Speed of Execution of Market Order Trades and Specialists' Inventory Risk-Management at the NYSE

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Abstract

We show that the execution of market orders on the New-York Stock Exchange (NYSE) is not instantaneous upon reception of the orders as is often expected. From traders' point of view, delays in execution of market orders are more costly compared to limit orders as the execution price is uncertain in the case of market orders. Since such trade orders are taking place instead of limit orders, presumably for arbitrage purposes, where the success of the arbitrage requires that several transactions be executed simultaneously, the question of the speed of execution of market orders is of utmost importance. From the specialist point of view, execution delay may be a decision tool that he might use to mitigate information advantage of informed traders. Glosten and Milgrom (1985) have argued that the determination of the quotes serves as a defense mechanism when face trade orders that are placed by informed traders. However, the NYSE evaluates specialists' performance, in part, on 'price continuation', implying that the specialist is evaluated on the bid-offer spread. More over, the specialist's ability to affect this spread has been reduced drastically on February 3rd 2003 when quotes on the NYSE stocks have been automated. Delaying of executions may enable the specialist to learn better whether the order flow is originating from an informed trader, thus revising his probability of informed trader orders. Consequently affect his decision whether to participate in the trade as supplying the counter side of the order to provide liquidity and insures 'an orderly market'. Also, delaying an execution increases the probability of a counter side order to appear, which can be matched with orders submitted. Thus saving the specialist from trading on own account.

It is shown that delays in the execution of market orders are significant and that they depend on the size of the flow of the orders, the "surprise" factor in the order, and that they vary between the different specialists. These delays are closely correlated with the bid-offer spread and with adjustments in the inventory levels of the specialists, and can be considered as important factors in their inventory risk management system.

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I. Introduction

The specialist activities on the New-York Stock Exchange (NYSE) were subject to research for several decades that primarily focused on two issues: The determination of the bid-offer spread and of the level of stock inventory that the specialist holds and their adjustments.[1] Whereas the bid-offer spreads and the inventory levels the specialists hold constitute a dynamic process over time (see Easley et al 1996), they are often treated in the literature as static and their time dimension is overlooked. In a dynamic process, time can serve as a decision tool to be used to learn the evolution of information based trades, and to better manage the specialist's own inventory. The current literature however, fails to link this important variable into the overall framework of the specialist's activities. Since a large portion of the transactions of trades are made for purposes of arbitrage, where the success of the arbitrage requires that several transactions be executed simultaneously, the question of the speed of market orders execution is of utmost importance. This additional dimension raises several questions which include: What role does time (delays in execution) play in the specialist's decision making process when executing market orders? and, how does this variable correlate with the other decision variables (bid-offer spread, and inventory adjustments)? Moreover, the change in the trade mechanism constituted by the NYSE, which took effect on February 3rd 2003, considerably limited the ability of

[1] For elaborate discussion, see for example, Easley et al [1992] and Huang and Stoll [1997].

the specialists to manage the quotes. As it will be argued bellow, this change may have increased the importance of the timing of orders executions.

Specialists at the NYSE often face potential losses by transacting with informed traders. A typical way to overcome or compensate for such an information disadvantage upon facing a one-side order (a buy-order with no matching sell orders or vice versa) is to judiciously adjust the bid-ask spread (Harris, 1990). In this paper we argue that alternatively, specialists can overcome their informational disadvantage by using time to obtain better knowledge about the information possessed by the traders they face. The specialist may wait for other orders to arrive before executing any given order to obtain better information on the trends in stock prices and/or on the nature of the traders (whether they are informed or liquidity traders).[2] Delays in execution could also be used when the specialists' inventory levels in the traded stock deviate from the specialists' 'desired' level (Amihud and Mendelson, 1980). In such cases, the specialist may attempt to match any given order with a counter side order by waiting for such orders to come, a strategy that also involves delays in executions. In addition, by waiting for counter side orders to come, the specialists could also gain as they may change the quotes after such an execution.

It is the objective of the current study to relate the delay of execution strategy to the other two decision variables: the bid-offer spread, and the inventory adjustment, and examine how they are simultaneously applied. As noted earlier, the change of February 3rd,2003 to automated quotes, the ability of the specialists to

[2] Chapter 2 of the "Floor Official Manual" states, 'The specialist helps ensure that such markets are fair, orderly, operationally efficient…An "orderly" market is characterized by regular, reliable operation with price continuity and depth…', p.7. It later continues, 'Rule 103A provides standards with respect to performance of these duties…Where circumstances warrant, the Exchange may take disciplinary action…' p.8. Madhavan and Panchapagesen [2000] model specialist's wealth that explicitly recognizes a loss of reputation capital due to specialist's deviations from such standards.

affect the spread considerably curtailed their strategic use of the spread in their trading behavior. Thus, in this paper we attempt to show whether and how the specialists trading strategies have changed due to the Exchange change in trading mechanism. We first investigate the trading strategies prior to February 3rd, 2003. In particular, we consider the relationships between the three decision variables: execution delay, spread determination, and specialist's participation rates (the extent to which the specialist matches orders by supplying liquidity from own inventory). In the second stage of the study, we look at the strategic relationships between execution delay and specialists participation after the exchange moved to quotes automation.

Since we hypothesize that delays of execution could be used to obtain information, we carried our empirical tests on a sample of stocks that had a "major event" that resulted in both higher than usual order flows and price changes. For such firms we explored the behavior of the specialists during the "major event" period which potentially resulted from major informational surprises (surprise cash dividends announcements), and also during "ordinary" periods where the potential asymmetry of information is lower. This was done to facilitate the analysis of the effects of variations in the amount of information on delays of execution, and examine the specialists' strategic behavior during "normal periods" and during big information events separately, and compare their behavior between these two types of periods.

We find that execution time varies considerably across information events. Prior to February 3rd 2003, the data exhibit correlations between the execution delay and the bid-offer spread, the specialist's participation rate, the volume of trade, and also by the trade intensity. It is found also that trading strategy varies considerably

between specialists. After the quotes automation took place we also find similar relationships between the execution delay and these variables. We also find strong correlation between the bid-offer spread and the delays in execution.

The paper is structured as follows: In Section II, we review the literature and how it relates to execution time. Section III discusses the sample characteristics and methodology, while Section IV provides the results of the empirical tests. Section V concludes the paper.

II. Motivation

In his classical paper Roll [1984] argues that, in the absence of information asymmetry, the quotes reflect execution costs born by the specialist.[3] However, when some traders possess private information regarding future stock value, they will trade against other (liquidity) traders and possibly against the specialist. Glosten and Milgrom [1985] (hereafter referred to as GM) developed a model where the specialist response to his exposure to informed traders is through a revision of probabilities which is culminated by differential prices for buy and sell orders, i.e. varying the quotes and thus modifying the bid-offer spread. As orders flow continues, the specialist revises informed-trader probability, and accordingly he continues to revise the quotes. Easley and O'Hara [1992] (henceforth EO) expanded GM's model, and focus on changes in the specialists' beliefs as several information event occur. They consider three tier traders: proprietary information traders, uninformed (liquidity) traders, and no-action traders. 'No action' traders dealing during no-event period have a low probability of being informed trades, and in such situations the specialists'

[3] See also Harris [1990] for empirical evidence.

conditional belief that an information event has occurred decreases and consequently their bid-offer spread will be lower. When an information event occurs, asymmetry of information gives rise to intensified trading. In such a case the proportion of information-based trades out of all trades increases and the specialists belief that the probability that any given order originates from an information-based trader will also increase leading the specialists to increase the spread. Therefore, higher spreads will usually follow a higher volume of trade which in turn usually follows new information arrival. In developing their model Easley and O'Hara [1992] 'divide the trading day into discrete intervals of time denoted t = 1,2,···. Each time interval is long enough to accommodate *at most one trade*.' (p. 581, *italic* added). EO thus acknowledge that time is used to obtain information and that it serves the specialists as a strategic tool. They do not analyze however the properties of this variable. Easley et. al. [1996], for example, are more explicit about the Bayesian process of learning which the specialists employ, where the *accumulation* of orders is observed by the specialist prior to determining his quotes, a process that is time consuming.

That implies that the specialist may use slow orders executions as a strategic tool. Furthermore, during event periods information gathering may become of prime importance to the specialist. He is expected to increase execution delays to observe side-market orders that will impact the quotes that he sets. Also, he may delay executions because of his reluctance to trade on own inventory as it may deviate from his 'desired' inventory boundaries, thereby he may wish to wait for a counter-side order to arrive in order to execute currently placed order. Taking into consideration also that the NYSE requirement of an '"orderly" market that is characterized by regular, reliable operations with price continuity and depth' (see footnote 2), it is

hypothesized that the specialist will act on all three decisions simultaneously: execution delays, modifying the quotes, and changing his participation rate. As delays in execution could act as a decision variable to complement the bid-offer spread and inventory adjustment decisions, it is instructive to investigate whether these variables are correlated and in which way.

