of competition. Turn now to a more precise specification of the variable and the development of appropriate proxies for variables that are not directly observable.

The spread, s_i, offers no difficulty and is defined as

$$s_i = \frac{P_i^a - P_i^b}{P_i}$$

where P_i^a and P_i^b are the ask and bid prices respectively and where $P_i = (P_i^a + P_i^b)/2$. Note that the theory specifies the use of percentage spread rather than absolute spread.[10]

The variance of the stock's return, σ_i^2, is estimated from weekly data for the period 4/3/72 to 3/27/73 and 5/2/73 - 7/17/73. Use of the variance is appropriate if the dealer trades one stock at a time. A positive sign is expected.

The holding period, τ_i, is not directly observable and is assumed to be a function of volume, V_i, in the stock. The greater the volume the easier it is for the dealer to reverse a position given the number of other dealers in the stock. The dollar value of trading volume was used, and it was estimated over 64 days of trading in the period 4-3/72-3/27/73, 5/2/73-7/17/73 rather than on the 6 days of daily data because it was felt that this length period would give a beter estimate of expected volume. A negative sign is expected on V_i.

Adverse information cost, F_i, of a trade is also not directly observable. It is assumed that the expected cost of adverse information is greater in stocks with greater informational trading, and the level of informational trading is assumed to be correlated with turnover. In the absence of informational trading, investors would hold well diversified portfolios and would tend to trade amounts proportional to the amount of the stock outstanding. If investors believe they have information, trading will be concentrated in stocks about which information is possessed and volume in those stocks relative to shares outstanding will exceed that of other stocks. Turnover is defined as V_i/T_i, where T_i = dollar value of shares outstanding. A positive sign is expected.

The minimum cost, G_i, is also not directly observable. It is assumed to be a function of the price, P_i, of the stock because quotations are for 100 shares so that a minimum cost is spread over more dollars for high priced stocks. One would expect a negative sign. Another reason for expecting a negative sign on P_i is the minimum allowable spread of 1/8 dollar that can cause low priced stocks to have artificially high spreads. Finally, there is some evidence that price is negatively correlated with risk of a stock.[11] If this is the case, P_i might pick up some of the risk not reflected σ_i^2, and this would also cause a negative sign. A positive influence on the coefficient of P_i comes from the appearance of P_i in (5) to reflect the dollar value of positions taken by dealers. Larger positions require larger spreads. There will also be a statistical bias toward a negative sign to the extent there is measurement error in price since the error will show up on the denominator of the left hand side and the numerator of the right hand side. It is not clear a priori whether these offsetting tendencies will result in a positive or negative sign.

Variables to represent the <u>degree of competition</u> are the number of different dealers listed, d_i, and the concentration of dealer trading. A proxy for dealer wealth is also entered. These will receive more extensive discussion in the empirical section. The remaining variable, z, is impounded in the constant term.

B. Results

Table 5 gives results for 4 different log-linear regression equations, the means and standard deviations of the logs of the variables, and the correlation matrix of the logs of the variables. Regression 1, in which the proportional spread is regressed against the variance of return, dollar volume, turnover, stock price, and number of different dealers listed in the stock during the six day period is quite similar to the regressions run in other studies. It differs in the use of proportional spread and the inclusion of turnover. All variables have the expected signs and are highly significant. Over 82 per cent of the cross section variation in proportional spreads is explained by the five independent variables. As is the case in all studies of this type, the activity variable, volume, is negatively related to spreads. Price is negatively related to proportional spread. This result is consistent with a positive coefficient less than one found in the other studies using dollar spread as the dependent variable. It implies that the minimum order cost element and risk elements outweigh the higher holding cost incurred in higher priced stocks. The significance of the risk variable is inconsistent with the findings of Tinic [14] for a sample of NYSE stocks and Tinic and West [15] for a sample of OTC stocks. In those studies measures of risk were statistically insignificant. Their results are probably due to the use of less complete data. Tinic used only 19 trading days in calculating the variance. Tinic and West were forced to use the relative difference between high and low prices on a single day as their measure of risk. The informational trading variable--turnover--is highly significant and has the expected positive sign. In fact this variable has the largest percentage effect on spread with an elasticity of 1.2.

