Dealer Inventory Behavior: An Empirical Investigation of NASDAQ Stocks

by

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I. Introduction

Important elements in almost every financial market are the dealers who stand ready to trade for their own accounts and thereby provide to the public the convenience of being able to trade immediately. Today the structure of securities markets is in the process of major change; and as part of this restructuring, a major issue is the way in which dealer services ought to be provided and what the appropriate balance between regulation and competition ought to be.

In this paper the quality of dealer services in the over-the-counter (OTC) market as reflected in the nature and degree of dealer inventory changes is examined using NASDAQ (National Association of Securities Dealers Automated Quotation) system data on closing prices and dealer purchases and sales for each stock for each of six trading days between July 9, 1973 (Monday) and July 16, 1973. Appendix I contains a detailed discussion of the data.[1]

The most extensive earlier study of the quality of dealer services was carried out by Seymour Smidt in Chapter 12 of the Institutional Investor Study (IIS) where he examined the inventory behavior of NYSE specialists and other dealers in NYSE stocks.[2] His principal finding for specialist behavior in the aggregate is that it is "apparently stabilizing" by which is meant that specialists tend to buy stocks on price declines and sell stocks on price increases. This is consistent with less sophisticated analyses of specialist behavior such as the tick test.[3]

This study finds that the inventory behavior of OTC dealers is consistent with an underlying model of rational economic behavior and is similar to the "apparently stabilizing" characteristic of NYSE specialists. Since the specialist possesses a monopoly franchise and is thought to be highly regulated whereas the OTC dealer is prohibited from such a franchise and is relatively unregulated, these findings suggest either that regulation is relatively ineffective in changing behavior or that it is consistent with the economic interest of dealers.

In the next section a model of dealer inventory behavior is presented. Section III carries out regression tests which follow from the model of Section II. In Section IV the data are analyzed according to Smidt's cross tabulation procedures and are compared with his findings. The conclusions are presented in Section V.

II. The Model

In the process of taking inventory positions for their own accounts, dealers incur three costs - holding costs, order costs, and information costs.[4] An expression for holding costs can be derived by using the Sharpe-Lintner capital asset pricing model and 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 non-optimal in terms of his preferences and the proper diversification. By taking on inventory positions,the dealer incurs holding costs he would not otherwise incur and for which he requires compensation. For an individual dealer specializing in a single stock, it can be shown that the dealer's marginal holding cost of changing his dollar inventory position is given approximately by

$$\frac{z\sigma^2\tau}{W} Q$$

where

Q = Dollar value of dealer's holdings of the stock. $Q > 0$ is a long position. $Q < 0$ is a short position.

z = Dealer's coefficient of relative risk aversion.

W = Dollar wealth of dealer devoted to making a market in the stock.

τ = Number of time periods stock is expected to be held.

σ^2 = variance of return of stock per time period.

Thus the dollar cost per dollar inventory change - i.e., the percentage cost - depends on the initial inventory level, Q, the dealer's wealth, relative risk aversion and expected holding period, and on the risk of the stock. If the dealer is able to maintain a diversified portfolio the systematic portion of total risk would be substituted for σ^2.

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 function of the size of the transaction. Information costs arise when the public trades because it has information not available to the dealer. Since the dealer is unable to determine which traders have information, he must charge an amount on each transaction which reflects the expected value of the adverse information possessed by those that trade with him. This is assumed to be a constant percentage amount, a, a fraction > 0 if the dealer goes short and < 0 if the dealer goes long.[5]

It is assumed that the dealer operates under competition in which case marginal cost is equal to price. However, dealers typically have two price quotations - the proportional deviation of the bid price from the equilibrium price and the proportional deviation of the ask price from the equilibrium price. The equilibrium price is the price the dealer believes to be "correct" based on the information currently available to him. If the dealer's information is the same as the general public's (which we shall later see appears to be the case), his equilibrium price is the same as the equilibrium price based on the information publicly available. The term a reflects the dealer's expectation that an investor with non-public information, unavailable to the dealer, may, in the next moment, trade with him. The two equilibrium quotation equations for transactions of dollar size T for a dealer with initial inventory of Q are given by

$$\frac{P^e - P^b}{P^e} = A[Q + T] - a^b + \frac{M^b}{T} \qquad (2)$$

$$\frac{P^e - P^a}{P^e} = A[Q - T] - a^a + \frac{M^a}{-T} \qquad (3)$$

where

b refers to bid price, the case in which the dealer buys T dollars of stock.

a refers to ask price, the case in which the dealer sells T dollars of stock.

$A = \frac{z\sigma^2 \tau}{W}$

Assuming $a^b = -a^a$ and $M^b = M^a$, averaging (2) and (3), and solving for Q yields

$$Q = \frac{1}{A}\left[\frac{P^e - P}{P^e}\right] \qquad (4)$$

where

$P = \frac{P^a + P^b}{2}$, the average of bid and ask prices, henceforth termed the market price.

