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Regulation Fair Disclosure and the Cost of Adverse Selection

ABSTRACT

Regulation FD became effective in October 2000. The Regulation is designed to create a level playing field by prohibiting selective disclosure of material private information to particular groups such as analysts and institutional investors. Several studies have concluded that Regulation FD has led to a 'chilling effect' whereby corporations disclose less information. Such a chilling effect implies that inside information becomes long lived and therefore more valuable to insiders. Hence leading to an increase in the cost of adverse selection and the probability of informed trading. We employ the bid/ask spread model of Bollen Smith and Whaley (2004) which allows us to estimate each of the components of the bid/ask spread as well as the probability of informed trading. In evidence consistent with a chilling effect, we find that the cost of adverse selection and the probability of informed trading have increased after the introduction of Regulation FD.

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1. INTRODUCTION

Regulation FD became effective in October 2000. The Regulation was introduced in response to claims that disclosure of information by corporations to selected groups (such as analysts and institutional investors) ahead of the rest the market afforded these informed parties a trading advantage. The introduction of Regulation FD is an effort by the SEC to create a level playing field by prohibiting selective disclosure of material private information to particular groups. Several studies have concluded that Regulation FD has led to a 'chilling effect' whereby corporations disclose less information. Such a chilling effect implies that inside information becomes long lived and therefore more valuable to insiders. This would in turn lead to an increase in the cost of adverse selection and the probability of informed trading. Prior work has addressed these issues in either an indirect or an incomplete fashion. We employ the bid/ask spread model of Bollen Smith and Whaley (2004) which allows us to estimate each of the components of the bid/ask spread as well as the probability of informed trading. In evidence consistent with a chilling effect, we find that the cost of adverse selection and the probability of informed trading have increased after the introduction of Regulation FD.

The rest of the paper is organized as follows. Section 2 outlines the background to the introduction of Regulation FD. Previous literature is summarized in section 3. Section 4 describes the bid/ask spread model of Bollen Smith and Whaley (2004) while section 5 describes our data and results. We summarise in section 6.

2. BACKGROUND

On August 15, 2000,[1] the Securities and Exchange Commission (SEC) introduced the Selective Disclosure and Insider Trading Regulation, to become effective on October 23, 2000.[2,3] In a section popularly referred to as "Regulation Fair Disclosure" (hereafter Regulation FD), the SEC exercised its intention to create a "level playing field" for all investors with respect to accessing price sensitive information. Regulation FD prohibits the selective disclosure of material non-public information to exclusive groups or individuals such as investment analysts or

[1] See http://www.sec.gov/answers/regfd.htm
[2] See http://www.sec.gov/rules/final/33-7881.htm
[3] Securities and Exchange Commission, Regulation FD, CFR 243, 100-243.103.

institutional investors. If material disclosures are intended through such briefings, the same information is required to be disclosed to the investing public simultaneously. In the event of any inadvertent selective disclosure of material information, a public announcement is required to be made "promptly" and certainly within 24 hours by filing a Form 8-K or through a medium capable of mass and unbiased distribution (SEC 2000a).

This regulatory change was motivated by a belief that certain segments of the investment community with access to private information had a trading advantage at the expense of the wider investing public. It is widely appreciated that corporate managers, for example, have in the past used private briefings with key analysts to guide or manage earnings forecasts of analysts so as to minimize surprises and sudden price movements on earnings announcements. Richardson et.al. (2003) document evidence of firms providing private information to analysts to manage EPS expectations and then subsequently beating analysts' forecasts. The former SEC Chairman Levitt expressed the view that this constituted artificial smoothing and delayed the price discovery process giving undue trading advantage to a favored few and their clients (SEC 2000a). He also commented that,

> *"…when information travels only to a privileged few, when that information is used to profit at the expense of the investing public, when that information comes by way of favored access rather than by acumen, insight, or diligence, we must ask, "Whose interest is really being served?" If investors see a stock's price change dramatically—but are given access to critical market-moving information only much later—we risk nothing less than the public's faith and confidence in America's capital markets."*