The competition variable in regression 1 is the number of different dealers listed during the six day period. The significant negative coefficient for this variable is consistent with the findings of Tinic and West and of Benston and Hagerman. There is some difficulty with their interpretations of the negative coefficient as implying that competition reduced spreads since the number of dealers may be correlated with the total amount of capital used in making markets. The best solution to this difficulty would be explicitly to include a variable for dealer wealth. Such data is, in theory, public information available from the SEC.[12] However, a summer's attempt to compile a complete and accurate data file proved fruitless. Instead regression 2 includes a proxy for dealer wealth--the log of the average absolute daily inventory change per dealer in the stock, ΔI.[13] This is a proxy for W_0 in (5) on the assumption that wealthier dealers tended to take larger positions. The difficulty with this variable is, of course, that it also depends on other variables in the equation (such as the risk, σ_i^2, and willingness of the dealers to take risk, z). The significant negative coefficient for ΔI implies that stocks in which the average dealer took larger positions have lower spreads. Given the activity in the stock and the number of dealers, it is not inappropriate to attribute the influence of ΔI to differences in wealth. The important conclusion in terms of the role of competition is that stocks with more dealers continue to have lower spreads.[14]

Regression 3 takes account of the concentration of dealer activity as well as the number of dealers. The variable C is a concentration ratio defined as the proportion of total volume during the six day period accounted for by the dealer with the greatest volume in the stock. This is a "purer" measure of competition--or the lack thereof--than d_i because it cannot be interpreted as a proxy for the amount of wealth devoted to making markets in the stock. The significant positive coefficient indicates that stocks in which trading is more concentrated in the top dealer tend to have larger spreads. The beneficial effects of competition are strongly supported by regressions 2 and 3.

In regression 4 an attempt is made to determine the relative importance of systematic and unsystematic risk which can be derived from the market model. The market model is

$$\tilde{R}_{i,t} = a_i + b_i \tilde{R}_{m,t} + \tilde{e}_{i,t} \qquad (6)$$

where

$\tilde{R}_i$ = return for stock $i = P_t/P_{t-1} - 1$

$\tilde{R}_m$ = return for market index $= I_t/I_{t-1} - 1$

$\tilde{e}_i$ = random error term with $Ee_i = 0$, $cov(e_i, R_m) = 0$,

$cov(e_{i,t}, e_{i,t-1}) = 0$.

Then

$$\sigma_i^2 = b_i^2 \sigma_m^2 + \sigma^2(e_i) \quad . \qquad (7)$$

The first term on the RHS of (7) is the systematic risk. The second term is the unsystematic risk which can be avoided by appropriate diversification. The two terms on the RHS of (7) are calculated for each stock on the basis of regressions for (6) using 52 weekly observations for the period 4/3/72-3/27/73,[15] and the sum of the logarithms substituted for the logarithms of σ_i^2.[16] R_m is calculated from the NASDAQ composite index (similar results were achieved using the NYSE index). It proved difficult to calculate reliably the division into systematic and unsystematic risk, and the conclusions at this point should be interpreted with more caution than the other conclusions of the study.[17]

Regression 4 shows that both systematic and unsystematic risk are statistically significant; however, unsystematic risk is clearly more important, since it has an elasticity of .1322 as compared with .0098 for systematic risk. This implies that dealers are concerned about the total risk of individual stocks, a result consistent with the model of dealers summarized here in which spread depends on the stock's total risk even if the dealer's initial portfolio is well diversified.

Benston and Hagerman find systematic risk is not statistically significant and argue this is because "expected return on the stock should compensate the dealer for this risk." The reason for the relevance of systematic risk in the model summarized here is that market-making causes the dealer to move from his desired position on the efficient risk-return frontier to a point yielding a lower level of utility. The expected return of the stock is not sufficient compensation for the loss of utility.

V. Equilibrium Number of Dealers

The cost function shown in Figure 1 implies that an optimum scale of operations exists because firms' declining order costs are offset by increasing holding costs. If the equilibrium number of dealers in a stock is given by the number that demand can support at the minimum proportional cost, the optimum output point, denoted by Q_i^* in Figure 1, is[18]

$$Q_i^* = \pm \sqrt{\frac{2MW_0}{z\tau_i\sigma_i^2}} \quad . \tag{8}$$

Assuming identical cost functions for all dealers in a stock, the expression for the equilibrium number of dealers is

$$d_i^* = \frac{|D_i|}{|Q_i^*|} = |D_i| \cdot \left| \sqrt{\frac{z\tau_i\sigma_i^2}{2MW_0}} \right| , \tag{9}$$

where

$|D_i|$ = The demand for dealer services at a price for these services corresponding to the optimum output level of the dealer. This can be viewed as the expected absolute value of dollar imbalances between public purchases and sales, which must be met by dealers.

The remaining variables are defined as in (2). Note that a, the percentage cost of adverse information, does not appear in (9) because it is assumed constant and independent of output and, therefore, does not affect the optimum scale decision.