III. The Data

A sample of US companies traded on the NYSE that had significant price reactions to cash dividend announcements during the period of January 2002 through mid November 2004 was collected.[4] We classified as major events those cases where the dividend announcement was accompanied by at least a 3% abnormal return (either positive or negative) over the 3 trading-days window surrounding the dividend declaration day. A search through the CRSP data detected 93 such cases. The precise time-of-day, in which the dividend declaration was made, was obtained from Factiva. Trade data for the sample's stocks were retrieved from the New York Stock Exchange files: System Order Database (SODP), and from the Specialist Equity Trade (SPET).[5] As the current study focuses on short trading intervals, only actively traded stocks that had at least 1,000 daily market-orders on the dividend announcement day were included in our sample so as to avoid cases with no market orders.[6] [7] This last requirement reduced the initial sample to 53 cases. For each dividend event, trading data were collected for 9 trading days surrounding the

[4] The current paper focuses on the execution delay as a decision tool in the specialist's trading activities. Therefore the current study differs from other studies that examined corporate announcement information effects on trading behavior, *c.f.*, Woodruff and Senchack [1988] who investigate the stock price adjustment patterns following unexpected earnings announcements and Koski and Michaeli [2000] who investigate information asymmetry impact on trades, quotes and spreads. They report that liquidity effects resulting from information content that is primarily attributed to unexpected dividends. Graham *et al* [2006] investigate the impacts of unanticipated dividend announcements on trades and quotes. The current study incorporates such possible effects in determining the strategic behavior of the specialists.

[5] SPET data file covers full trade information through mid November 2004.

[6] Market-orders require 'immediate' execution and have execution priority over 'limit-orders' with respect to timing of execution. Therefore, when measuring execution reaction time, market-order execution time is the best and most accurate measure of execution time.

[7] We also eliminated outlier observations that have an execution delay that is greater than 500 seconds and/or extreme stock price movements, i.e. when the return is greater or lower than 50 percent.

dividend declaration date: the declaration day, and the 4 days preceding and following it. To be able to control for time-of the day effects each NYSE trading day (6 and a half hours from 9:30 AM-4:00 PM) was divided into 390 intervals of 1 minute. Because the SODP file maintains HH/MM/SS clock trade data and the SPET file's clock is HH/MM, each trading data item on the SODP file that recorded transactions within each minute were aggregated to provide a single one minute observation for each variable..[8]

Figure 1 below provides the average daily distribution of the four variables in this study. First, we notice that in Panel B the spreads exhibit higher average at the beginning and the end of the day. This U shape type of spread is consistent with the spread distribution reported in the literature (e.g. McInish and Woods [1992] and Madhava *et al* [1997]). The figure also shows, in Panel A, the average daily distribution of the market order execution. This distribution is similar to that of the spreads. In particular, market orders executions are longer at the beginning and the ending of the day. In Panel C we note that the participation rate is more volatile after the quotes automation, then before it.In Panel D, one may observe that the level of inventory in the period after February 3rd, 2003, the level of inventory through out the trading day is mostly negative (i.e. the specialists' short position). In Section 4 elaborates on these findings.

The current study attempts to examine whether the specialist's trading strategy incorporate order execution delay. For that purpose we investigate that claim during two information environments: i. when the probability of asymmetric information is low (i.e. relatively low trade volume), and ii. When there is a considerable probability of information asymmetry (relatively high trade volume). Therefore, the data sets

[8] McInish and Wood [1992] and Madhavan et al [1997] have shown that there are considerable intraday changes in the bid-offer spreads, which may be described as a 'smile' (U-shaped) function. In the current study, we also observe this phenomenon.

where used to compile two data subsets files each one to be used to examine the specialist's strategic trading behavior in a different trading environment: a 'small event' file that includes trade observations for all 8 days surrounding the surprise dividend announcement (low probability of information asymmetry), and a "Major Event" data file which includes "benchmark" observations. The Major Event file includes observations regarding transactions that took place in the 90 minutes window surrounding the actual dividend announcement time (44 minutes prior and 45 minutes after the actual declaration, or less if the event occurred less than 44 minutes after opening time or less than 45 minutes before closing time). The benchmark observations are taken from the 8 days surrounding the event that are matched with observations in the Major Event file. The matching was made, for each event case, on the basis of identical trading time as in the major event. Thus, the Major Event file contains, for identical time of the day trades, data during the high probability information asymmetry period and low probability information asymmetry period[9]

For each market order that was placed with the specialist, the time when the market order appeared for the first time on the specialist's monitor and the time when that order was filled were collected. Therefore, the market order's execution time (hereafter, also called delay) is computed as the interval between these two times. We are mainly attempt to see how delays are correlated with the other decision variables and with certain control variables. Therefore, for each order executed we also recorded the bid-offer spread, the specialist's inventory prior to the trade, the part of

[9] Actual dividend declaration varies rather randomly over the time of day (Eastern Standard Time). In cases where the announcements are made within 45 minutes prior to the closing of that day trading, the event period is considered as the remaining trading periods remaining to the end of trading day. When announcements are made within the first 44 trading minutes, the observations included in the sample are from the opening session to 45 minutes after the announcement was made. In cases when the announcements are made after the closing of trades, the first 45 minutes of trades during the following trading day were collected.

the order the specialists supplied out of their own inventory, and additional items that serve as control variables, as will be discussed below. We consider the delay, the participation rate (the proportion of the market order that was filled by the specialist out of his own inventory),[10] and the bid-offer spread to be the specialist's main decision variables.[11]

The specialist's determination of trade[12] strategy may also be affected by other condition (control) variables as follows: The volume of the order flow as it is the main driver of information effect and it requires time to carry out; the specialist's level of inventory prior to the order execution - as it the source of liquidity provided by the specialist.; the bid and offer prices prior to each trade, the trade intensity (the number of shares in the order relative to the stock's daily volume) to which the specialist is required to respond and influences his timing of execution, the market-side imbalance (the difference between buy and sell orders in any minute) the higher the imbalance the more the specialist involvement is expected, the imbalance-rate (the proportion of the market-side imbalance relative to total daily shares volume) this variable aids the specialist's decision on whether and when to participate in the trade; the variability of the specialist's both the participation rate and his level of inventories, the daily volume variability, and the stock returns. Each of these control variables is included as each affects the specialist' s decisions.

The variable notations and their definitions are presented in Table 1.[13]

[10] Note that the specialist may short the security, i.e. he may hold negative inventory, as indicated by the data statistics, see Table 1.

[11] Inventories could be considered as decision variables; however it is customary to consider target inventories as decision variables.

[12] Volume of trade has a special effect on the delay of executions: as higher volume requires more time to fill, but it is also a source of information that might influence the execution time.

[13] The control variables in the reported regressions estimates are as described in this section However, several variations of these variables were also applied – e.g. the control variables where measured with

IV. Descriptive statistics

We analyze the data in both ways: univariate and multivariate, respectively. The main purpose of the univariate analysis is to examine whether delay is a prevalent strategy and if so, whether it is correlated to the other specialist's decisions variables: the determination of the quotes and his participation rates.

Table 2 has two panels. Panel A relates to the period prior to the quotes automation and Panel B displays the same statistics as in Panel A yet for the period after it. The table provides the statistical description of the 'small event' sample: the means, standard deviations, medians, minimum, and maximum levels of the variables as listed in Table 1, for all the observations in the 8 days surrounding the dividend announcement day, excluding the declaration day. First note, in Panel A, that the delays are not trivial, the mean execution time (Delay) is 10.9 seconds with a median of 5.7 seconds. The mean Spread is 5.4 cents with a median of 4 cents. The mean Participation Rate is 0.30 percent with a median of 0.10. Also, note that there is a considerable variation in the explored variables: We observe a coefficient of variation of 2.09 for the delays (22.796/10.902) as compared with only 0.92 for the Spread (4.969/5.398). and 2.72 (0.805/0.296) for the Participation Rate. These statistics imply that the relative variation of the execution delay is grater than that of the spread, hence the importance of tracking the source of this variation of the execution delay. It is important to note that the average inventory held by the specialists, 2,315 shares, has a very high variability which may include short sales (SD of 30,365 shares ranging from -150,600 t0 180,800). This statistic implies that the amount of inventory in monetary terms, is very high (e.g., assuming an average stock price of $50 implies

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and without transaction price weights. The actual regressions results were found to be robust with regards to changes of the alternative measures.

an average inventory of $115,650 with a range of $-7,530,000 to $9,040,000). Therefore, the specialists are exposed to a very high costs and risk by carrying inventory to facilitate liquidity. This last fact can be also observed from the average daily turnaround (the ratio of inventory to the daily market orders volume) of 15.87. Panel B, provides the data description parallel to that of Panel A but for the post quotes automation period. When comparing with Panel A, we notice that the mean execution delay increased to 11.1 seconds (with a median of 6.3 seconds), the mean spread decreased to 3.1 cents (a median of 2.0 cents) and a lower mean participation rate of 0.25 percent (a median of 0.07 percent). Using a non-parametric, the Wilcoxon tests are used to compare the distributions of the key variables for pre and post the quotes automation (i.e. prior and after February 3rd, 2003). The results are shown in Table 3. The table indicates all variables distributions after the NYSE move to automated quotes are significantly different (at a 1% confidence level) from the distribution prior to the change in the adoption of the new quotes system. It is apparent that on the average the specialists have changed their execution decisions following the quotes automation. In particular, note that while the spread is lower after the quotes automation, the execution delay of market orders is longer and the average level of inventory held by the specialist's decreased after the quotes automation. Figure 1 illustrates the changes in the specialists' decisions after the quotes automation. Panel A in figure 1 shows that the market orders executions delay over the trading day. In particular note that the market order execution delays are more volatile after the quotes automation. This may indicate that indeed the specialists use the timing of market orders execution as a decision tool more aggressively when their ability to determine the spreads became more constrained.