Arthur Levitt, Former Chairman of SEC (SEC 2000b)

Regulation FD has been plagued by a continuing debate with respect to its desirability and efficacy. The SEC argued that Regulation FD would improve investor confidence in the integrity of the capital markets by reducing the "potential for corporate management to gain or maintain favor with particular analysts or investors" (SEC 2000a). Reliance on private briefings may have compromised analysts into issuing favorable reports so as to maintain access to corporate management; the new regulation would force analysts to do more independent research. The regulation would improve information flow to the market and remove the opportunity for selective recipients to trade on private information. Finally, implementation would not be costly given recent technological developments that facilitate rapid and mass dissemination of information.

Views amongst the investment industry have been mixed, however. The Council of Institutional Investors (CII) expressed the view that Regulation FD would not reduce communications from corporations because

> *"… in order to continue attracting capital, issuers will meet the market's demand for investment information …"* (CII, 2000).

Others claim that Regulation FD will reduce the quality and quantity of information flowing to the market. They argue that firms prefer to release information to a selected audience (rather than to the investing public at large) for several reasons: firms bear proprietary costs of disclosure, as well as, litigation risk from misinterpretation of detailed or complex information releases to less skilled users. There is also a belief that analysts can be constrained to using private information purely to inform earnings forecasts and for no other purpose.[4]

Thus, critics of the regulation believe that a 'chilling' effect would result whereby corporations reduce information given to analysts and institutional investors in order to avoid legal action by the SEC. Analysts would receive less guidance on making earnings forecasts which provide a means of forming market expectations. Information would be released in standard or raw form with little value added in terms of management guidance. Without guidance from management (through the analyst community) with respect to interpretation, users would now have to make their own inferences (Weber, 2000). Similarly, the Association for Investment Management and Research (AIMR) was concerned that

> *"Corporations will almost certainly curtail the information flow to the market to avoid having to decide on the spot whether certain information will be deemed to be material after the fact by the SEC …."* (AIMR 2000).

This type of response by corporations would interfere with the potential for informed trading rapidly incorporating information into prices and improving market efficiency. It would create an environment where inside information becomes long-lived and hence more valuable to the informed. Thus, investors overall could be worse off than before Regulation FD.

However, several countervailing effects could protect against a deterioration of the information environment post-Regulation FD (Heflin, Subramanyam and Zhang, 2003). First, analysts may be able to substitute information previously supplied by management with

[4] See Irani and Karamanou (2003) for a more detailed account.

information gleaned through their independent research.[5] Second, corporations may choose to supply increased quality and quantity of information through public media. Third, Regulation FD may not be perfectly implemented and private issuance of information may continue undetected at some levels. Thus, Heflin et. al. (2003) characterize the effect of Regulation FD on the information environment as an empirical issue.

3. PRIOR LITERATURE

The preceding debate has stimulated several empirical investigations which we classify into three streams. First, are studies which investigate changes in the disclosure environment (e.g., quantity, quality and frequency of voluntary disclosure, differences in announcement effects). Second, is a stream which examines the effects of the regulation on trading volume, volatility of returns and, accuracy and dispersion of analysts' forecasts. Both streams speak to the question of whether or not there has been a "chilling effect" on information releases, induced by Regulation FD. If there has been a "chilling effect", then private information becomes more long-lived and is more valuable to informed traders and one can expect a higher, rather than a lower, probability of informed trading. A third stream of work, related to ours, is directed at the effect of the regulation on the bid/ask spread and the probability of informed trading.

3.1 Changes in the disclosure environment

Heflin, Subramanyam and Zhang (2003) provide evidence on the effect of Regulation FD on the financial information environment. In this context, they investigate (1) the informational efficiency of stock prices prior to firms' earnings announcements (i.e., the speed and extent to which prices anticipate information in upcoming announcements) and (2) the frequency of firms' voluntary disclosures. They find no evidence that information available to the market prior to earnings announcements had deteriorated after Regulation FD – if anything they find a *smaller* 'information gap'[6] between pre- and post-announcement price *after* the introduction of

[5] The AIMR (2001) survey, for example, found that a majority of members believed the accuracy of their earnings forecasts and stock recommendations would not be compromised by Regulation FD.