Since (9) represents a long-run equilibrium relationship, it poses some empirical problems if precise parameter estimates are desired because the RHS of (9) will contain transitory elements that cause parameter estimates to be biased toward zero. The purpose of the paper is not, however, to make precise parameter estimates of (9). Rather tests of (9) should be viewed in a more general way as tests of whether there is any systematic way that dealers allocate themselves to stocks at a given moment of time. Differences in numbers of dealers per stock could be purely random and unrelated to characteristics of stocks, and this would suggest the absence of an optimum scale of operation. However, a finding that differences across stocks in the number of dealers are significantly related to characteristics of stock would be (particularly in view of the possible statistical biases) strong evidence that there is an optimum scale of operations--that certain arrangements of dealers and stocks are better than others.

In regression 1 of Table 6 there is a highly significant positive relation between the number of dealers and volume and riskiness of the stock.[19] This implies that an optimum scale of operations does exist and that a system of multiple dealers is preferable to a system in which one dealer specializes in a stock. Of particular interest is the positive coefficient on the risk variable, the variance of return. This finding is due to the fact that any single dealer would tend to take smaller positions the riskier the stock. Since the optimum scale of operations is smaller, more firms are required to meet a given level of volume. The turnover variable is not statistically significant in regression 1. Tinic and West [15] also find that volume is highly significant in determining the number of dealers in a stock; however,they do not consider other variables.

The inclusion of the logarithm of the stock's price in regression 2 not only results in a highly significant negative coefficient on P but also has a substantial effect on the other coefficients. There are several reasons for the negative coefficient on P. First, the price level may be a partial proxy for the risk of the stock. If low priced stocks are riskier, and if more dealers are required in risky stocks, a negative coefficient would result. The correlation matrix in Table 5 confirms that P_i and σ_i^2 are negatively correlated. The reduced significance of σ_i^2 with the entry of P_i is probably the result of this correlation. Second, higher priced stocks require each dealer to take a larger position on any 100 share trade. As a result fewer dealers would be in a position to make a two sided market. Third, (and related to the second point) is the possibility that low priced stocks tend to be more profitable and, therefore, attract more dealers, holding other things constant. This profitability may result from the fact that the minimum spreads of 1/8 of a point may be a significant fraction of some prices and/or the existence of inefficiencies in the market that cause investors to willingly pay larger transaction costs in low priced stocks.[20] Note that any such inefficiency would be in addition to the excessive volume that sometimes occurs in low priced stock with speculative interest since volume has already been considered.

The inclusion of P_i raises the coefficient of V_i from .22 to .35. This reflects the fact that V and P are positively correlated causing V in regression 1 to pick up some of the negative effect of P. Turnover became statistically significant and takes on a larger negative coefficient. In other words, given the price of a stock, greater turnover reduces the number of dealers and greater volume increases the number of dealers. The significance of turnover implies that, contrary to the assumption underlying (9), informational trading does affect the scale decision. Holding constant other characteristics of the stock, high turnover implies fewer dealers and, therefore, a greater scale of operation per dealer. This is sensible because it is easier for a dealer to assess possible adverse information if trading is not dispersed among many dealers. As a result there are economies of scale which arise from reducing uncertainty in stocks where informational trading takes place. These potential economies are not reflected in (9).

In regression 3 the systematic and unsystematic components of the variance are substituted for σ_i^2. Of the two, only systematic risk is statistically significant. Thus, it appears that long run decisions about the scale of operations and the number of dealers in a stock are based on systematic rather than unsystematic risk, whereas short run pricing decisions are more significantly related to unsystematic risk (see Table 5).

VI. Summary and Conclusions

The study utilizes closing bid and ask prices for each NASDAQ stock for six consecutive trading days in July 1973 and volume of trading for each dealer in each NASDAQ stock during the same period. The characteristics of the NASDAQ dealer system are described in Section II. In Section III a dealer cost function is set out that hypothesizes a positive relation between bid-ask spreads and the riskiness of the stock, the reluctance of the dealer to bear risk, the amount of informational trading, the level of order costs and the lack of competition among dealers in a stock.

An operational version of the model is tested in Section IV and supported by the data. The risk of the stock is measured by the variance of return and by volume of trading which determines how long the dealer is exposed to price risk. Both variables have the expected signs (+ and - respectively) and are highly significant. Variance of return is decomposed into its "systematic" and "unsystematic" components. Both components are statistically significant, which is consistent with the model used here.