Panel B of figure 1 displays the distributions of the averages of the spreads, which has been reduced after the quotes automation. Panels C and D shows the changes of the specialist's participation rate over the trading day and the average inventory holdings by the specialists. In both panels we can observe that the specialist's decreases the participation in trades and that of the inventory levels. More over, the variability of the two panels indicates an increase after the quotes automation. In particular, note the changes in the average level the specialist's inventory which indicates that the specialist's uses short sales activity in more aggressive manner, resolving to short sales. Thus, one may presume that since the exchange restricted the use of one of the decision variables of the specialists (the ability to affect the quotes), the specialists use another decision variables more aggressively (increase in delay of execution and lowering liquidity and the participation rates). This argument is supported also when we observe the differences in the three variables distributions in Panels A and B, which may be viewed as further evidence of the shift in the specialist strategies in response to the exchange move to quotes automation.

Table 4 compares the specialist's decision variables that belong to the "Major information Event" period with that of the average benchmark period (i.e., the benchmark period observations are matched and averaged over the 8 days surrounding the declaration day for identical time of day as in the event period). The table provides the means of the main variables used in this study, the non-parametric Wilcoxon Two Sample Tests and the levels of their significance. Also, as in the former table, there are two panels Table 4, panel A and panel B, which are referring to prior and post quotes automation, respectively. However, it is very important to note that the means and medians in the event panel represent statistics that relate to

the entire 90 minutes event window. However, the effects of each event may be considerably shorter than the 90 minutes window (see discussion bellow and Figure 2). However, since the exact starting and ending of each event may be different than others a uniform shorter window cannot be applied. Therefore, the statistics of the dividend declaration sample and presented in these panels are *downward biased* due to the procedure that applies window period. It may be observed that the distributions of the two samples, the benchmarked and the major event, in both panels, are different for most of the variables that are examined. Among the specialist's three decision variables, the participation rate distributions of the benchmark and major event, in both panels (that of the prior and that of the post quotes automation) are significantly different, where as the spreads distributions are significant in Panel A (prior to quotes automation). The major event mean trade volume is greater than that of the benchmark period in both panels (4,525 vs. 3,291 and 5,631 vs. 3,339 shares in panels A and B , respectively), and the specialist's trade on own account (OwnShars) is about 20 percent higher during the major event period in both panels. Regarding the specialist's decision variables, Table 4 indicates also considerable difference during the two periods. The mean delay time during the major event period is 12.5 and 12.1 seconds, compared with 11.2 and 11.5 in the benchmark period, in Panels A and B, respectively. The difference in the means spread between the major event and the benchmark periods are also noticeable. The participation rate is significantly lower (i.e. lower liquidity) during the major event period compared with the benchmark period in both panels, differences that are found to be significant at the 1 percent level. These differences are consistent with what one would expect from the specialists' defense strategy, given the higher potential informational disadvantage

which they face during big events times. Figure 2 which is similar to Figure 1, illustrates the changes in the specialists' decisions during the major information event as a result of the quotes automation. First, comparing Figure 2 to Figure 1, we note first that for all three variables (execution delay, spreads, and participation rate) the volatility of the each variable over the trading day is higher after the quotes automation of February 3rd, 2003. However, the change in the volatility on the major information event is looks as if larger that the changes that occurred during the small information events. This may be an indication that after the quotes automation (i.e. when the specialists' discretion regarding the determination of the quotes has been drastically reduced) the specialists' decisions became more during an information event aggressive than either before the quotes automation and compared to the small information event (after the quotes automation).

While specialists may follow identical defensive strategies to protect themselves from losing to the informed trader, their emphasis on each of the decision variables and the trade off between these variables may be different. Table 5 provides such statistics regarding the three decision variables, for the periods prior and after February 3rd, 2003. The table provides the means, standard deviations and the number of observations for each of the specialists' decision variables (delays, spreads and the participation rates) for 5 specialists that trade in stocks in our sample. It may be observed that the there is a great deal of variations in the three decision variables across specialists. It may be also observed that in most cases, the means delays increase after February 3rd, 2003 compared to the period preceding it and the coefficients of variation have decreased. In the cases of the other two variables, it may be observed that the means of these variables decreased with the increases in

their coefficients in variation during the period after the introduction of the quotes automation, compared with the period preceding it.

Figure 3 provides a useful illustration of the specialist's delay strategy in reacting to new information. The figure is a diagram of the evolution of market-order flows and delays during the period surrounding one typical major event. On the horizontal axis we present the relative 2-hour window period in the day of the dividend declaration around the event time. This 2-hour window period is divided into 40 equal intervals of 3 minutes. Trade data was averaged over 3 minutes trade intervals so as to reduce noise. The dividend announcement is represented in this figure in the middle of the horizontal axis (i.e. at 20). One observes the spike in the trade orders was delayed by about 15 minutes after the announcement, and surprisingly also a smaller spike few minutes before the announcement. The data indicate that a large portion of these orders are buy orders, as the announcement conveyed 'good news' – a surprise cash dividend. The volume of market orders increases highly significantly at the beginning of the 25^{th} interval (i.e. 15 minutes after the announcement was made). Note also that 25 minutes after the declaration the delay phenomenon disappears.

The next section extends our study to a multivariate analysis, where we investigate the correlations between the decision variables and the exogenous variables that may affect them. Two sets of tests were conducted: The first covers the small event period and the second the major-event period. Then we compare the specialists' strategic behavior between the two periods.

V. The Relationships Between Delay Time Spread and Volume of Trade

We begin with examining the specialists' strategies for all transactions during a 'normal' ('small information events') period -- the 8 days surrounding the dividend declaration day.

Table 4 provides a Spearman correlation matrix for the main variables used in the study for the period prior to February 3rd, 2003. Note that the all, but one, correlation coefficients in the table are highly significant. Regarding the three decision variables, the value of the correlation coefficients are not high, even though are significant. The table reveals that the volume of trade is highly correlated with the delay decision (.30). This is of no surprise as the higher the volume, the more work is required by the specialist to handle the order flow which consumes more of his time, compared with a low volume period. The negatively high correlation between the volume of trade and the participation rate (-.33) needs to be contrasted with its correlation coefficient with the number of shares that the specialist trade on own account (OwnShars) (.30). This implies that when the volume of trade is high the specialist increases the trade on own account, but *relative* to the increase in volume, his *relative participation* declines. These correlations are consistent with the role of the specialist on the NYSE.[14]

To further explore the correlations between the variables the following sets of regressions were run (see Table 1 for the definitions) :

$$\text{Dly}_{i,t} = \alpha_0 + \beta_1 \text{Sprd}_{i,t} + \beta_2 \text{Part-rate}_{i,t} + \beta_3 \text{Dly}_{i,t-1} + \beta_4 \text{Sprd}_{i,,t-1} + \gamma_1 \text{Imblnce}_{i,t} + \gamma_2 \text{Imblnce}_{i,t-1} + \gamma_3 \text{Return}_{i,t-1} + \gamma_5(\text{Vol})_{i,t} + \gamma_6 (\text{Volsq})_{i,t} + \gamma_7 \text{Beg-day}_{i,t} +$$

[14] The Affirmative Obligation of the NYSE specialist suggests that '….a specialist should do the following: Buy and sell securities as principal when such transactions are necessary to minimize an actual or reasonably anticipated short-term imbalance between supply and demand in the auction market.' P. 19, Floor Official Manual, NYSE 2004.

$$\gamma_8 \text{ End-day}_{i,t} + \varepsilon_{i,t}. \quad (1)$$

$$\text{Sprd}_{i,t} = \alpha_0 + \beta_1 \text{ Part-Rate}_{i,t} + \beta_3 \text{ Sprd}_{i,t-1} + \beta_4 \text{ Part-rate}_{i,t-1} + \gamma_1 \text{ Imblnce}_{i,t} + \gamma_2 \text{ Imblnce}_{i,t-1} + \gamma_3 \text{ Intns}_{i,t} + \gamma_4 \text{ Intns}_{i,t-1} + \gamma_5 \text{ Post}_{i,t} + \gamma_6(\text{Vol})_{i,t} + \gamma_7 (\text{Volsq})_{i,t} + \gamma_8 \text{ Beg-day}_{i,t} + \gamma_9 \text{ End-day}_{i,t} + \varepsilon_{i,t}. \quad (2)$$

$$\text{Part-Rate}_{i,t} = \alpha_0 + \beta_1 \text{ Dly}_{i,t} + \beta_2 \text{ Sprd}_{i,t} + \beta_3 \text{ Sprd}_{i,t-1} + \beta_4 \text{ Dly}_{i,t-1} + \beta_5 \text{ Part-rate}_{i,t-1} + \gamma_1 \text{ Imblnce}_{i,t} + \gamma_2 \text{ Imblnce}_{i,t-1} + \gamma_3 \text{ Intns}_{i,t} + \gamma_4 \text{ Intns}_{i,t-1} + \gamma_5 \text{ Return}_{i,t-1} + \gamma_6 \text{ var-Post}_{i,t} + \gamma_7 \text{ var-Post}_{i,t-1} + \gamma_8 \text{ var-Part}_{i,t} + \gamma_9 (\text{Vol})_{i,t} + \gamma_{10} (\text{Volsq})_{i,t} + \gamma_{11} \text{ Beg-day}_{i,t} + \gamma_{12} \text{ End-day}_{i,t} + \varepsilon_{i,t}, \quad (3)$$

where, i and t designate the stock in the sample and the time of trade, respectively. It is noteworthy to mention the addition of two control variables to the regression equations: as it has been noted, the execution time of orders may depend on the volume of trade, hence the added two control variables – Vol , the number of shares in each transaction in a given trading minute (scaled by dividing by 1000) and Volsq, the volume squared. Also, because the opening and closing session trades are subject to required procedures,[15] a dummy variable that assumes the value of one for orders placed in the first 20 minutes of the day and zero otherwise, (Beg-day), is added to equations (1), (2), and (3). Another and similar dummy variable, End-day, is set for market orders submitted during the last 15 minutes of the trading day.