[6] They conceptualize the "information gap" as the absolute deviation between pre- and post-announcement stock prices (after controlling for market wide movements) both before and after Regulation FD came into effect. Specifically, they measure absolute cumulative abnormal return from 64 days before to 2 days after an earnings

Regulation FD. They also find a significant increase in the frequency of voluntary public disclosures.

Critics of the new regulations claimed that curtailment of privileged access to management guidance would make the reaching of consensus among analysts more difficult, increase the dispersion (disagreement) and reduce the accuracy of analysts' forecasts. Heflin et.al (2003) also investigate this claim and find no significant change in analyst forecast accuracy or dispersion post-Regulation FD. In contrast, others (Agrawal and Chadha, 2002; Mohanram and Sunder, 2001; Shane, Soderstrom and Yoon, 2001) report that analysts' forecasts are less accurate *and* have higher dispersion post-Regulation FD.[7] Irani and Karamanou (2003), and Bailey, Li, Mao and Zhang (2003) also report an increase in forecast dispersion. Meanwhile, Mohanram and Sunder (2001) report analysts who were ranked as All-Stars (superior analysts) are less impacted and that there is also a greater importance placed on idiosyncratic information search and analysis in the post-FD period. They assert superior analysts are, therefore, more likely to differentiate themselves in the post-FD environment and that the regulation has not negatively impacted on analysts' incentives to gather information.

Survey evidence assembled by professional bodies is largely suggestive of a "chilling effect". In a recent survey, the Security Industry Association documents that 72% of analysts interviewed believe that information flowing to the public from corporations is now of lower quality (i.e., since the implementation of Regulation FD).[8] Likewise, a March 2001 survey of members of the Association for Investment Management and Research (AIMR) revealed that 57% (14%) of its members believed that Regulation FD had reduced (increased) the *quantity* of information flow to investors. Similarly, 56% (15%) believed that the *quality* of information had decreased (increased) (AIMR, 2001). Further, 71% stated that the reduced information flow increased market volatility. In contrast, a survey by PricewaterhouseCoopers finds 80% of executives surveyed see a positive or neutral effect through the introduction of Regulation FD (PricewaterhouseCoopers, 2001).

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announcement. The smaller the "information gap" the greater the information available to the market prior to the announcement.

[7] Shane et.al. (2001) add that deterioration in forecast accuracy in the post-FD period tends to be true for forecasts issued earlier in the quarter as opposed to those issued later in the quarter. In other words, shorter-term forecasts do not suffer deterioration in accuracy.

[8] Downloaded on 17 June 2003 from: http://www.sia.com/testimony/html/kaswell5-17.html

3.2 Effect of the regulation on trading behavior

The skeptics of Regulation FD argued that less frequent information releases (compared with the previous more or less continuous flow via analysts / investment managers) would cause large variations in price (higher volatility) as opposed to gradual adjustments made with frequent disclosures. If the quantity and quality of information released also suffered, less information would lead to higher volatility. Most of the work investigating volatility of returns reports a significant decrease post-Regulation FD (Heflin, Subramanyam and Zhang, 2001; Gadarowski and Sinha, 2002; Shane et.al., 2001) or no change (Eleswarapu, Thompson and Venkataraman, 2004) rather than the predicted increase. Bailey et.al. (2003), however, find that a seeming decrease in returns volatility post-Regulation FD is due to decimalization of stock trading rather than the adoption of the regulation. Likewise, Heflin et. al. (2001) conclude that the decrease in volatility cannot be attributed to Regulation FD. Bailey et.al. (2003) report significant increases in trading volume which they attribute to differential informed judgment or difference in opinion (having controlled for decimalization).