The amount of informational trading is measured by turnover (volume/shares outstanding) on the grounds that trading is large relative to shares outstanding if certain investors believe they have information that other investors and the dealers in the stock do not have. This variable has a large and significant positive effect on spread. Order costs and the willingness of dealers to bear risk are less readily measured. Absolute price of the stock is entered on the grounds that fixed order costs per trade would be spread across more dollars in high priced stocks with the result that percentage spread would be lower the greater the price. This is in fact the case. However, price may also be a proxy for risk or may capture the fact that minimum spreads (of 1/8 point) are a larger percentage of low priced stocks. Willingness of the dealers to bear risk is measured by the average absolute daily inventory change by dealers in a stock. Larger values are presumed to reflect a greater amount of dealer wealth and, therefore, a greater willingness to take risk. The negative sign on this variable (which is statistically significant) is consistent with this interpretation.

Competition is measured by the number of dealers in a stock and by the concentration of trading activity in the top dealer in a stock. The statistical results clearly demonstrate that increased competition--either in the form of more dealers or lesser concentration, given the number of dealers--reduces spreads. These findings have the important policy implication that reducing the number of dealers in a stock would increase costs of trading on NASDAQ.

Section V shows that the number of dealers in a stock is significantly related to characteristics of the stock. This implies that there is an optimum number of dealers per stock and, therefore, that there is an optimum scale of operation for each dealer in each stock. It would, therefore, be undesirable to limit the number of dealers in a stock since such a limit forces each dealer to operate at a nonoptimal scale thereby imposing higher than necessary costs on investors. In addition such a limit may allow dealers to price as monopolists.

Appendix I: The Data

The data used in this study are the closing representative bid and ask price (RBA) for each common stock listed on the NASDAQ (National Association of Securities Dealers Automatic Quotation) System in the six trading days between July 9 (Monday) and July 16, 1973 and the purchases and sales of each dealer in each stock. Price quotations of individual dealers were not available. The representative bid is the median bid; and the representative ask is the median bid plus the median spread. The spread tends to be larger than the inside quotation which is the best bid and best ask. Prices have been adjusted for splits and stock dividends.

Volume of an individual dealer in a stock is defined as the greater of his purchases from and sales to non-dealer customers. There is said to be relatively little inter-dealer trading. (See NASDAQ release, "NASDAQ Volume Reporting Procedures," April 1973, for a detailed description of what is included in volume.) Since NASDAQ is a quotation system and not a transaction reporting system, dealers are responsible for reporting their volume at the end of each day. Inventory change is simply the difference between purchases and sales during the day.

Only common stock of U.S. companies traded exclusively in the OTC are included in this analysis. This means that stocks also traded on the NYSE are not included. A number of edit procedures were carried out which resulted in some corrections and the dropping of a number of stocks. Edits included checks that two dealers exist in each stock (a NASDAQ requirement), that price and volume changes and spreads are not extreme, and that there be internal consistency between total reported volume and the volume of individual dealers. There is little basis for correction except for splits or dividends since we were supplied with the primary data source. However, although data were not incorrect, they were sometimes incomplete due to inactivity in the stock. Stocks were dropped if there was not both a bid and an ask price available. The final sample was quite large and covered over 2000 stocks and 500 dealers in the 6 day period.

The market index used is the NASDAQ composite index. Stock return variances and covariances with the index are calculated using the average of the RBA for one day per week for the period 4/3/72 to 3/27/73 and 5/2/73 to 7/17/73, a total of 64 observations. These data are not ideal because the day of the week is not always the same (the data was ued for surveillance purposes) and because the time period covered is relatively short. Use of this data was, however, preferred to the alternative of not making the desired calculations.

Table 1

Selected NASDAQ Statistics

VARIABLE	DATE						
	1972				1973		
	4/3	6/27	9/28	12/26	3/27	6/27	7/11
1) NASDAQ Composite Price Index	128	130	129	131	117	100	103
2) NASDAQ Share Volume for Week Containing Date (Millions)	53	38	40	32	33	23	27
3) Median % Spread							
Financial Stocks	2.7	2.8	2.9	3.0	3.6	4.2	4.2
Industrial Stocks	5.1	5.6	6.3	6.7	8.0	10.5	10.5
4) Median $ Volume ($100)							
Financial Stocks	101	79	74	80	75	54	101
Industrial Stocks	75	48	32	39	21	15	22
5) Median Price							
Financial Stocks	26	25	26	26	23	19	19.4
Industrial Stocks	11	10	8.9	8.5	7.3	5.9	5.9
6) Median Number of Dealers Listed							
Financial Stocks	5	5	5	5	5	5	5
Industrial Stocks	5	5	5	5	4	4	4

Note: Median calculated across all non third-market common stocks.