Equation (4) will be interpreted as an industry supply function which means that Q now refers to the inventory position of all dealers in a particular stock taken together and $\frac{1}{A}$ refers to the sum of individual dealer's $\frac{1}{A}$'s. It is assumed P^e are the same for all dealers and that arbitrage keeps P the same for all dealers.

Since data on inventory levels are not available in the study and since past analyses concentrated on inventory changes, it is necessary and desirable to take the first difference in (4):

$$Q_t - Q_{t-1} = -\frac{1}{A}\left[\frac{P_t}{P^e_t} - \frac{P_{t-1}}{P^e_{t-1}}\right] \qquad (5)$$

which says that dealers increase their long positions (or decrease their short positions) if the market price falls relative to the equilibrium price. They decrease their long position (or increase their short position) if the market price rises relative to the equilibrium price.

One can define stabilizing behavior by dealers as trading which tends to keep market prices as close as possible to equilibrium prices. Because the equilibrium price in (5) is not observable, such a definition is, however, consistent with different observable patterns of behavior. On the one hand, if the dealer acts passively and assumes an unchanged equilibrium price, he will tend to accumulate inventory on market price declines and decumulate inventory on market prices increases. On the other hand if the dealer acts actively because he believes the equilibrium price has changed, inventory change and market price change would be positively related: If the dealer believes the equilibrium price has risen he will raise his bid-ask quotation in order to accumulate inventory; if he believes the equilibrium price has fallen he will lower his bid-ask quotation in order to decumulate inventory. To the extent that the dealer has the same information as the general public, he will tend to act in a passive manner.

Equation (5) represents the supply side, i.e., the inventory response of dealer to market price changes. It is assumed that most demand is randomly distributed around zero at the dealer's equilibrium price so that estimates of (5), are, in fact, possible. Some of the public's demand to trade between t-1 and t can, however, be induced by dealer's quotations at t-1. If dealers set a market price different from the equilibrium price, which they will do if their inventory is non-zero, trading by the public will be induced. For example consider the passive dealer and suppose that in the first period the dealer purchases stock (at P_t^b). At the end of the period the average price (P_t) will be set below the equilibrium price (P^e) in order to create incentives for the public to buy this stock rather than some other stock. In the absence of data on the prior period's inventory level the best alternative variable to reflect this tendency for inventory levels to return to zero is the prior period's inventory change:

$$\Delta Q_t = -\frac{1}{A}\left[\frac{P_t}{P_t^e} - \frac{P_{t-1}}{P_{t-1}^e}\right] - b\Delta Q_{t-1} \qquad (6)$$

where the sign on ΔQ_{t-1} is expected to be negative. A similar negative relation is to be expected for the active dealer who believes the equilibrium price is wrong if the equilibrium price in the following period changes in the direction anticipated by the dealer. Simply put, (6) says that even if the ratio $\frac{P_t}{P^e_t}$ remains unchanged inventory changes will be observed because $P_t \neq P^e_t$.

III. Empirical Tests

A. Operational model

In order to make (6) operational, a substitution for the unobservable P^e must be made. Two approaches are taken here. The naive model assumes $P_t^e = P_{t-1}$, that the dealers' estimate of today's equilibrium price is last period's market price. In that case (6) becomes

$$\Delta Q_t = -\frac{1}{A}\left[r_t - r_{t-1}\right] - b\Delta Q_{t-1}, \qquad (7)$$

where

$$r_t = P_t/P_{t-1}.$$

The perfect foresight model assumes $P_t^e = P_{t+1}$, that the dealers' estimate of today's equilibrium price is tomorrow's market price. Under this model (6) becomes

$$\Delta Q_t = \frac{1}{A}\left[\frac{P_{t+1} - P_t}{P_{t+1}} - \frac{P_t - P_{t-1}}{P_t}\right] - b\Delta Q_t. \qquad (8)$$

Since a price change relative to the initial price is very close to the same price change relative to the final price when one is dealing with daily intervals, one can write

$$\Delta Q_t = -\frac{1}{A}\left[r_t - r_{t+1}\right] - b\Delta Q_{t-1} \qquad (9)$$

which has more intuitive appeal than (8). It is unrealistic to expect the perfect foresight model to hold exactly since one would not expect dealers to be able exactly to foresee prices. They may, however, have some forecasting ability in which case the coefficient on r_{t+1} would be positive, although probably less than $\frac{1}{A}$. If dealers possess poor forecasting ability, i.e., if investors trading with them are superior forecasters, the coefficient of r_{t+1} would be negative.