[15] The NYSE 'Floor Official Manual' states ' In opening and reopening trading in a listed security, a specialist should do the following: Initiate trading in each security as soon as market conditions allow at price that reflects a thorough, professional assessments of market conditions at the time and appropriate consideration of the balance of supply and demand as reflected by orders presented in the auction market…'p.10. Madhavan and Panchapagesan [2000] developed a model that examines this single-price opening auction procedure.

Although the specialist's decision strategies are represented by three simultaneous equations, these equations are well identified. Note the use of the different coefficients symbols in these equations: β's denote the coefficients related to the specialists' decisions and γ's denote the control variables coefficients.[16]

The results of these regressions presented in Panel A of Table 7 Columns 2, 3, and 4 providing the results of the equations for delay, spread, and participation rate where they are considered as dependent variables, respectively. Also, the table reports the goodness of fit (the adjusted r^2) and the significance tests (F-values) for each of the equations. As may be seen, the three equations are highly significant as indicated by their adjusted r^2 and their F-values.

The first and most striking results reported in Panel A of Table 7 is the high significance of the coefficients related to the decision variables in each of the three regression equations. It may be observed in Column 1 (the delay equation) that the coefficients of both the spread and the participation rate are positive. Because the specialist is reluctant to trade on own account, high participation rate will induce the specialist to increase the execution delay of outstanding orders. An interesting observation is the negative coefficient of the lagged spread variable: The specialist who increases his quotes has done so in order to mitigate information disadvantage, consequently is less reluctant to delay current order execution.

Of course, the execution time increase as the volume of trade increases because higher volume requires more work to be done and hence the positive and the high significance of the volume variable. At the same time, the specialist tends to

[16] The control variables used in these regressions estimates are as described in Section III. However, variations of these variables were also applied – e.g. the control variables where measured with and without transaction price weights. The actual regressions results were not affected significantly when alternative measures were used.

increase the execution delay time when faces additional observations of one-side trades as this information may be an indication of informed traders placing execution orders.

In the second column of Panel A of Table 7 the coefficients of the regression with the spread being the dependent variable are presented. One notes that the coefficient of the participation rate is positive and statistically significant. This may be explained by the fact that the specialist is reluctant to trade on own account and when is he feels 'compelled' to do so he tends to increase the spread as an action to mitigate possible loss to informed traders. Also note that the spread tends to increase when the trade intensifies but not solely by volume of trade.

In the third regression equation the specialist's participation rate serves as the dependent variable. One may note that both coefficients of the endogenous variables, that of the delay and that of the spread, are positive and significant, and so is the market orders intensity. The negative coefficients of the volume variables is a manifestation to the fact that the specialist tend to decrease his participation rate when volume of trade increases. Again, this is consistent with the specialist's strategic decisions as described by the previous two equations.

Panel B of Table 7 provides the results of the simultaneous regression equations for the period preceding the move to automated quotes. This panel is very similar in structure to that of Panel A with one very important difference. The set of the simultaneous equations is composed of only two equations. The spread equation is no longer included in the decision set as the spread from the automation is determined externally (as far as the specialist is concern). The results of the two regression equations are very similar, in their trends, to their counterparts in Panel A. However,

there are several noticeable differences between the coefficients reported in the respective regression equations in the two panels: The impact of the spread on the decision variables (delay of execution and the participation rate) is reduced drastically. The effect of the participation rate on the delay decision is much greater when the spread is determined exogenously – meaning that there is more aggressive use of the delay in the absence of a 'control' over the spread.

The results of the simultaneous regressions provide supporting evidence to the claim that the specialists delay strategy is correlated with their trading decisions which may assist them to reduce their exposure to a loss due to trades with informed traders. In the next part of this study, we will attempt to examine this hypothesis during major information event manifested by higher than 'usual' trade volume.

V.2. Specialists Delay Strategy During Major Event Period

The previous part of the study reported significant correlations between market orders delay executions with actual trading decisions. The hypothesis was tested for 'small information event' transactions. In this section the hypothesis that market orders execution delay may be used by the specialist as a strategic decision to supplement his trading decisions during major information event is tested. Bearing in mind that the specialists are required to provide 'reliable operation with price continuity and depth', the specialist task becomes more complicated when the volume of trades submitted to him increases substantially and possibly may be described as one-side orders , due to major information event. For that purpose, we adopt a similar approach to the one taken in the previous section by using similar regression techniques with several modifications.

In Table 8 we essentially repeat the analysis of the former subsection but includes important modifications: (a) The data used contains that of the 90 minutes observations surrounding the information events and that of the benchmark trade transactions (for the same securities, for the identical time of the day trades as during the information events, for the 8 days prior to and after the information event). (b) To examine the impact of the new information arrival 5 dummy variables were added to the regression equations as follows: 1.designating event observations (EVENT – 1 if the observation belongs to the event period, otherwise it takes the value of 0), 2.designating delay for the event observations (Dum-Dly = EVENT * Dly), 3.designating spread for the event observations (Dum-Sprd = EVENT * Sprd), 4.designating participation rate for the event observations (Dum-Part = EVENT * Part-Rate), and 5.designating volume for the event observations (Dum-Vol = EVENT * Vol).

The three simultaneous regression equations were used for the period prior to automated quotes and two simultaneous equations and the regression coefficient estimates are presented in Panels A and B, respectively. All regressions in both panels are significant at 1% level of confidence, as their F values indicate, whereas the regressions adjusted r^2 are ranging from 0.098 to 0.15.

One may note that generally, the regressions variables' coefficients in Table 8, which also appear in Table 7 (in both panels) are very similar. The EVENT coefficients in Table 8 are significant for spread equation (Panel A) and for the participation rate equation (in both panels). The signs of these coefficients are consistent with the specialist's strategy – he tends to increase the spread and decrease his participation rate when faces new information. Also note that although insignificant, the sign of the

EVENT coefficient in the delay equation is also consistent with the specialist' strategic behavior, i.e. increase execution delay when faces possible information disadvantages. Also note the coefficient of the dummy delay variable in Panel B for the participation rate equation. This coefficient is significantly positive, implying that the specialist tends to increase his participation when increases his order execution delays. Put it another way,

VI. Conclusions

This paper suggests that the NYSE specialists' protecting their wealth when trading against possibly better informed traders involves delaying execution of market orders when necessary. This strategy enables the specialists to obtain more information about the traders they face and their motivation for the trades. The current literature assumes that the only tools the specialists use in such situations are the bid-ask spread and adjustments in their inventory levels. This paper contributes to the existing literature by arguing that the specialists adopt an additional decision variable in their trading strategy, namely judicious choice of the execution time. We examined the specialists execution time in two samples: during periods where there was no remarkable information asymmetry (i.e., non-event), and during periods when there were noticeable information triggered trade flows (time surrounding "surprise" dividend declarations).

We show that the execution of market orders is not instantaneous upon reception of the orders as is often expected. It is shown that delays in the execution of orders are significant and that they depend on the size of the order, the "surprise" factor in the order, and that they vary between the different specialists. These delays are closely correlated with the bid-offer spread and with adjustments in the inventory

levels of the specialists, and can be considered as important factors in their inventory risk management system. Moreover, as the NYSE moved to automated quotes and the specialists' ability to modify the quotes can no longer serve as a strategic tool, the use of the execution delay as an alternative strategy has been found to be used more aggressively.