Table 2

Stock Characteristics

Cross-Section Deciles on Average Values
for the 6 Trading Days From 7/9/73 to 7/16/73

Decile	% Spread	$ Volume Per Day	NR of Dealers Listed Per Day 1/	NR of Dealers Per Day With Volume 2/	Absolute Daily $ Inv. Change 3/
			Industrial Stocks (2214)		
1	3.79	154	.00	.33	29
2	5.42	548	3.00	.50	83
3	6.90	1073	3.33	.83	137
4	8.61	1719	4.00	1.00	200
5	10.49	2837	5.00	1.33	283
6	12.58	4373	6.00	1.67	379
7	15.38	7312	7.00	2.17	504
8	19.05	13517	9.67	3.00	716
9	25.64	31564	19.00	4.50	1204
			Financial Stocks (294)		
1	1.77	683	2.00	.50	52
2	2.25	2015	3.00	.83	102
3	2.82	4183	4.00	1.17	188
4	3.54	7644	4.17	1.50	276
5	4.10	11962	5.00	2.00	375
6	4.73	17566	6.00	2.50	473
7	6.15	30625	7.00	3.17	692
8	8.00	51885	9.00	3.83	880
9	10.62	122710	10.00	6.50	1544

Notes:
1. Number of dealer-days of listing divided by number of days = 6.
2. Number of dealer-days with volume divided by 6.
3. For any stock defined as

$$\frac{1}{6} \sum_{t=1}^{6} \left[\sum_{j=1}^{d_i} \$Pur_j - \sum_{j=1}^{d_i} \$Sal_j \right]$$

where t refers to the day, j to the dealer, d_i = number of dealers in stock i, $\$Pur_j$ = \$ purchases of dealer j, $\$Sal_j$ = \$ sales of dealer j.

Table 3

Dealer Characteristics for the
6 Trading Days in the Period 7/9/73-7/16/73

Variable	Stock Category		
	Financial (1)	Industrial (2)	All (3)
1. Number of Stocks in Class	294	2214	2508
2. Number of Dealers <u>Listed</u> at Least Once in at Least 1 Stock	283	527	537
3. Number of Stocks Listed by Dealer			
Maximum Number	111	434	455
Median Number	3	9	10
4. Number of Stocks Traded at Least Once by Dealer			
Maximum Number	110	329	417
Median Number	2	6	7
5. 6 Day $ Inv. Change in $1000			
Largest Dealer	4470	3846	4290
Median Dealer	0	-1.884	-1.788
Smallest Dealer	-1068	- 990	-1404
6. Average of Daily Absolute $ Imbalances in $1000			
Largest Dealer	835	954	1235
Median Dealer	3.000	3.623	4.149
7. Average of Daily $ Volumes in $1000			
Largest Dealer	2112	3775	5832
Median Dealer	5.011	7.711	9.750

Table 4

Distribution of Number of Stocks by Number of Active Dealers Per Stock and for Each Dealer Category - Daily $ Volume of Median Stock and Concentration of Trading Volume of Median Stock. 7/9/73-7/16/73

NR of Active Dealers[1] (1)	NR of Stocks[2] (2)	Values for Median Stock in Each Dealer Category: Avg Daily $ Volume (3)	Values for Median Stock in Each Dealer Category: Concentration of Volume in %[3] (4)
Industrial Stocks			
1	283	188	100
2	464	1,175	75
3	450	2,088	60
4	317	4,305	51
5	218	5,398	45
6	150	10,401	39
7	107	12,084	34
8	76	22,527	33
9	57	28,735	31
10	31	53,277	30
11	26	29,268	25
12	12	45,372	24
13	14	132,134	27
14	13	131,703	22
15	7	38,110	20
16	7	85,907	14
17	2	85,696	15
18	4	230,959	18
19	3	156,572	15
20	1	357,771	13
21	2	39,776	11
27	1	517,355	20
Financial Stocks			
1	18	168	100
2	54	1,999	67
3	47	4,290	61
4	42	11,963	52
5	39	15,631	44
6	28	19,793	38
7	14	35,149	45
8	19	55,707	32
9	14	48,630	33
10	8	72,090	28
11	3	174,165	32
12	3	67,170	15
13	5	210,245	21
14	2	211,631	18
15	2	91,814	16
17	2	550,672	13
18	1	304,246	19
22	1	430,161	22
23	1	520,097	22

Notes: 1. An active dealer in a stock is one who had at least one trade in the 6 day period. 2. The total number of Financial and Industrial stocks exceeds the number in Table 2 because the requirement for both a bid and ask price on each day was not necessary. 3. The concentration ratio is the % of 6 day volume carried out by the dealer with the most volume in the 6 day period.