B. Empirical results

Using 10,260 stock-days as the units of observation, equations (7) and (9) are estimated in unconstrained form with the following results:[6]

Naive:

$$\Delta Q_{i,t} = \underset{(4.5)}{84.75} \; \underset{(-7.96)}{-109.29}\, r_{i,t} + \underset{(1.77)}{24.29}\, r_{i,t-1} - \underset{(-11.0)}{.105}\, \Delta Q_{i,t-1} \qquad \text{adj } r^2 = .0172 \quad DW = 1.829$$

Perfect Foresight:

$$\Delta Q_{i,t} = \underset{(7.3)}{141.11} \; \underset{(-6.85)}{-96.47}\, r_{i,t} - \underset{(-3.15)}{44.47}\, r_{i,t+1} - \underset{(12.8)}{.127}\, \Delta Q_{i,t-1} \qquad \text{adj } r^2 = .0206 \quad DW = 2.021$$

where "i" refers to the stock and "t" refers to the day. Numbers in parentheses are t statistics; DW = Durbin-Watson statistic. Since $r_{i,t}$ is a price relative, this variable will fluctuate around 1. The dimensions of $\Delta Q_{i,t}$ are $1,000. The same regressions were run using returns relative to the market and eliminating observations with $\Delta Q_{i,t} = 0$ (about 30% of all observations). The procedure and the results, which are substantially the same, are reported in Appendix II.

The coefficients of $r_{i,t}$ and $\Delta Q_{i,t-1}$ are statistically significant[7] and of approximately the same magnitude in both models. The negative coefficient on $r_{i,t}$, the inventory responsiveness coefficient, suggests that dealers are passive and tend to assume that the last price is "right." They tend to buy a stock when its market price falls and tend to sell a stock when its market price

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generally thought to be desirable ("stabilizing") because [illegible]ens p[illegible] fluctuations. However, dampened price fluctuations are desirable onl[illegible] sofar as the last price is in fact the right price.

The negative coefficient for ΔQ_{t-1} implies that there is a tendency for inventory levels to return toward zero; that is, in the absence of any price changes, bid-ask spreads are set to encourage trading in a direction which reduces the dealer's inventory exposure. The magnitude of the coefficent implies that only between 10% and 13% of an initial inventory change is reversed during the next day; or, in other words that it takes in the neighborhood of 10 to 8 days to undo a position in the average NASDAQ stock.

The perfect foresight model is preferred over the naive model because it has greater explanatory power (its r^2 is 20% higher). The coefficient of $r_{i,t-1}$ in the naive model has the sign predicted by (7) but is not statistically significant. It appears that dealers pay relatively little attention to yesterday's price change. The coefficient of $r_{i,t+1}$ in the perfect foresight model is statistically significant but has an unexpected negative sign. This suggests that the closing price on day t is not, in fact, the "right" price. Prices tend to fall the day after investors sell stock to the dealer and tend to rise the day after investors buy stock from the dealer. Investors who trade appear to have more information than the dealer and tend to benefit at his expense. The dealer, on the other hand, can be viewed as having inferior (not neutral) forecasting ability.[8]

Why is the dealer unable to learn and eliminate the systematic profits that certain informed investors appear to be making at his expense? A bona fide dealer must stand ready to trade (100 shares on NASDAQ) at his quote which is set on the basis of the information available to the dealer. In the absence of superior information, the dealer must lose to informed traders. That such informed traders exist is supported by the significant negative coefficient on r_{t+1}. Dealer losses must be recouped (at the expense of other investors) by setting a wide enough spread if dealers are expected to stay in business.

Although all regression coefficients are statistically significant by the usual standards, only a small fraction of the total variation in inventory changes is explained by the regression equation. This should not detract from the significance of these findings but should point out that there are many factors which are unaccounted for in this version of the model. Some of the factors are related to the characteristics of the data. Since price data have been collected only for the end of each day, changes in the equilibrium price during the day can bring about the appearance of "non-stabiliing" behavior where the dealer buys on price increases and sells on price decreases. For example, suppose dealers buy 1,000 shares during the morning at \$10, down from yesterday's closing price of \$11. During the afternoon new information causes the price to rise to \$12 on one sale by dealers of 100 shares. The daily price change is +9.1%, and the inventory change is + 900 shares, which appears to be "non-stabilizing." In fact, every trade was "stabilizing." Another difficulty with the NASDAQ data is the fact that bid-ask spreads are not available for each dealer. As a result we have relied on the RBA (median ask, median bid). This can cause difficulties because individual dealers that trade can change their spreads without affecting the RBA. Furthermore since dealers are given equal weight in arriving at the RBA while inventory changes will vary greatly greatly according to dealer size and other variables, it is possible for aggregate inventory and the RBA to change in the same direction even though most trading is of a "stabilizing" nature.

Other factors are related to the variables underlying the coefficient, $\frac{1}{A}$, in (6), which are not in the regressions, as well as characteristics of the public and the markets which are captured neither in the regressions nor the theoretical model.