3.3 Effect of the regulation on the bid/ask spread and the probability of informed trading

While mixed, the evidence documented above suggests that there may indeed have been a "chilling effect" post-Regulation FD. A third stream of research takes a more direct approach to the issue of information asymmetry. Sunder (2002) uses the bid/ask spread as a proxy for the level of information asymmetry between informed and uninformed traders of firms using conference calls to communicate. In the pre-FD period, he finds firms disclosing information through 'restricted' conference calls had higher bid/ask spreads (higher information asymmetry) than firms that used 'open' conference calls.[9] However, these differences do not persist in the post-FD period. While Sunder (2002) controls for other factors known to affect bid/ask spreads (trading volume, share price, depth, price volatility), his approach does not *explicitly* recognize or model information asymmetry as only one component of the spread (along with minimum tick size, order processing costs, competition and inventory-holding costs, that can vary in cross-section).

[9] Firms using 'restricted' conference calls made their calls available to analysts and institutional investors only while those using 'open' calls always held calls accessible to all investors.

Eleswarapu et.al. (2004) proxy information asymmetry using the bid/ask spread but include a measure of the order flow imbalance in the manner of Huang and Stoll (1996). Using data on trading days surrounding earnings-related announcements, they find a reduction in information asymmetry after the introduction of Regulation FD, with the reduction being most noticeable in less liquid firms. However, they do not explicitly model the other components of the bid/ask spread.

Straser (2002) uses two measures of information asymmetry: (a) the probability of informed trading based on Easley, Keifer, O'Hara and Paperman (1996); and (b) the adverse selection component of the spread derived from a modified version of Huang and Stoll (1997). The modification involves treating inventory costs as zero. This is consistent with the Easley et.al. (1996) model in which the spread is only a function of asymmetric information. The problem with this approach is that there are many components to the bid/ask spread – minimum tick size, order processing, competition and inventory-holding costs.[10] Ignoring one or more of these components is likely to produce misleading results. The main finding is that the probability of informed trading increases and the adverse selection cost component increases between the pre- and post- period.[11] Aslan (2002) also uses the Easley et.al. (1996) model and concludes that the probability of informed has decreased for medium to large firms but has increased for small firms.

The mixed results from the previous models means that it is especially important to identify all of the components of the bid/ask spread. We use the innovation in Bollen, Smith and Whaley (2004) which explicitly models the bid/ask spread as a function of minimum tick size, order processing costs, competition, inventory-holding costs, and adverse selection. Their model permits a direct estimation of the probability of informed trading. We describe this approach in the following section.

[10] Other problems with the approach are that 1) it is difficult to aggregate the PIN for individual companies into a market wide figure, and 2) the approach is not intended for use with long lived information as is likely to be the case here.

[11] Straser (2002) uses data from 68 days either side of 23 October 2000, the effective date for Regulation FD. There is no attempt to match up on a monthly or quarterly basis in the pre- and post-periods which raises concerns about seasonal patterns in corporate disclosure.

4. Bollen Smith Whaley Model Specification

The factors that drive the level of market maker bid/ask spreads are minimum tick size, order processing costs, competition, inventory-holding costs, and adverse selection costs.[12] Bollen Smith and Whaley (2004) (hereafter BSW) develop a formal model of the market maker's bid/ask spread which accounts for all of these factors. We review their model below. First, we show the inventory-holding premium that the market maker expects to incur when he consummates a trade with a public customer. Second, we analyze trades by informed and uninformed customers separately, and model the expected inventory-holding premium of each. Third, we address the issue of stochastic time to the unwinding of the market makers position. Finally, we gather all cost components of the spread into a single regression model specification.