Table 5

Spread Regressions

	s	σ^2	V	V/T	P	d	ΔI	C	$b^2\sigma^2_m$	$\sigma^2_{(e)}$	CONST	s.e./r^2
1.	DEP	.1405	-.1971	1.238	-.3713	-.2462					.0873	.3183
		(19.03)	(-19.53)	(14.56)	(-25.07)	(-15.84)					(.9325)	.8222
2.	DEP	.1418	-.1676	1.164	-.3412	-.2312	-.0566				.2081	.3148
		(19.41)	(-15.61)	(13.74)	(-22.46)	(-14.91)	(-7.453)				(2.214)	.8261
3.	DEP	.1440	-.1562	1.121	-.3457	-.1710	-.0526	.1440			.1270	.3118
		(19.88)	(-14.52)	(13.33)	(-22.96)	(-9.728)	(-6.973)	(7.036)			(1.354)	.8294
4.	DEP		-.1565	1.126	-.3444	-.1690	-.0530	.1427	.0098	.1322	.1581	.3122
			(-14.46)	(13.34)	(-22.77)	(-9.603)	(-7.015)	(6.953)	(3.046)	(17.78)	(1.593)	.8290
mean	-2.424	-5.599	9.711	1.0620	1.971	1.5970	7.151	-.6094	-8.735	-5.729		
St. Dev	.7548	1.119	1.392	.1146	.898	.5365	1.418	.4361	2.344	1.127		

Correlation Matrix

	s	σ^2	V	V/T	P	d	ΔI	C
σ^2	.440							
V	-.655	.069						
V/T	.291	.478	.310					
P	-.848	-.460	.597	-.354				
d	-.363	.207	.573	.231	.151			
ΔI	-.717	-.132	.739	-.035	.687	.424		
C	.409	-.143	-.553	-.158	-.235	-.677	-.448	
$b^2\sigma^2_m$	.075		.300	.388	-.116	.283	.132	-.264
$\sigma^2_{(e)}$	.467		.023	.455	-.484	.172	-.167	-.107

Notes: Regressions are run on natural logarithm of variables. 2474 observations. t values in parentheses. Last column gives standard error and adjusted r^2.