To summarize: The findings, which are statistically significant, are consistent with the proposition that dealers believe in the random walk - that the best estimate of tomorrow's price is today's price and that the history of prices is not useful information. Dealers behave passively, selling on price increases and buying on price declines; and do not distinguish fully between liquidity traders (who do not possess information) and information traders. A certain number of investors possessing information do, in fact, exist because there is a tendency for dealers to take inventory losses with respect to the next day's price changes. Presumably bid-ask spreads are large enough to offset these losses. There is a strong tendency for inventory levels to return to normal.

C. Analysis of coefficients

The underlying model of dealer behavior suggests that the coefficient of $r_{i,t}$ is given by $\frac{1}{A} = \frac{W}{z\sigma^2{}_\tau}$, variables which reflect dealer's wealth and risk aversion, and the riskiness of the stock. Since one would expect more dealer wealth to be devoted to high volume stocks than to low volume stocks, one would expect this variable to increase as the volume class increases. In addition, one can make some rough calculations of the average wealth devoted to making markets in stocks in each volume category if one is willing to accept estimates of z, σ^2, and τ; and the reasonableness of the resulting wealth figure can be a check on the reasonableness of the dealer responsiveness coefficient estimated in the regression equation.

Table 1 gives regression results for the perfect foresight model for 3 volume classes. Volume classes are defined over average daily volume based on data for 1 day per week in the period 4/3/72-3/27/73, 5/2/73-7/17/73. As expected, the coefficient of $r_{i,t}$ increases for higher volume classes. A stock with a 5% positive price change today ($r_{i,t}$ = 1.05), no price change tomorrow ($r_{i,t+1}$ = 1) and no inventory change yesterday ($\Delta Q_{i,t-1}$ = 0) would have the following inventory changes in the three volume classes: -$810 (low volume), -$1,660 (mid volume), -$11,090 (high volume). With a 5% negative price change ($r_{i,t}$ = .95) and other assumptions, the same inventory changes would be $730, $1980, $14690 respectively in the three volume classes.

Estimates of dealer wealth require estimates of z, σ^2, τ. Friend and Blume have provided us an estimate for z of 2.[9] An estimate of dealer's holding period in each volume category is given by the reciprocal of the coefficient of ΔQ_{t-1}. However, since this coefficient is significant only for the high volume category, that estimate (8 days) is used in the high volume category and the holding period for low volume and middle volume stock is arbitrarily set at 16 and 12 days respectively. The daily variance for each stock category is calculated over the five day period covered by the data. The calculations follow:

	Volume Category			
	Low	Middle	High	All
z	2	2	2	2
τ (Days)	16	12	8	12
$\sigma^2(r_i)$/day	.00131	.00116	.00118	.00122
$-a_1$	15.31	36.37	257.8	96.47
W_i(in $1000) = $(-a_1)[\sigma^2(r_i)](\tau)(z)$	.6418	1.013	4.867	2.825

The wealth of all dealers devoted to a single stock on a typical day is estimated at $642 for low volume stocks, $1013 for middle volume stocks, and $4867 for high volume stocks. These figures appear quite low, but they are surprisingly consistent with estimates of dealer inventory investment made elsewhere.[10] According to the findings there, dealers invested $3793 per day in the median stock. This is consistent with the typical equity investment of $2825 because the dealer has considerable borrowing power which can raise his available funds several fold over his own equity.[11] The consistency of these findings therefore lends support to the reasonableness of the estimated inventory responsiveness coefficient.

IV. Comparison of NASDAQ and NYSE Dealer Behavior

In Chapter 12 of the Institutional Investory Study, Seymour Smidt, using data for NYSE specialist units, carried out cross tabulations of (9) (excluding the variable ΔQ_{t-1}). The principal cross classification is reproduced here as Table 2.[12] For the sake of comparison, exactly the same cross tabulation was produced in Table 3 using the NASDAQ data. The basic unit of observations is the stock-day and rates of return are after subtraction of the market return (S&P Industrial Index or NASDAQ Composite Index). The IIS data cover 93 stocks for the trading days between July 1, 1968 and September 30, 1969. The NASDAQ data were described earlier. The Smidt analysis examines inventory changes of the single specialist in a stock whereas this study examines the aggregate inventory change of all dealers in a stock. (The number of dealers listed varies from 2 to over 20 per stock.)

The results of the two cross tabulations are remarkably similar in spite of the different stocks and time periods covered. Smidt's description of the NYSE data apply equally well to the NASDAQ data as a comparison of the row averages will show:

> The inventory change on the given day is dominated mainly by the price change on that day. Regardless of the amount of price change on the following day, if the price change on the given day was positive, NYSE specialist units sold stock on the average. Similarly, when the price declined on the given day, they bought stock on average.[13]

Since the IIS considered the larger NYSE stocks, dollar amounts are greater (by about a factor of ten) as compared with the average of all NASDAQ stocks, but the nature of the relationship between price change and inventory change on the same day is the same. We know from the regression analyses that the NASDAQ relationship is statistically significant. It is apparent from Table 2 and 3 that the NYSE relationship is as strong or stronger.