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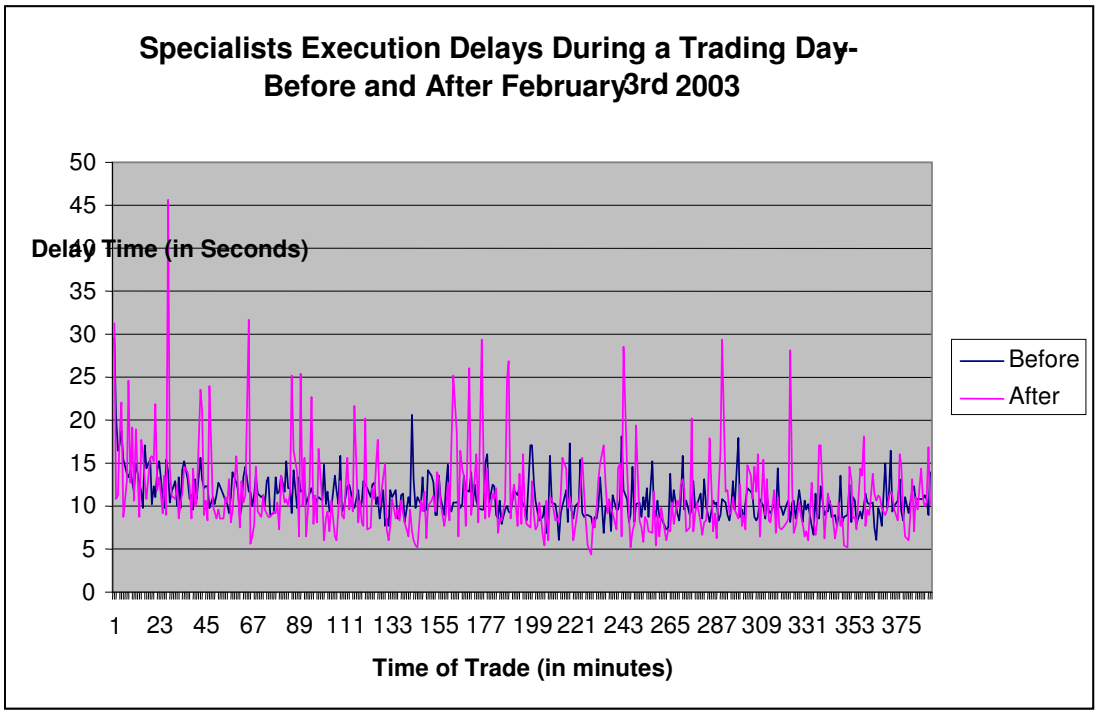
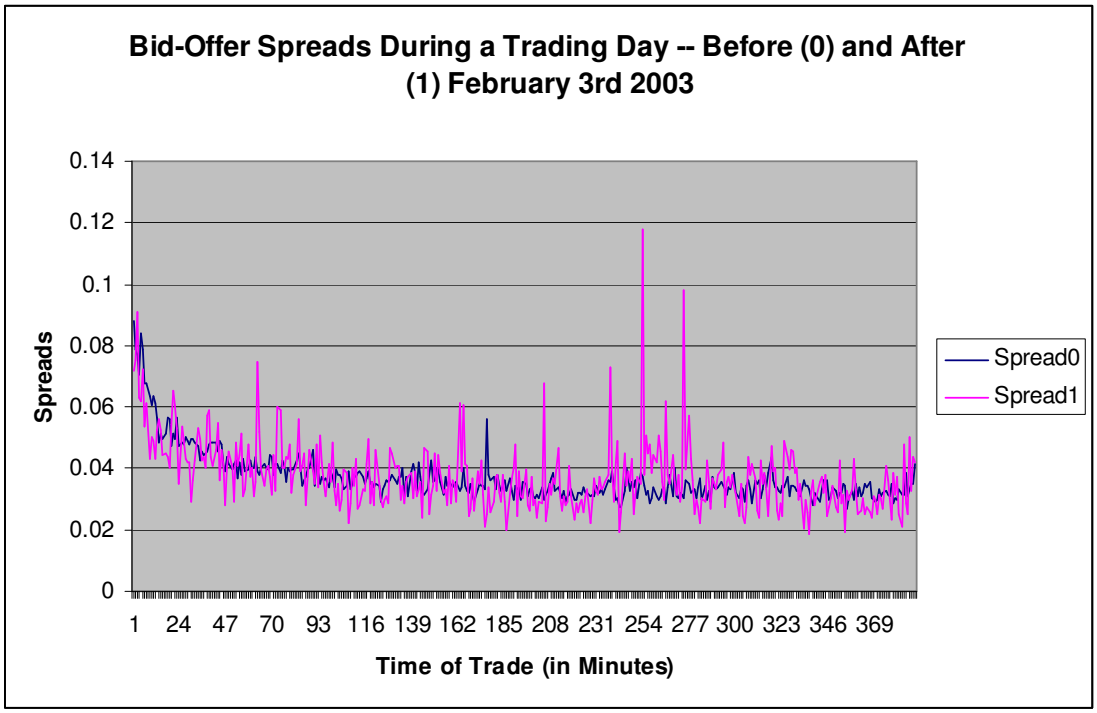
Figure 1

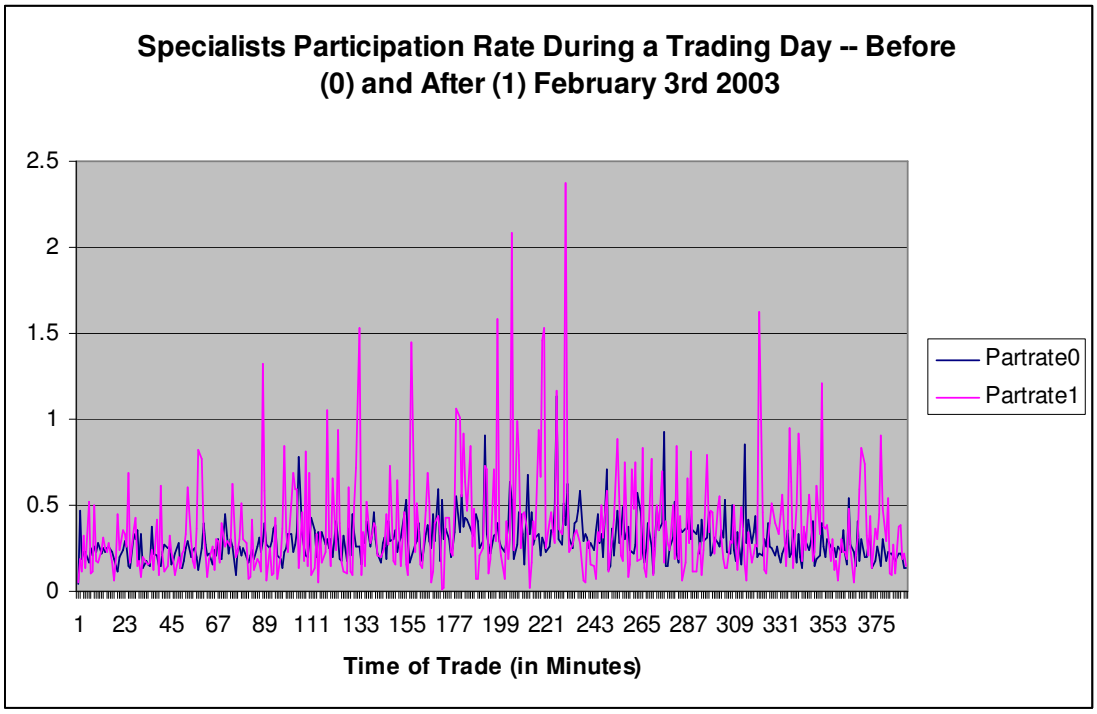
Panel A



Panel B



Panel C


Specialists Participation Rate During a Trading Day -- Before (0) and After (1) February 3rd 2003
2.5
2
1.5
1
0.5
0
1 23 45 67 89 111 133 155 177 199 221 243 265 287 309 331 353 375
Time of Trade (in Minutes)
Partrate0
Partrate1