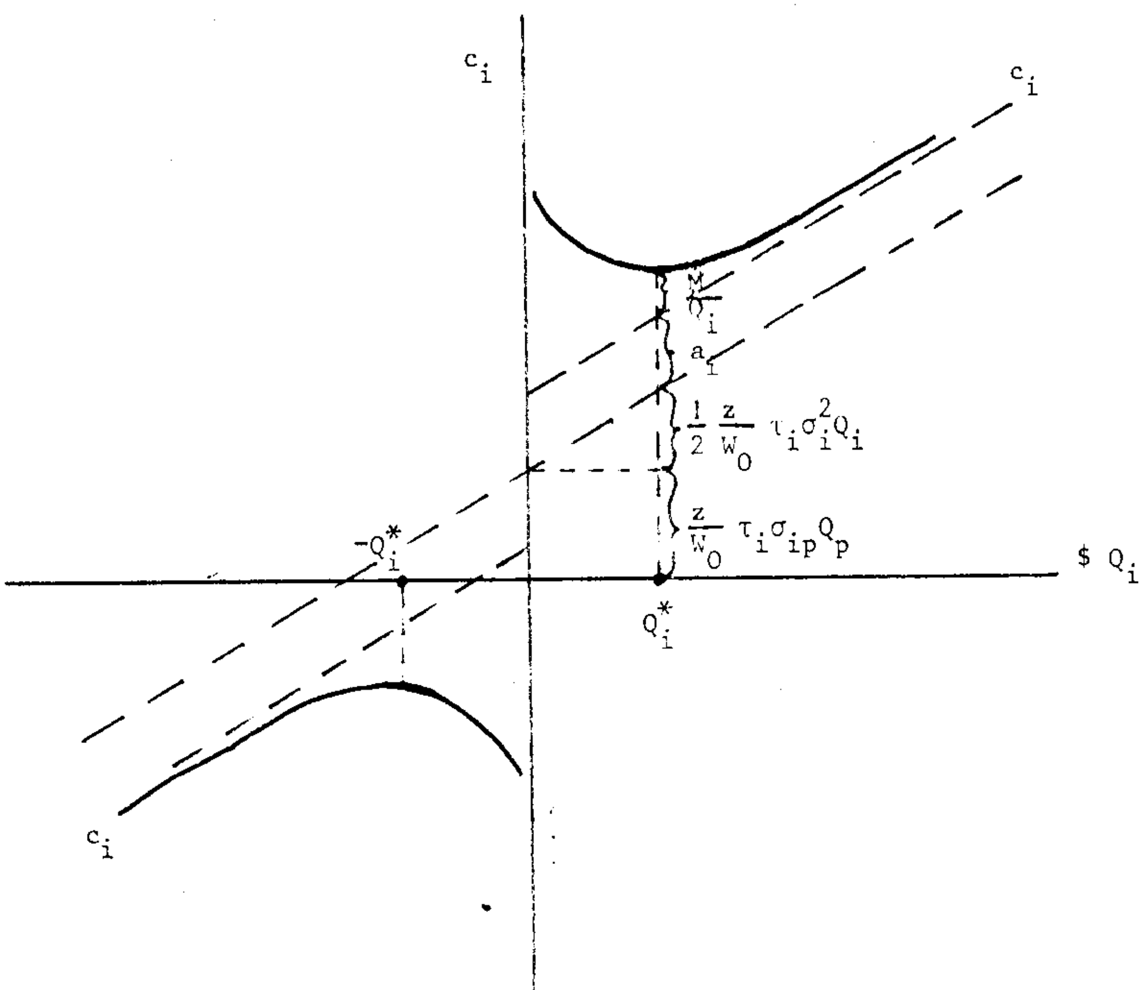
Table 6

Dealer Regressions

Dependent = d_i = number of different dealers listed during 6 day period

	Independent Variables							st. error
	σ_i^2	V_i	V_i/T_i	P_i	$b^2\sigma_m^2$	σ_e^2	CONST	adj r^2
1	.0878 (9.928)	.2199 (33.46)	-.1548 (-1.709)				.1187 (.9389)	.4305 .3562
2	.0213 (2.230)	.3546 (32.41)	-1.118 (-10.37)	-.2762 (-15.05)			.0048 (.0397)	.4121 .4101
3		.3523 (31.71)	-1.127 (-10.44)	-.2790 (-15.17)	.0093 (2.197)	.0080 (.8197)	.0501 (.3908)	.4120 .4103

Notes: Regressions are run using natural logarithms of all variables. Same data base as in Table 5.



c_i
c_i
$\frac{M}{Q_i}$
a_i
$\frac{1}{2}\,\frac{z}{W_0}\,\tau_i\sigma_i^2 Q_i$
$\frac{z}{W_0}\,\tau_i\sigma_{ip}Q_p$
$-Q_i^*$
$\$\ Q_i$
Q_i^*
c_i

Figure 1

FOOTNOTES

[1] The "true" price is the price that would, in the dealer's opinion, exist in the absence of transaction costs.

[2] See the SEC White Paper [10] for a discussion.

[3] See Santomero [11] for an analysis of the effects of the introduction of the NASDAQ system on spreads.

[4] There is some difficulty in calculating volume because it is not always clear to a dealer whether he is trading with a broker-dealer representing the public or himself. This is particularly true for block trades. See NASD Release, NASDAQ Volume Reporting Procedures", April 1973, for a detailed discussion.

[5] Even a dealer who is also a retail broker, as is often the case, is likely to charge a brokerage fee to individual investors for executing transactions since this service involves additional costs.

[6] See Stoll [12]. The principal assumption underlying the holding cost equation (other than the standard one leading to optimal individual portfolios) is that the dealer's inventory positions are financed solely by borrowing at the risk free rate of interest or by lending proceeds of short sales at the risk free rate of interest and not by selling short or purchasing other stocks. The multiperiod equation (1) differs slightly from the one developed in [12] by neglecting to divide the RHS by a term slightly less than one. The difference is not important for the empirical work of this paper.

[7] See Bagehot [1] and Jaffe and Winkler [9] for a discussion of adverse information costs.

[8] The value of Q_p may undergo changes even without purchases or sales by the dealer because of price changes in the stock which cause revaluation of inventory, but these are likely to be extremely small as compared to changes caused by dealer purchases or sales. Furthermore, the capital gains or losses imposed on the dealer by these price changes will also affect his wealth, and the net effect of these two factors would be very small. It should be noted, of course, that capital gains or losses have no other effect on dealers. There are "sunk" gains or losses. The dealer has no opportunity to regain losses, for example.

[9] See Stoll [12] for a more detailed discussion of this and other aspects of holding costs.

[10] Cf. Demsetz [5], Tinic [14], Tinic and West [15], Benston and Hagerman [2] who use dollar spread per share.

[11] See Blume and Husic [4].

[12] On its form 17a-5. The data were, however, extremely incomplete and out of date. In addition, it takes weeks for file on each broker-dealer to be retrieved.

[13] $\Delta I = \frac{1}{t \cdot d_i} \sum_{t=1}^{6} \sum_{j=1}^{d_i} |Pur(j,t) - Sal(j,t)|$

Where Pur(j,t) and Sal(j,t) are dollar purchases and sales respectively by dealer j on day t in stock i. d_i is the number of dealers in stock i.

[14] These results may understate the importance of competing dealers for the following reason: If the holding period (and therefore the risk) of any single dealer is positively related to the number of other dealers, spreads would be positively related to the number of dealers. The negative coefficient on d_i suggests that any such effect is more than offset by the competitive effect.