The similarity of results for relatively unregulated OTC dealers and more highly regulated specialists suggest that dealers respond on the basis of the underlying economic principles reflected in (9) and not on the basis of regulatory admonitions. The most striking characteristic of this behavior is the passive reaction to price changes, which was also observed in the regression results.

The IIS table, and the NASDAQ table to a lesser extent, show that inventory changes tend to be in a direction opposite to the following day's price change (examine the column averages). In other words (as described earlier) specialists and NASDAQ dealers are unable to anticipate price changes as well as some members of the public. They thereby lose money to information traders, losses which are presumably offset by income from the spread.

It is important to reiterate that, while the observed tendency in both listed and OTC stocks is for dealers to trade opposite the price change on the same day, the relationship is by no means perfect. As discussed earlier this is due in part to the limitations of the data and in part to the limitations of the model. The results do not deny the possibility that certain NASDAQ dealers or NYSE specialists are doing a poor job and are less responsive than other dealers.

One crude basis of determining whether dealers in one market are inferior to those in another is by calculating the percentage of times in which inventory-price change combinations are contrary to the "stabilizing" tendency observed, i.e., where inventory change and price change are in the same direction.

Table 4 presents the fraction of stock-days with "non-stabilizing" inventory changes by volume category and by absolute price change (relative to the market). The price change category is defined as in the IIS for the sake of comparability. The first part of the table gives the proportion of non-stabilizing inventory changes among all stock days. The second part of the table considers only stock days in which at least two-thirds of the listed dealers had some trading. This classification is used because the RBA is likely to be less representative when only a small fraction of the dealers are active.

Both parts of the table show that "non-stabilizing" behavior is less frequent the larger is the absolute price change. This is consistent with the hypothesis that larger price changes are "more exogenous" to the dealer. There is also a tendency in the first part of the table for "non-stabilizing" inventory changes to decrease as volume increases. This may be due to the non-representativeness of the RBA since this tendency is eliminated in the second part of the table.

The IIS found that 10% to 42% of the specialists' inventory changes were "non-stabilizing," the percentage depending on the volume category, the price change category, the extent of institutional interest, and the inventory activity of the specialist.[14]

Comparisons between the NYSE and NASDAQ are not readily made because of the much greater NYSE volume and the smaller price changes in the NYSE. The IIS also omits data on the 0-1% price change category into which a larger fraction of "non-stabilizing" NYSE trades are likely to fall. Comparisons at the extreme price change and volume categories suggest similar behavior by specialists and NASDAQ dealers. In the high NYSE volume category (top 20%) and the top price change category (5% or more), specialists were "destabilizing" an average of about 24%. This compares with 20% in the high volume (top 30%) and top price change (5% or more) category for NASDAQ dealers. In the same volume categories and a price change category of 1%-4.99%, specialists were "destabilizing" an average of about 35% of the time. This compares with 46% for NASDAQ dealers. Since "destabilizing" transactions decline with greater volume and greater price change, the percentage of such transactions tends to be biased upward on NASDAQ when compared to NYSE transactions. This is due to the fact that the NASDAQ high volume category includes 30% of the stock days rather than 20% on the NYSE and to the fact that larger price changes are probably less unusual on the more volatile NASDAQ market and therefore result in a weaker dealer response.

One cannot conclude from these comparisons that NASDAQ dealer responsiveness is different from that of NYSE specialists.

V. Summary and Conclusions

1. This paper presents and tests a model of dealer inventory response. The estimated inventory responsiveness coefficient is statistically significant and its magnitude is consistent with reasonable values of underlying variables which, it is hypothesized, determine the coefficient.

2. The sign of the inventory responsiveness coefficient indicates that dealers tend to be passive and acquire shares when prices fall and sell shares when prices rise. This type of behavior is sometimes termed "stabilizing".

3. Dealer inventories tend to increase on days prior to price declines and tend to decrease on days prior to price increases; that is, inventory changes tend to be "destabilizing" with respect to future price changes. This implies that a fraction of the public trade on superior information and that dealers tend to lose money to such information traders.

4. There is a strong tendency for dealer inventory levels to return to normal--presumably zero. The implied typical inventory holding period is on the order of 8-10 trading days.

5. Comparison of NASDAQ dealers and NYSE specialists shows that the pattern of inventory responsiveness is very much the same for the two. This suggests that both act in accord with the underlying economic model and that differential regulation has little effect on typical inventory responsiveness.