4.1 Modeling expected inventory-holding costs

BSW assume that the market maker is concerned only with the risk of the stock price moving against him while the stock is held in inventory. They show that the required compensation for this risk, dubbed the inventory holding premium (hereafter IHP) may be computed as the probability that the stock will move against the market maker multiplied by the expected price change conditional upon the stock moving against him. Suppose the market maker takes a long position in a share of stock as a result of accommodating a customer sell order. The inventory holding premium follows straightforwardly from BSW. Since the market maker is long the stock he is concerned about the stock falling while the stock is held in inventory, that is,

$$IHP = -E\left(\Delta S \mid \Delta S < 0\right) p\left(\Delta S \mid \Delta S < 0\right). \qquad (1)$$

Note that expression (1) is an at-the-money option with expiration given by the time the stock is held in inventory. Suppose a market maker with no inventory accommodates a customer order by buying at the bid. He needs protection against the price falling below his purchase price before he can unwind his position. Conversely, if the market maker has no inventory and accommodates a customer order to buy by selling at the ask, he needs protection against the price rising above his sales price. In the first case, the market maker needs to buy an at-the-money put

[12] See Stoll (2003) and Bollen Smith and Whaley (2004) for a comprehensive review of the components of the bid/ask spread.

written on the stock, and, in the second, he needs to buy an at-the-money call. Suppose the market maker needs to buy a call. The IHP can be valued using the Black-Scholes (1973)/Merton (1973) option valuation formula. Assuming the hedge interval is sufficiently short, the risk-free rate can be ignored, and the expected loss described by (1) may be written

$$IHP = S\left[2N\left(.5s\sqrt{t}\right)-1\right]. \tag{2}$$

where S is the true stock price at the time at which the market maker opens his position, s is the standard deviation of security return, t is the time until the offsetting order, and $N(\cdot)$ is the cumulative unit normal density function.[13]

4.2 Stochastic time to offsetting trade

The difficulty in valuing the expected inventory-holding premium using (2) is that the market maker, at the time of trade, does not know when an offsetting transaction will occur. The appropriate inventory-holding premium is therefore stochastic:

$$I\tilde{H}P = S\left[2N\left(.5s\sqrt{\tilde{t}}\right)-1\right]. \tag{3}$$

For the problem at hand, however, BSW show that the expected hedging cost is approximately linear in $\sqrt{t}$. Thus, the market maker's expected *IHP* can be computed as

$$E\left(IHP\right)=S\left[2N\left(.5s\,E\left(\sqrt{t}\right)\right)-1\right], \tag{4}$$

where $E\left(\sqrt{t}\right)$ is the expected value of the square root of the time between offsetting trades. This expectation is easily estimated using transaction data and is the only aspect of the distribution of arrivals that is necessary to approximate expected *IHP*.

4.3 Informed versus uninformed traders

A market maker will demand different expected inventory-holding premia for trades with informed and uninformed traders. Assume that the market maker currently has no inventory, and

[13] Of course, the inventory-holding premium may also be valued using the put valuation formula, which leads to identical results.

a trader steps forward and buys at the market maker's posted ask price, S_{ask}. The market maker, now short a share of stock, is concerned about his expected loss should the share price increase. If the trader is *uninformed* (*U*), the expected inventory-holding premium, IHP_U, equals the value of a slightly out-of-the-money call option with an exercise price equal to S_{ask}. Presumably the true price of the underlying stock is somewhere between the bid and ask price quotes. On the other hand, if the trader is *informed* (*I*), the true price of the stock rests somewhere above the ask price, in which case the expected inventory-holding premium, IHP_I, equals the value of a slightly in-the-money call. In both cases, the valuation of the *IHP* is

$$IHP_i = S_i N\left(\frac{\ln(S_i/X)}{s\sqrt{t}} + .5s\sqrt{t}\right) - XN\left(\frac{\ln(S_i/X)}{s\sqrt{t}} - .5s\sqrt{t}\right), \qquad (5)$$

where $i = U, I$ depending upon whether the trade was with an uninformed or an informed trader.