[15] The regressions were actually run in price relative rather than rate of return dimensions. Dividends were excluded.

[16] This involves some misspecification since the logarithm of the sum is not the same as the sum of the logarithms.

[17] The data covered only one year and contained the additional difficulty that prices were available only for different days in each week. Although index values were, of course, collected for corresponding days, the fact that returns were calculated over different time spans could cause difficulty if the market model is not stationary. Even with reliable data there are numerous statistical difficulties in calculating unbiased estimates of b_i in (3). See, e.g., Black, Jensen, Scholes [3] and Friend and Blume [6]. The median r^2 for the 2474 individual stock regression was only .045 and the median b_i was .7484 for industrial stocks and .4724 for financial stocks.

[18] Take the derivative of (2) with respect to Q_i.

[19] The volume variable reflects the net effect of $|D_i|$ and τ_i ; and in principle, the sign on the volume variable is ambiguous. Let the terms other than τ_i under the square root sign in (8) be given by A. Let

$\tau = \frac{\alpha}{V}$ where α is a constant > 0. In other words the holding period is large for small volume and declines as volume increases. Let $|D_i| = \gamma V^{\theta}$, where γ and θ are constants greater than zero. The assumed imbalances during a short trading interval are larger the larger is volume, although not necessarily by proportional amounts. Then

$$\ln d = \ln \gamma V^{\theta} + \tfrac{1}{2} \ln \frac{A\alpha}{V}$$

$$= A' + (\theta - \tfrac{1}{2}) \ln V.$$

There is a positive relation between $\ln d$ and $\ln V$ only if $\theta > \frac{1}{2}$, which is not necessary. The strong positive relation which is in fact found may be due to the fact that NASDAQ dealers are also brokers (or act as brokers when they carry out so called riskless principal transactions). In that case demand for their services is directly related to volume so that $\theta = 1$, $\gamma = 1$.

[20] The significant and puzzling role of the absolute price level of a stock has been observed elsewhere. Blume and Husic [4] find that price level helps in predicting returns. Gould and Galai [7] show that the price level of a stock is an important discriminator in separating stock for which put call parity holds from those in which it does not.

References

1. Bagehot, W., (pseud.), "The Only Game in Town," Financial Analysts Journal, (March/April 1971).

2. Benston, George J. and Hagerman, Robert L., "Determinants of Bid-Asked Spreads in the Over-the-Counter Market," Journal of Financial Economics, 1, (Dec. 1974), pp. 353-364.

3. Black, F., Jensen, M., Scholes, M., "The Capital Asset Pricing Model: Some Empirical Tests," in Jensen (ed), Studies in the Theory of Capital Markets, (New York: Praeger, 1972).

4. Blume, M. and Husic, F., "Price, Beta, and Exchange Listing," Journal of Finance, XXVIII, (May 1973).

5. Demsetz, Harold, "The Cost of Transacting," Quarterly Journal of Economics, LXXXII, No. 1 (February 1968).

6. Friend, I. and Blume, M., "Measurement of Portfolio Performance Under Uncertainty," American Economic Review (September 1970).

7. Gould, J. P. and Galai, D., "Transactions costs and the Relationship Between Put and Call Prices," Journal of Financial Economics, 1 (July 1974), pp. 105-130.

8. Institutional Investor Study Report of the Securities and Exchange Commission, 92nd Congress, 1st Session House Document No. 92-64, March 12, 1971. Washington: G.P.O., 1971. Part 4, Ch. 12.

9. Jaffe, J. and Winkler, R., "Optimal Speculation Against an Efficient Market," Journal of Finance, XXXI (March 1976).

10. Policy Statement of the Securities and Exchange Commission on the Structure of a Central Market System, in Securities Regulations and Law Report, No. 196, April 4, 1973, published by Bureau of National Affairs, Inc.

11. Santomero, A. M., "The Economic Effects of NASDAQ: Some Preliminary Results," Journal of Financial and Quantitative Analysis (Jan. 1974).

12. Stoll, H.R., "The Supply of Dealer Services in Securities Markets," mimeo.

13. Stoll, H.R., "Dealer Inventory Behavior: An Empirical Investigation of NASDAQ Stocks," forthcoming Journal of Financial and Quantitative Analysis (Sept. 76)

14. Tinic, Seha M., "The Economics of Liquidity Services," Quarterly Journal of Economics, LXXXVI (February 1972).

15. Tinic, Seha M., and West, Richard, "Competition and the Pricing of Dealer Services in the Over-the-Counter Market," Journal of Financial and Quantitative Analysis, VII (June 1972).