6. This finding does not obviate the possibility that individual dealers or specialists behave in atypical or undesireable ways, and that the extent of such atypical behavior might depend on the degree of public regulation of dealer activities. An exhaustive comparative study of deviations from normal behavior was not possible. However, it was possible to compare the frequency of non-stabilizing transactions in which price change and inventory change on a given day are in the same, rather than opposite, direction. One could not conclude that NASDAQ dealers had more non-stabilizing activity than NYSE specialists.

Table 1

$$\Delta Q_{i,t} = a_o + a_1 r_{i,t} + a_2 r_{i,t+1} + a_3 \Delta Q_{i,t-1}$$

	a_o (t)	a_1 (t)	a_2 (t)	a_3 (t)	adj r^2	OBS	$\%\Delta Q_{i,t}=0$	DW
Low 30% volume	18.98 (12.45)	-15.31 (-13.87)	-3.71 (-3.18)	-.0263 (-1.59)	.0644	3072	55%	1.980
Mid 40% volume	53.40 (7.98)	-36.37 (-7.52)	-16.87 (-3.59)	.0311 (1.47)	.0174	4104	28%	2.028
High 30% volume	372.2 (5.84)	-257.8 (-5.47)	-112.6 (-2.42)	-.1316 (-7.33)	.0269	3084	8%	1.986

Table 2

AVERAGE NET INVENTORY CHANGE OF NYSE SPECIALISTS, ON GIVEN DAY BY CHANGE IN PRICE OF STOCK RELATIVE TO S&P ON THE GIVEN DAY AND THE FOLLOWING DAY
(Thousands of Dollars)

Percent Change in Price of Stock Relative to S&P on the Given Day	Percent Change in Price of Stock Relative to S&P on the Following Day							
	-5.0 or less	-4.9 to -3.0	-2.9 to -1.0	-0.9 to 0.9	1.0 to 2.9	3.0 to 4.9	5.0 or over	Row Average
5.0 or over	-74	- 12	-131	- 67	- 89	-106	-172	-90
3.0 to 4.9	-75	- 37	- 73	-104	-105	- 61	- 58	-87
1.0 to 2.9	-13	- 27	- 25	- 59	- 73	- 52	- 5	-51
-0.9 to 0.9	5	6	10	1	- 2	0	- 15	2
-2.9 to -1.0	35	24	37	53	38	17	- 40	42
-4.9 to -3.0	144	98	144	91	72	68	- 31	88
-5.0 or less	67	166	101	185	131	86	154	137
Column Average	22	10	8	1	- 10	- 12	- 24	

Source: App. B, table XIII-B-14.

Table 3

Average Net $ Inventory Change of NASDAQ Dealers and Number of Observations on a Given Day by Change in Price of Stock Relative to NASDAQ Composite Index on the Given Day and the Following Day[1]

% Change in Price of Stock Relative to NASDAQ Index on Given Day	% Change in Price of Stock Relative to NASDAQ Index on Following Day							
	-5.0 or less	-4.99 to -3.0	-2.99 to -1.0	-.99 to +.99	1.0 to 2.99	3.0 to 4.99	5.0 or more	Row Average
5.0 or more	-271.88 / 40	-32.01 / 27	57.54 / 158	-88.30 / 109	-135.73 / 127	-197.90 / 50	-134.81 / 113	-87.56 / 624
3.0 to 4.99	-17.02 / 14	7.14 / 18	-15.43 / 125	-106.83 / 91	-130.15 / 131	57.91 / 29	-80.00 / 50	-67.97 / 458
1.0 to 2.99	3.45 / 102	-12.65 / 87	2.16 / 1490	-12.43 / 287	-70.63 / 248	-99.07 / 90	-42.98 / 110	13.37 / 2414
-.99 to +.99	-14.60 / 42	20.95 / 90	8.71 / 323	23.27 / 335	-10.80 / 1452	-107.11 / 115	-19.90 / 110	07.42 / 2467
-2.99 to -1.0	12.18 / 141	14.41 / 105	20.97 / 1317	-10.17 / 1450	68.86 / 273	-66.97 / 135	-28.58 / 156	5.98 / 3577
-4.99 to -3.0	32.23 / 11	51.54 / 15	109.37 / 118	7.13 / 95	20.06 / 66	11.35 / 13	120.32 / 20	55.00 / 338
-5.0 or less	23.44 / 37	2118.17 / 10	30.34 / 105	30.38 / 92	31.04 / 66	62.88 / 21	-.32 / 51	82.15 / 382
Column Average	-21.80 / 387	66.81 / 352	15.65 / 3636	-10.73 / 2459	-19.17 / 2363	-81.73 / 453	-46.26 / 610	-6.33 / 10260

[1] $ inventory change, in upper left of cell, is in $100. Number of observations in cell is shown in lower right of cell.