Panel D

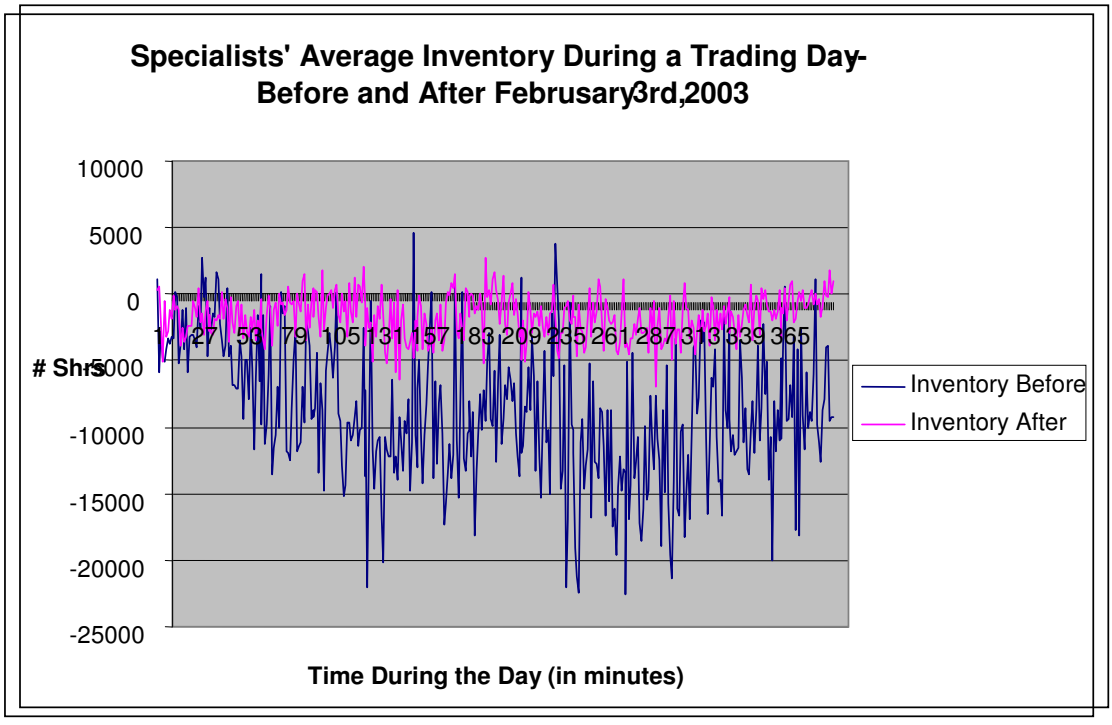
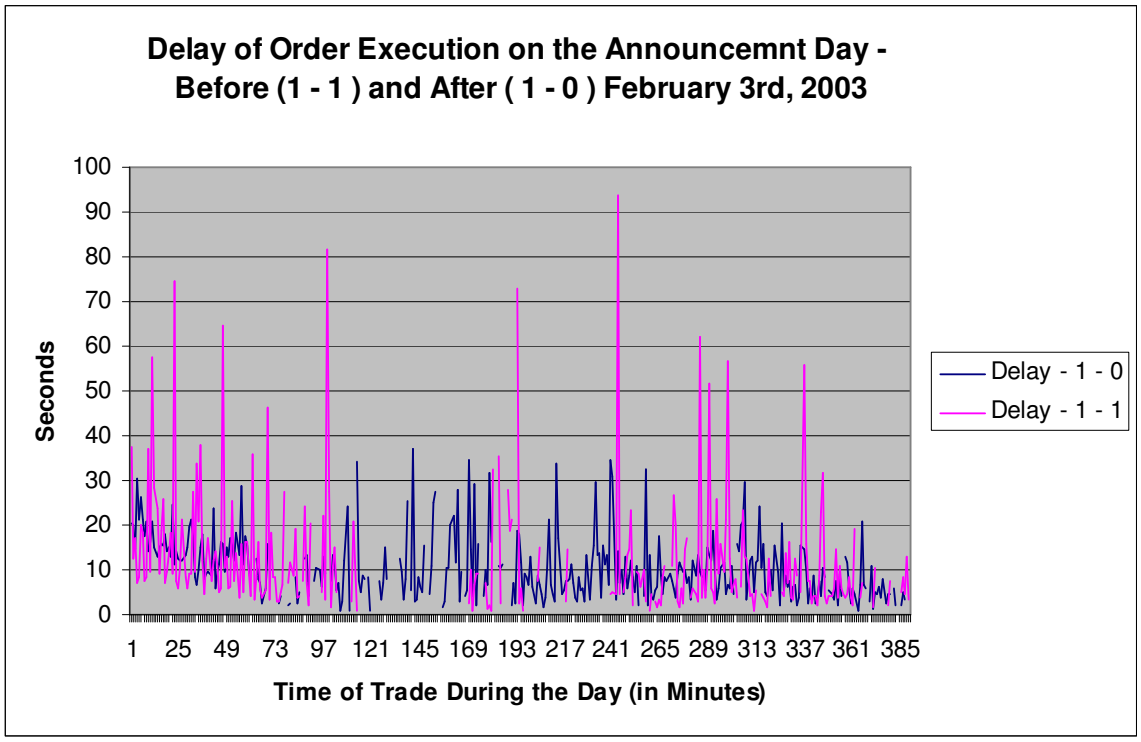
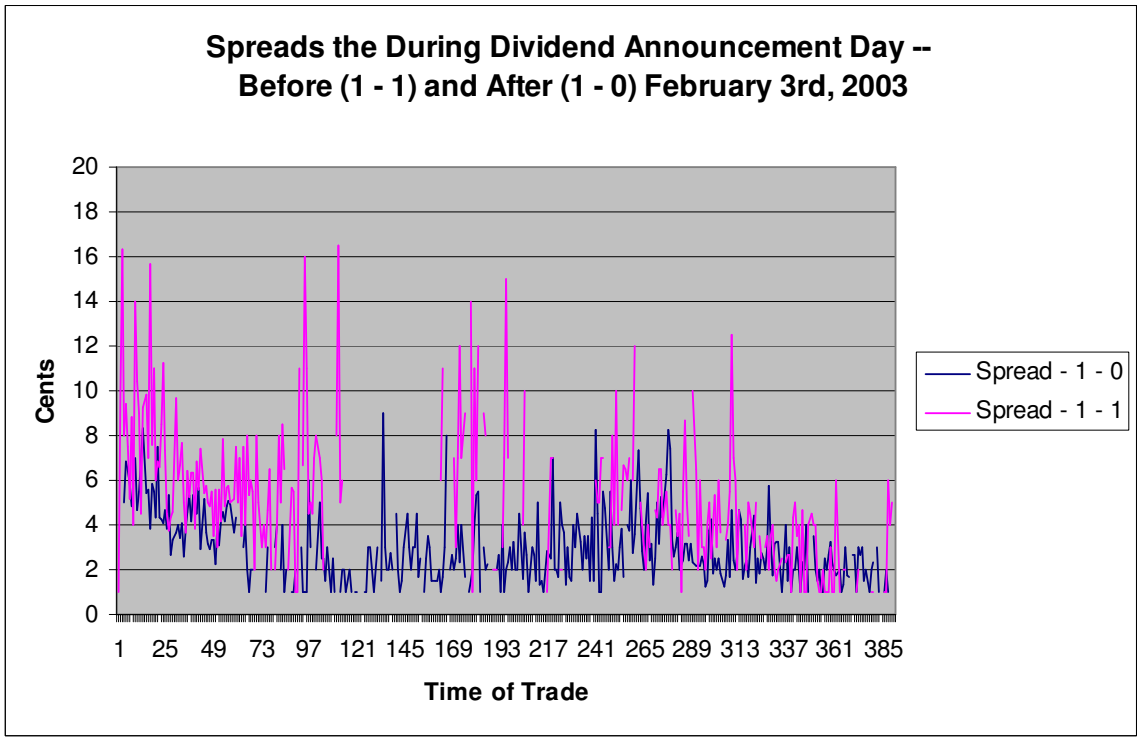

Specialists' Average Inventory During a Trading Day- Before and After Februsary 3rd, 2003
10000
5000
0
-5000
-10000
-15000
-20000
-25000
Shrs
1 27 53 79 105 131 157 183 209 235 261 287 313 339 365
Time During the Day (in minutes)
Inventory Before
Inventory After