From the market maker's perspective, the expected inventory-holding premium, *IHP*, equals the sum of the inventory-holding cost and adverse selection cost components of the spread, and can be expressed as a weighted sum of the two premia, that is,

$$IHP = (1 - p_I)IHP_U + p_I IHP_I, \qquad (6)$$

where p_I $(1 - p_I)$ is the probability of an informed (uninformed) trade. To illustrate the tradeoff between the expected costs of uninformed and informed trades, we conduct a simple simulation. First, assume that the spread equals the sum of the expected costs of trading with uninformed and informed traders, that is,

$$SPRD = (1 - p_I)IHP_U + p_I IHP_I. \qquad (7)$$

To value the *IHP* for the uninformed trader, we value a slightly out-of-the-money call option. The true stock price is assumed to equal to the midpoint of the bid/ask spread, and the exercise price is assumed to be equal to the ask price.[14] The bid/ask midpoint is assumed to be \$27.50, and the bid/ask spread is assumed to be \$.10. The volatility rate of the stock is set equal to 50%. To value the *IHP* for the informed trader, we need to compute a range of option values over a range of "true" stock prices, since the "true" stock price is unobservable. Thus, we value an ITM option, representing compensation for trading with an informed trader, for stock prices between 1% and 10% higher than the exercise price. The average time between offsetting trades is allowed to vary between 5 minutes and 30 minutes. The simulated values are reported in Table 1. Where the true price is only slightly above the ask price, the probability of an informed trade is high. But, if the "true" price exceeds the exercise price by a large amount, the probability that the trade is with an informed trader is low. The fact that the probability decreases monotonically in each column of the table reflects the tradeoff between the "true" price and the probability of an informed trade as the inventory-holding premium of the uninformed trader is constant.

4.4 Regression model specification

With a means of computing the expected *IHP* in hand, we now formally specify our regression model,

$$SPRD_i = a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_i + e_i \ , \qquad (8)$$

where $InvTV_i$ is the inverse of trading volume and MHI_i is the modified Herfindahl index. The market maker's total order-processing costs are largely fixed. This means the order-processing cost per share is directly proportional to the inverse of trading volume. As trading volume approaches infinity, the order-processing cost per share approaches zero. Competition among market makers influences the level of spread. Of the proxies used in past research, the Herfindahl index makes the most sense in that it accounts for the number of market makers in a particular stock as well as the relative activity of each market maker. In its raw form, the Herfindahl index has a range from $1/NM_i$ (perfect competition) to 1 (single monopolist), where NM_i is the number of market makers. We create and apply a modified version of the Herfindahl index,

$$MHI_i = \frac{HI_i - 1/NM_i}{1 - 1/NM_i} . \qquad (9)$$

MHI_i has a range from 0 to 1, thereby permitting the coefficient of MHI_i in our regression model (16) to have a more natural interpretation, that is, where $MHI_i = 1$, the coefficient is an

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[14] Given the symmetry of the problem, the illustration considers only trades at the ask. A complementary analysis can be conducted using a slightly out-of-the-money put whose exercise price equals the bid price.

estimate of the rent per share being charged by a monopolistic market maker and, where $MHI_i = 0$, the rent is zero.

In estimating the model, the coefficient a_1 is expected to be positive and may be quite large. After all, it represents the market maker's total order-processing costs. If the market is extremely competitive, however, the market maker may not have the ability to recover fixed costs, in which case the coefficient will be indistinguishably different from zero. The coefficient a_2 should be positive. The fewer the number of dealers and the less evenly distributed the trading volume across dealers, the higher the modified Herfindahl index, and the higher the spread. The coefficient a_3 should also be positive—the higher the expected inventory-holding premium, the greater the bid/ask spread. In this initial specification, IHP_i is estimated as a single at-the-money option, with no distinction drawn between informed and uninformed traders. With a precise estimate of the expected length of market maker's holding period, the coefficient value should be one.

The regression specification (8) has a number of virtues. First, unlike past studies, we have identified the structural relation between bid/ask spread and its determinants. As (4) shows, the marginal costs of inventory-holding and adverse selection are a specific function of share price, return volatility, and the time that the market maker expects the position to be open. Entering the variables separately on the right-hand-side of the regression equation, as has been done in past work, obfuscates their role. The standard linear or log-linear specifications used in prior studies cannot capture the relation between these variables without error.