Table 4

Proportion "Non-Stabilizing" Inventory Changes

Absolute Price Change Category $\lvert R_{i,t} - R_{m,t} \rvert$	Volume Category: Low 30%	Middle 40%	High 30%	All
All Stock Days				
G. T. 5%	$\frac{94}{227} = .41$	$\frac{131}{443} = .30$	$\frac{67}{336} = .20$	$\frac{292}{1006} = .29$
3% to 4.99%	$\frac{67}{109} = .61$	$\frac{118}{360} = .33$	$\frac{111}{327} = .34$	$\frac{296}{796} = .37$
1% to 2.99%	$\frac{1670}{2053} = .81$	$\frac{1507}{2390} = .63$	$\frac{746}{1548} = .48$	$\frac{3923}{5991} = .65$
0% to .99%	$\frac{558}{687} = .81$	$\frac{515}{911} = .57$	$\frac{453}{869} = .52$	$\frac{1526}{2467} = .62$
All	$\frac{2389}{3076} = .78$	$\frac{2271}{4104} = .55$	$\frac{1377}{3080} = .45$	$\frac{6037}{10260} = .59$
Stock Days in which at Least 2/3 of Dealers Traded				
G.T. 5%	$\frac{11}{58} = .19$	$\frac{39}{193} = .20$	$\frac{53}{270} = .20$	$\frac{103}{521} = .20$
3% to 4.99%	$\frac{4}{8} = .50$	$\frac{25}{101} = .25$	$\frac{72}{219} = .33$	$\frac{101}{328} = .31$
1% to 2.99%	$\frac{29}{55} = .53$	$\frac{118}{273} = .43$	$\frac{228}{541} = .42$	$\frac{375}{869} = .43$
0% to .99%	$\frac{7}{16} = .44$	$\frac{39}{106} = .37$	$\frac{161}{320} = .50$	$\frac{207}{442} = .51$
All	$\frac{51}{137} = .37$	$\frac{221}{673} = .33$	$\frac{514}{1350} = .38$	$\frac{786}{2160} = .36$

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 RBA is the median ask and the median bid; and the resulting spread tends to be larger than the inside quotation which is the best bid and best ask. Since this study is concerned with price changes and will examine only aggregate activity of all dealers in a stock, the RBA is satisfactory although not ideal. 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 used 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.

Appendix II: Additional Tests of the Naive (7) and Perfect Foresight (9) Models

1. Returns taken relative to the market

Let

$$r^*_{i,t} = r_{i,t} - \hat{r}_{i,t}$$

$$\hat{r}_{i,t} = \hat{K}_i + \hat{B}_i r_{m,t}$$

$r_{m,t}$ = ratio of the NASDAQ composite index on successive days

$\hat{B}_i = \dfrac{\mathrm{Cov}(r_{i,t}\ r_{m,t})}{\sigma^2(r_{m,t})}$. Estimated using weekly data for the period 4/3/72 - 3/27/73 and 5/2/73 - 7/17/73. See Appendix I: The Data.

$\hat{K}_i$ = is chosen such that $\sum_{t=2}^{6} (r_{i,t} - \hat{r}_{i,t}) = 0$, in other words, each daily return is taken relative to the 5 day average return for the stock taking account of its "long-run" (about 1 year) β_i. Use of a long-run constant term resulted in very high correlations between r^*_t and r^*_{t-1}. This was due to the fact that stock which had high returns in the past and behaved normally in the sample period exhibited successive negative residuals. Similarly stocks which had been poor past performers tended to exhibit successive positive residuals.

Then

$$\Delta Q_{i,t} = \underset{(-1.56)}{-.7467} \quad \underset{(-3.79)}{-57.14\, r^*_{i,t}} \quad \underset{(2.29)}{+34.96\, r^*_{i,t-1}} \quad \underset{(-10.85)}{-.103\Delta Q_{i,t-1}} \qquad \begin{array}{ll} \text{adj } r^2 & =.0133 \\ \text{DW} & =1.829 \end{array}$$

$$\Delta Q_{i,t} = \underset{(-1.04)}{-.5104} \quad \underset{(-4.29)}{-67.12\, r^*_{i,t}} \quad \underset{(-3.42)}{-53.00\, r^*_{i,t+1}} \quad \underset{(-12.62)}{-.125\Delta Q_{i,t-1}} \qquad \begin{array}{ll} \text{adj } r^2 & =.0172 \\ \text{DW} & =2.021 \end{array}$$

The principal difference between the use of r and r^* is in the constant term and this is due to the different dimensions of the two variables.

2. Elimination of observations with $\Delta Q_{i,t} = 0$

Thirty percent of the observations have $\Delta Q_{i,t} = 0$. Exclusion of these observations produces the following results for the perfect foresight model:

$$\Delta Q_{i,t} = \underset{(6.31)}{157.39} \quad \underset{(-5.82)}{-102.85\, r_{i,t}} \quad \underset{(-2.83)}{-54.25\, r_{i,t+1}} \quad \underset{(-10.73)}{-.127\Delta Q_{i,t-1}} \qquad \begin{array}{ll} \text{adj } r^2 & =.0210 \\ \text{DW} & =2.044 \end{array}$$

As one would expect, the constant and the coefficients of the return variables are larger. Their significance is somewhat lower.