Figure 2

Panel A



Panel B



Panel C

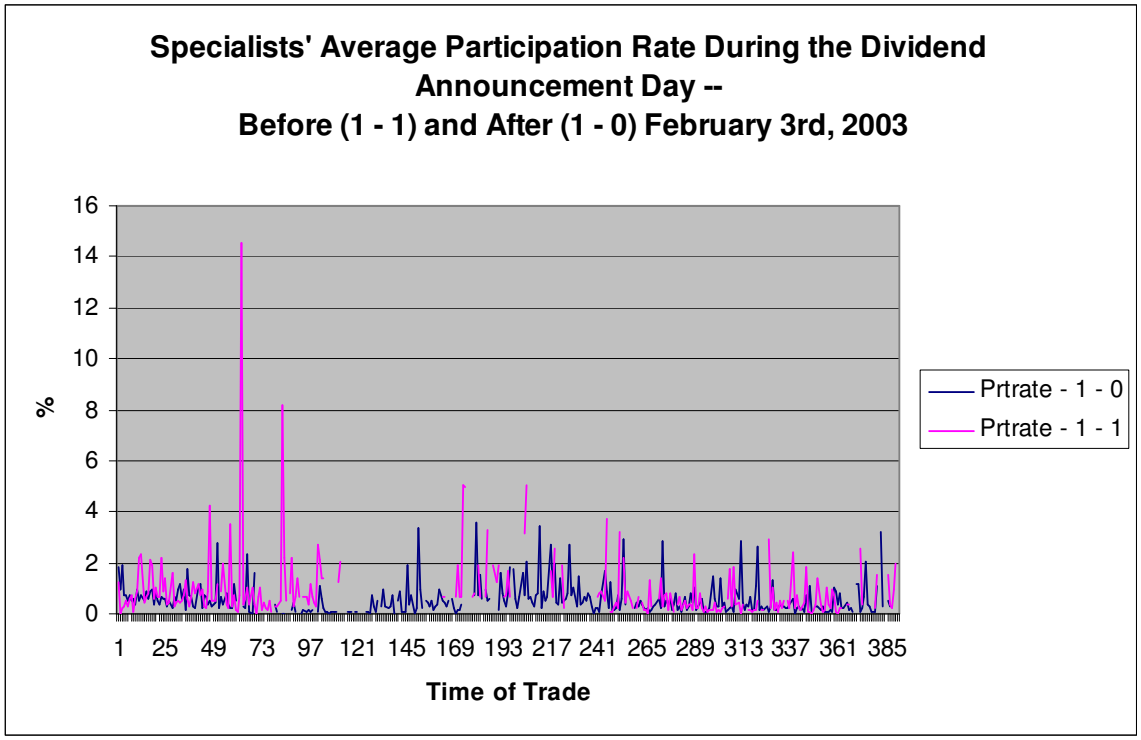


Figure 3

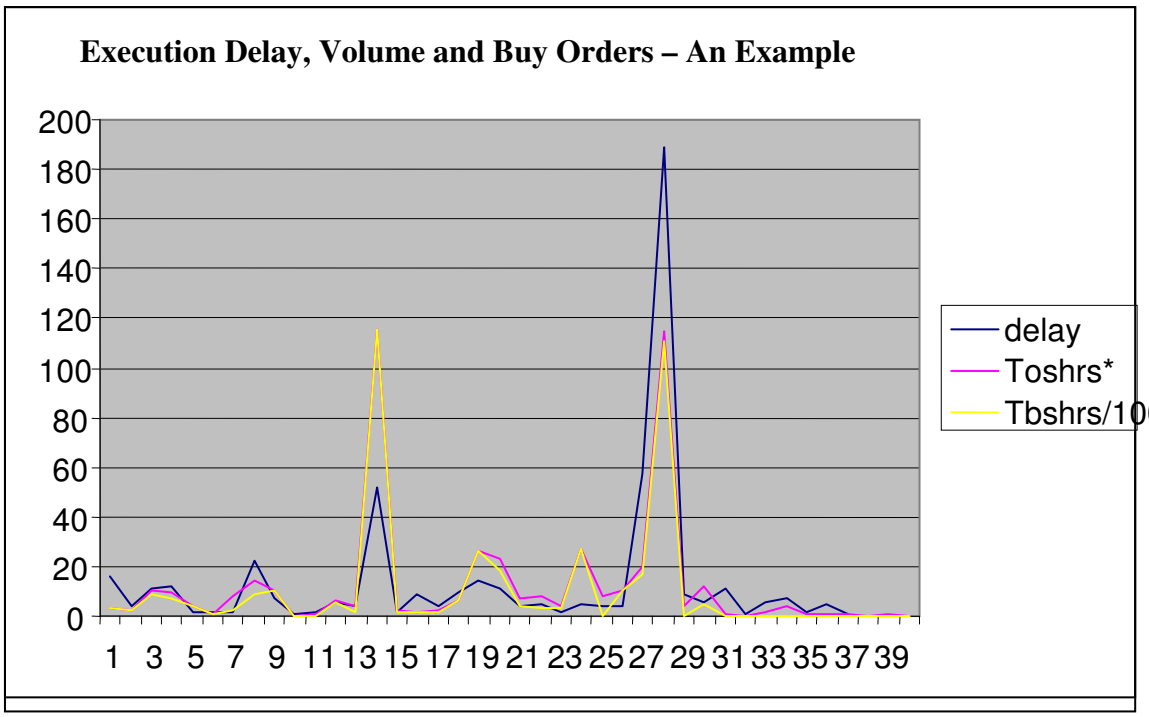


Table 1

Data Definitions

t designates time of trade'

OwnShrs is the number of specialist's shares traded on own account,

Vol is the total volume of shares traded,

$Volsq = Vol^2$

J = 1 or J= event-44 ; for the 'small information event' and the 'major information event' periods 'respectively,

M = 390 or M= event + 44 ; for the 'small information event' and the 'major information event' periods 'respectively,

BuyShrs is the buy shares in an order placed at t,

SellShrs is the sell shares in an order placed at t,

Invnt designates the number of shares in specialist's inventory prior to trade (at t-1),

H , L in a variable subscripts designate the high and the low values of the variable

$Delay_t$ = execution-time $_t$ – order-time $_t$,

$Dly_t = \ln(Delay_t)$.

$Spread_t$ = (offer price) $_t$ - (bid price) $_t$.

$Sprd_t = \ln(Spread_t)$.

Specialist's participation rate:

$$\text{Part-rate}_t = \{ \text{OwnShrs}_t \; / \sum_{j=J}^{M} vol_j \} \text{x} 100 ,$$

Shares Imbalance ;

$Mktsid_t = ((BuyShrs_t - SellShrs_t)$,

Trade imbalance :

$$\text{Imblnce}_t = (\text{Mktsid}_t) / \text{Vol}_t ,$$

Trade intensity:

$$\text{Intns}_t = \text{Vol}_t / \sum_{j=J}^{M} vol_j ,$$

Specialist's relative inventory position :

$$\text{Post}_t = (\text{Invnt}_t / \text{Vol}_t),$$

$$\text{Return}_t = (\text{price}_t / \text{price}_{t-1} - 1) \times 10^4 ,$$

Specialist's participation range:

$$\text{var-part} = (\text{OwnShrs}_H - \text{OwnShrs}_L) / \sum_{j=J}^{M} vol_j , +45,$$

Specialist's inventory range:

$$\text{var-post} = (\text{Invnt}_H - \text{Invnt}_L) / \sum_{j=L}^{M} vol_j ,$$

Trade range:

$$\text{var-vol} = (\text{Vol}_H - \text{Vol}_L) / \sum_{j=L}^{M} vol_j ,$$

Table 2 #

Descriptive Summary Statistics of all observations during the 8 days surrounding the dividend announcement, excluding the announcement day

Panel A – Prior to February 3rd, 2003

Variable	Mean	Std Dev	Median	Minimum	Maximum
Delay	10.902	22.796	5.667	0.200	499.000
Spread	5.398	4.969	4.000	1.000	117.000
Part-rate	0.296	0.805	0.102	0.002	25.025
Intns	0.645	1.646	0.277	0.002	57.146
var-post	15.872	14.850	11.562	2.120	99.729
var-part	4.314	3.805	3.403	0.443	27.399
var-vol	2,898	7,881	700	1.000	291,143
OwnShrs	694	2,165	200	100	84,400
Vol	3,097	11,9724	872	1.000	767,924
Invnt	2,315	30,366	1,175	-150,600	180,800
post	289	9866	63	-664,767	743,992
Mktsid	149	6,496	23	-280,861	144,000
Imblnce	2.287	83.954	6.796	-100.000	100.000
Return	-0.075	65.190	0	-43.03	38.49
N	17,839				

Panel B --- After February 3rd, 2003

Variable	Mean	Std Dev	Median	Minimum	Maximum
Delay	11.132	18.132	6.333	0.167	498.000
Spread	3.105	3.294	2.000	1.000	275.00
Part-rate	0.245	0.814	0.073	0.001	47.061
Intns	0.645	1.133	0.240	0.001	64.689
var-post	12.661	12.750	8.712	1.129	218.284
var-part	3.758	3.923	2.451	0.300	46.060
var-vol	12.520	9.002	10.295	1.445	64.690
OwnShrs	818	2,952	200	100	196,500
Vol	3,173	12,319	924	1.000	767,924
Invnt	2,103	32,858	123	-258,554	305,000
post					
Mktsid	343	10,866	20	-100	100
Imblnce	70.708	82.565	20.000	-100.000	100.000
Return	0.108	11.734	0	-49.875	50.000
N	46,359				

Variable definitions are found in Table 1.

Table 3 #

Wilcoxon Non Parametric Tests of the Differences
Between the Means of Variables Before and After February 3rd, 2003

Variable	Before 3rd of February, 2003	After3rd of February, 2003	Wilcoxon Two Sample Test
Delay (secs)	10.902	11.132	-13.8683***
Spread (¢)	5.398	3.105	74.1294***
Part-rate	0.296	0.245	24.0434***
Intns	0.641	0.645	12.2600***
var-post	15.872	12.661	37.4080***
var-Part	4.314	3.758	28.4164***
var-Vol	2,898	12.520	-14.2580***
OwnShrs	694	818	-9.9964***
Vol	3,097	3,173	5.58 E8 ***
Invnt	2,315	2,103	11.5494***
Mktsid	289		-7.9718***
Imblnce	149	343	-5.7816**
Return	2.287	70.708	-7.9718***
N	-0.075	0.108	

Variable definitions are found in Table 1.

Table 4 #

Samples Means of Variables During the Major Event Period and During the Benchmark Period and Wilcoxon Non Parametric Tests of the Differences

Panel A- Prior to February 3rd

Variable	Benchmark	Event	Wilcoxon Two Sample Test
Delay (secs)	11.164	12.505	0.7492
Spread (¢)	6.131	6.752	3.4193***
Part-rate	1.640	1.259	-4.3035***
Intns	3.184	2.879	-4.2883***
var-post	43.830	38.593	-2.2886**
var-Part	11.844	11.022	-2.5208**
var-Vol	22.652	30.054	5.0548***
Position	689	811	1.1140
Vol	3,291	4,525	-0.0186
Dposp	1,896	20,724	-7.5118***
Imbalance Rate	-14	902	2.4002**
Imblnce	1.241	9.649	2.1324**
Return	-0.602	0.536	1.8421*
N	3,643	513	

Panel B- After February 3rd

Variable	Benchmark	Event	Wilcoxon Two Sample Test
Delay (secs)	11.472	12.136	- 0.3383
Spread (¢)	3.356	3.361	0.2320
Part-rate	1.245	0.853	-8.0760***
Intns	3.022	2.714	-2.7317***
var-post	31.325	23.033	-12.6197***
var-Part	9.106	5.599	-12.0812***
var-Vol	23.920	23.407	-1.8227*
Position	763	966	0.2822
Vol	3,339	5,631	4.2244***
Dposp	-718	1,082	2.1478**
Imbalance Rate	889	14,029	-1.9305*
Imblnce	6.581	1.625	-2.0931**
Return	0.260	1.182	1.2215
N	10,039	1,400	

***Significant at 1% (Two Sided)
**Significant at 5% (Two Sided)
*Significant at 10% (Two Sided)
Variable definitions are found in Table 1.