A second virtue of our theoretical model (8) is that, unlike the models used in past studies, it is structurally consistent with the presence of an exchange-mandated tick size. The tick size of a security is its minimum allowable price increment. The importance of the tick size in this context is that it sets the lower bound of the market maker's bid/ask spread. For actively traded securities with highly competitive markets, the values of all three regressors on the right hand-side of (8) are near or at zero, and the bid/ask spread equals the intercept term a_0, that is, the stock's minimum price increment.

In the context of the pre and post Regulation FD period the regression model appears as

$$VWES_i = a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_i + a_4 d_t + a_5 InvTV_i d_t + a_6 MHI_i d_t + a_7 IHP_i d_t + e_i \quad (10)$$

where d_t is a dummy variable whose value is 0 in months preceding October 2000 and 1 in months after October 2000. The coefficient a_7 is the change in IHP between the pre and post Regulation FD period.

Other regression specifications are also considered. In estimating the inventory-holding premium, we use the average time between trades as a proxy for the market maker's expected holding period. Since trades are being executed by many market makers, our proxy understates the length of the holding period. To estimate the length of the holding period across market makers, we set the coefficient a_3 to one in (8) and estimate the length of the holding period t_i by scaling each individual stocks average square root of time between trades by a constant factor. The regression specification is

$$SPRD_i = a_0 + a_1 InvTV_i + a_2 MHI_i + IHP_i(t_i) + e_i . \quad (11)$$

Finally, our model of the inventory-holding premium is sufficiently rich that we can estimate the probability of informed versus uninformed trades across stocks. Recall that $IHP = (1 - p_I) IHP_U + p_I IHP_I$, which can be rearranged to isolate the probability of an informed trade $IHP = IHP_U + p_I (IHP_I - IHP_U)$. Thus, a regression specification that will allow us to estimate p_I is

$$SPRD_i = a_0 + a_1 InvTV_i + a_2 MHI_i + IHP_{U,i}(t_i) + a_4 (IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) + e_i . \quad (12)$$

Note that rather than using the level of the inventory-holding premium for the informed trader, we use the difference, $IHP_{I,i}(t) - IHP_{U,i}(t)$. This has two important consequences. First, it removes a serious collinearity problem that would likely exist between $IHP_{I,i}$ and $IHP_{U,i}$. Second, it allows us to interpret the estimate of a_4 as the probability of an informed trade, and we can test the hypothesis that the probability of an informed trade is different from zero.

In the context of the pre and post Regulation FD period the regression model appears as

$$\begin{aligned} VWES_i = {} & a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_{U,i}(t_i) + a_4 (IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) \\ & + a_5 d_t + a_6 InvTV_i d_t + a_7 MHI_i d_t + a_8 IHP_{U,i}(t_i) d_t + a_9 (IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) d_t + e_i \end{aligned} \quad (13)$$

where d_t is a dummy variable whose value is 0 in months preceding October 2000 and 1 in months after October 2000. The coefficient a_9 is the change in the probability of informed between the pre and post Regulation FD period.

5. AN EMPIRICAL EVALUATION

The focus now turns to estimating the model and ascertaining the probability of informed trading and the relative cost components. The first part of this section provides a description of the data used in our analyses. The second part contains a discussion of the regression results.