The same regression was not carried out for the naive model since the perfect foresight model is superior and is the basis for most of the discussion in the paper.

Footnotes

*Associate Professor of Finance, University of Pennsylvania. The author gratefully acknowledges the financial support of the University of Pennsylvania Law School Center for the Study of Financial Institutions and the assistance of the Rodney White Center for Financial Research. Bert Tyler of the White Center Research Fellow, provided general research assistance.

[1] I am grateful to the NASD for making these data available to me; and I wish, in particular, to thank John Hodges and Paul Luther for their assistance. Dealer identities were disguised by the NASD.

[2] U.S. Securities and Exchange Commission, Institutional Investor Study Report of the SEC. (IIS), Volume 4.

[3] For a description and discussion of the tick test see S. Robbins, The Securities Market, pp. 196-199.

[4] These costs are developed in H.R. Stoll, "The Economics of Dealers in Securities Markets." Mimeo.

[5] Information costs were first discussed in W. Bagehot (pseud.), "The Only Game in Town," Financial Analysts Journal, March/April 1971. For a theoretical model explaining why the dealer loses, see J. Jaffee and R. Winkler, " Optimal Speculation Against a Market-Maker." Mimeo.

[6] There are (5 days) . (2052 stocks) = 10260 stock days in the sample. (One day of the original 6 is dropped in calculating returns.) Means and standard deviations for all variables are: $\Delta Q_{i,t}$(\$1000) = −.6332 (50.05)

$\Delta Q_{i,t-1}$(\$1000) = −.5845 (49.44); r_{it} = 1.00631 (.0349); $r_{i,t+1}$ = 1.0060 (.0348).

[7] Using standard statistical tests which assume normality. The validity of the statistic depends as well on the independence of residuals. An indication that residuals are independent is given by examining the Durbin-Watson statistic. The regression results reported in the body of the paper are based on a data organization which reads in turn the five observations for each stock in the order in which the stocks appear (alphabetical). The D-W statistic cannot reject independence. The regressions in Table 1 are based on a data organization which ranks stocks on volume. Again, the D-W statistic cannot reject independence.

[8] It might be argued that the dealer induces the price change between t and t+1 in order to dispose of the position acquired between t-1 and t. This is not correct. The price at the end of day t reflects the cost to the dealer of taking inventory position. If the dealer believed it necessary to change prices tomorrow in order to dispose of his inventory, that price change would in fact have occurred today.

For example, if the dealer acquired 100 shared during the day, both bid and ask prices will be lower at the end of the dya (given P^e) than at the beginning, and $r_t < 0$. The fact that both bid and ask have fallen will provide incentives for the public to buy rather than to sell this particular stock during the next day. If there is no change in P^e, dealer sales out of inventory during the next day would cause him to raise his bid and ask with the result that $r_{t+1} > 0$. We , in fact, observe that $r_{t+1} < 0$ when $\Delta Q_t > 0$.

[9] Friend and Blume, "The Demand for Risky Assets by Households and Other Investors," White Center Paper, No. 1-74.

[10] In H.R. Stoll, "A Note on _Ex Ante_ and _Ex Post_ Revenues of Dealers on NASDAQ," mimeo.

[11] The accounting identity for the dealer's balance sheet is given by

$$A = L + S + W \qquad (F.1)$$

where

A = assets (the securities he carries)

L = liabilities (i.e., bank loans)

S = subordinated loans (counted toward capital by SEC)

W = dealer's equity

The SEC's definition of net capital is

$$C - A(1-h) - L \qquad (F.2)$$

where

h - % "haircut" or deduction from market value of assets to reflect their marketability.

The net capital requirement is

$$\frac{L}{C} \leq R, \qquad (F.3)$$

where R is a ratio sepcified by the SEC or self-regulatory body.

Subordinated loans are here assumed to be some multiple of dealer equity:

$$S = kW \qquad (F.4)$$

Using (F.1), (F.2) and (F.4) to substitute in (F.3) one gets

$$\frac{A - (1+k)W}{-hA + (1+k)W} \leq R.$$

At the point of equality, i.e., maximum borrowing by the dealer

$$\frac{A}{W} = \frac{(1+k) \quad (1+R)}{1+hR}$$

If R = 15, h = .3, and k = 1, $\frac{A}{W}$ = 5.8, and a dollar of dealer equity can support 5.8 dollars of stock in inventory.

[12] From _IIS_, _op. cit._, p. 1876.

[13] _IIS_, _op. cit._, p. 1877

[14] _IIS_, _op. cit._, pp. 1873-1874.