Table 5 #

Variation of Market Orders Execution Delay (in Seconds) and Spreads Among Specialists: Examples

Specialist's ID		Delay		Spread		Participation	
		Prior 03.02.2003	After 03.02.2003	Prior 03.02.2003	After 03.02.2003	Prior 03.02.2003	After 03.02.2003
I	Mean	8.11	11.13	6.39	2.88	0.3546	0.2435
	SD	18.84	20.25	5.73	2.90	0.8956	0.6768
	N	2,392	8,544	2,446	8,585	2,446	8,605
II	Mean	8.31	10.67	6.22	2.76	0.3473	0.1807
	SD	11.25	15.10	4.33	2.48	0.8126	0.6427
	N	1,179	8,806	1,188	8,966	1,192	8,987
III	Mean	10.57	10.37	5.71	3.37	0.51543	0.3138
	SD	25.40	18.46	4.82	3.00	1.226	1.2606
	N	2,713	5,065	2,760	5,151	2,760	5,165
IV	Mean	10.84	11.46	5.45	3.38	0.2706	0.2328
	SD	19.61	15.85	6.02	4.32	0.6687	0.6937
	N	5,389	13,183	5,460	13,248	5,460	13,293
V	Mean	12.68	11.45	4.66	3.09	0.18877	0.2818
	SD	26.47	21.40	3.48	2.79	0.60556	0.8962
	N	6,166	10,761	6,203	10,982	6,221	11,017

Variable definitions are found in Table 1.

Table 6 #

Spearman Correlation Coefficients – 8 Benchmark days
Prob > |r| under H0: Rho=0

	Spread	Prt-rate	Intns	Imblnce	OwnShrs	Vol
Delay	0.02544†	-0.02476†	0.27572†	0.02934†	0.14722†	0.29760†
Spread		0.17133†	0.13623†	0.00597	-0.02585†	-0.06286†
Prt-rate			0.30226†	-0.00346	0.45512†	-0.33252†
Intns				0.06339†	0.09178†	0.54792†
Imblnce					0.02325†	0.05623†
OwnShrs						0.30130†

† Significant at the 1% level
# Variable definitions are found in Table 1.

Table 7 #

Simultaneous two stage least squares (2SLS) Regression Results correlating Delay (column 1), Spread (column 2), and participation rate (column 3) with each other and with other explanatory variables for the benchmark file

Panel A – Prior to February 3rd 2003

Variable	Delay	Spread	Part-rate
Intercept	2.085 (10.77)***	-2.2554 -(89.34)***	0.2220 (136)
Dly			0.0769 (2.41)**
Sprd	0.4087 (4.81)***		0.1875 (2.60)***
Part-rate	0.1442 (3.82)***	0.1605 (5.05)***	
Dly lg	0.1777 (23.85)***		
Sprd lg	-0.0667 -(5.02)***	0.3292 (45.65)***	-0.845 -(3.46)***
Part-rate- lg		0.0039 (0.45)	0.0653 (8.22)***
Imblnce	4.37 E-4 (4.72)***	1.15 E-4 (1.65)*	7.00 E-5 (0.97)
Imblnce- lg	1.27 E-4 (0.84)	2.87 E-6 (0.97)	-1.00 E-5 -(0.14)
Intns		0.0311 (6.26)***	0.0403 (5.89)***
Intns - lg		0.0081 (2.08)**	0.0153 (3.88)***
var-post			0.0014 (0.13)
var-post - lg			0.0075 (0.71)
var-part			0.0159 (0.54)
var-part– lg			0.0058 (0.20)
Return	-3.50 E-4 -(1.83)*		
Post		3.72 E-7 (3.17)***	1.20 E-7 (0.97)
Vol	0.0572 (38.26)***	-0.0019 -(1.45)	-0.0086 -(4.56)***
Volsq	-2.50 E-4 -(19.39)***	2.83 E-6 -(0.81)	3.20 E-5 (2.63)***
Beg-Day	0.0677 (1.60)	0.3107 (12.52)***	-0.0964 -(2.73)***
End-Day	0.0505 (1.42)	-0.1069 -(4.08)***	0.1272 (4.74)***
R^2 - adj	0.1378	0.1377	0.1068
F - value	254.41***	233.17***	123.70***
N	17,444		

**** Significant at 1% ,
** Significant at 5%,
* significant at 10%

Panel B – After February 3rd 2003

Variable	Delay	Part-rate
Intercept	1.4001 (45.89)***	-0.0137 (0.35)
Dly		0.0509 (3.21)***
Sprd	0.0217 (3.41)***	0.0555 (11.11)***
Part-rate	0.2635 (16.07)***	
Dly lg	0.2133 (47.57)***	
Sprd lg	-5.5 E-4 -(0.09)	-0.0293 -(5.91)***
Part-rate- lg		0.0545 (11.86)***
Imblnce	3.00 E-5 -(0.49)	1.30 E-5 (0.30)
Imblnce- lg	-1.00 E-5 -(0.23)	-8.00 E-5 -(1.87)*
Intns		0.0552 (21.54)***
Intns - lg		0.0124 (6.28)***
var-post		0.0078 (1.85)*
var-post - lg		0.0033 (0.79)
var-part		0.0182 (1.75)
var-part– lg		0.0030 (0.29)
Return	-1.80 E-4 -(2.08)**	
Post		2.01 E-8 (0.75)
Vol	0.0319 (58.01)***	-0.0064 -(10.01)***
Volsq	-5.00 E-5 -(36.69)***	8.35 E-6 (6.44)***
Beg-Day	0.1289 (7.00)***	-0.0478 -(3.24)***
End-Day	-0.0206 -(1.03)	0.0472 (2.99)***
R^2 - adj	0.1279	0.1215
F - value	604.05***	369.25***
N	45,246	

**** Significant at 1% ,
** Significant at 5%,
* significant at 10%

Variable definitions are found in Table 1.

Table 8 [#]

Simultaneous Two Stage Least Squares (2SLS) Regression Results correlating Delay (column 1), Spread (column 2), and participation rate (column 3) with each other and with other explanatory variables for the benchmark file

Panel A – Prior to February 3rd 2003

Variable	Delay	Spread	Part-rate
Intercept	1.4500 (17.10)***	-3.5479 -(119.53)***	2.2983 (3.43)***
Event	0.0772 (1.00)	0.2127 (4.14)***	-0.5333 -(1.87)*
Dly			-0.8531 -(1.93)*
Sprd	0.0600 (2.92)***		0.1829 (2.40)**
Part-rate	0.0383 (2.61)***	0.0866 (5.49)***	
Dly lg	0.2171 (14.42)***		0.0906 (0.76)
Sprd - lg	0.656 (0.25)	4.1425 (19.16)***	-0.8262 -(0.85)
Part-Rate - lg		-0.0070 -(1.79)*	0.0164 (0.99)
Dum-Dly			3.0600 (1.06)
Dum-Sprd	-0.2173 -(0.27)		0.0235 (1.59)
Dum-Part-rate	-0.0183 -(0.87)	-0.0713 - (3.57)***	
Imblnce	3.64 E-4 (1.94)*	2.88 E-4 (1.79)*	-6.30 E-4 -(0.93)
Imblnce- lg	2.85 E-4 (1.54)	1.29 E-4 (0.81)	6.80 E-4 (0.99)
Intns		0.0076 (2.30)**	0.1201 (5.98)***
Intns - lg		-0.0023 -(0.86)	0.0242 (1.88)*
var-post			0.0172 (2.31)**
var-post - lg			-0.0117 -(1.56)
var-part			0.0175 (0.70)
var-part– lg			0.03332 (1.32)
Return	-6.00 E-5 -(0.54)		
Post		-7.26 E-9 -(0.02)	-5.96 E-7 -(0.43)
Vol	0.0219 (13.31)***	0.0011 (0.76)	-0.0327 -(0.34)
Dum-Vol	-0.0016 -(0.37)	0.0013 (0.35)	-0.0235 -(1.34)
Beg-Day	0.2760 (4.29)***	0.211 (3.87)***	0.1800 (0.68)
R^2 - adj	0.1246	0.1004	0.0984
F - value	44.69***	35.26***	22.79***
N	3,991		

Panel B – After February 3rd 2003

Variable	Delay	Part-rate
Intercept	1.4428 (26.07)***	2.5494 (5.85)***
Event	-0.0171 -(0.42)	-0.4317 -(2.52)**
Dly		-1.1579 -(4.20)***
Sprd	0.0176 (1.36)	0.2425 (5.74)***
Part-rate	0.0430 (5.84)***	
Dly-lg	0.2221 (24.52)***	0.30738 (4.33)***
Sprd - lg	0.0992 (0.44)	-1.5976 -(2.16)**
Part-Rate - lg		0.1275 (12.50)***
Dum-Dly		0.0391 (3.70)***
Dum-Sprd	-0.2145 -(0.26)	-2.2432 -(0.85)
Dum-Part-rate	-0.0033 -(0.24)	
Imblnce	1.31 E-4 (1.19)	-3.50 E-4 -(0.97)
Imblnce- lg	1.59 E-4 (1.44)	-6.30 E-4 - (1.76)*
Intns		0.1324 (12.45)***
Intns - lg		0.0243 (4.11)***
var-post		0.0025 (0.44)
var-post - lg		0.0072 (1.27)
var-part		0.0247 (3.31)***
var-part– lg		0.0120 (1.58)
Return	3.00 E-5 -(0.32)	
Post		-3.87 E-7 -(0.56)
Vol	0.0119 (19.02)***	-0.0037 -(1.23)
Dum-Vol	0.0027 (1.78)*	-0.0078 -(1.39)
Beg-Day	0.2454 (6.03)***	0.2284 (1.53)
R^2 - adj	0.1072	0.15084
F - value	102.40***	99.52***
N	10,980	

**** Significant at 1% ,
** Significant at 5%,
* significant at 10%