5.1 Data

The period of this study is May 2000 to March 2001. The trade and quote data used in this study were downloaded from NYSE's TAQ data files. Although the files contain information for all U.S. exchanges, our sample contains only NASDAQ stocks because information on the number of dealers is not available for NYSE and AMEX stocks. Historical files containing the number of dealers making markets on NASDAQ as well as their respective trading volumes are available on a monthly basis on www.NASDAQtrader.com. In June 1997, all exchanges changed the minimum price increment to one-sixteenth, in preparation for decimal pricing at the turn of the century. Finally, the switch to decimal pricing occurred in stages beginning in August 2000. By April 9, 2001, the NASDAQ move to decimal pricing was complete. For all time-stamped trades on TAQ, we matched the quotes prevailing immediately prior to the trade. From this matched file, we then computed six summary statistics for each stock each day: (a) the number of trades, (b) the end-of-day share price (i.e., the last bid/ask midpoint prior to 4:00PM EST), (c) the number of shares traded, (d) the equal-weighted quoted spread, (e) the volume-weighted effective spread, and (f) the average time between trades.

Thus far in this study, we have said little about the types of spread measures that have been used in past studies. Most prior studies examining the bid/ask spread use quoted spread, that is,

$$\text{Quoted spread}_t = \text{ask price}_t - \text{bid price}_t \, , \qquad (14)$$

where the subscript t represents the t-th trade of a particular stock during the trading day. The intuition for this measure is that, if a customer buys a stock and then immediately sells it, he would pay the quoted ask price and receive the quoted bid, thereby incurring a loss (i.e., a trading cost) equal to the bid/ask spread. This measure assumes that customers cannot trade within the quoted spread. It also assumes only market makers set the prevailing quotes and stand on the other side of customer trades. In general, past research has used the quoted spread at the end of the trading day as their variable of focus. We use an equal-weighted average of the quoted spreads (*EWQS*) appearing throughout the trading day.

More recent investigations of the spreads in the stock market have focused on effective spread.[15] The effective spread circumvents two weaknesses of the quoted spread. It is based on the notion that the trade is only costly to the investor to the extent that the trade price deviates from the "true" price, approximated by the bid/ask price midpoint,

$$\text{Midpoint}_t = \frac{(\text{bid price}_t + \text{ask price}_t)}{2} \tag{15}$$

On a round-turn, the cost would be incurred twice, hence the measure of the effective spread is

$$\text{Effective spread}_t = 2\left|\text{trade price}_t - \text{midpoint}_t\right|. \tag{16}$$

Naturally, if all trades take place at the prevailing bid and ask quotes, the effective spread is equal to the quoted spread. On the other hand, if some trades take place within the spread, the effective spread is smaller than the quoted spread.

The effective spread measure assumes that, if a trade takes place above the bid/ask midpoint, it is a customer buy order, and, if it takes place below the bid/ask midpoint, it is a customer sell order. The absolute deviation of the trade price from the bid/ask midpoint, therefore, can be interpreted as the cost incurred by the customer and/or the revenue earned by the market maker. Furthermore, the product of one-half the effective spread times the trading volume can be interpreted as the market maker revenue from the trade. While the effective spread is a better measure for customer trader costs than the quoted spread, it remains overstated in the sense that it fails to account for the fact that trades may be executed between customers

[15] See, for example, Christie, Harris, and Schultz (1994) and Huang and Stoll (1994). Lightfoot *et al* (1986) examine effective bid/ask spreads in the stock option market.

and may not involve the participation of the market maker at all. For such a trade, the effective spread equals zero, that is, the price concession conceded by one customer is awarded the other. Absent knowing the identity of both parties in the trade, however, no better measure is possible. The volume-weighted effective spread (*VWES*) is a volume-weighted average of the effective spreads of the trades occurring throughout the day.

With the six summary statistics compiled for each stock each day, we computed average values for each stock across all days in the month. To mitigate the effects of outliers, we then constrained the sample to include only stocks whose shares traded at least five times each day every day during the month. The sample contains 16,274 month stock observations, the pre sample (May 2000 – September 2000) contains 8,706 observations and the post sample (November 2000 – March 2001) contains 7,568 observations.

Three additional measures were then appended to each monthly stock trade record. First, the modified Herfindahl index was computed. This competition measure incorporates the numbers of dealers making a market as well as their respective trading volumes. Second, the rate of return volatility for each stock was computed using daily returns over the sixty trading days preceding the sample month. The returns were obtained from the CRSP daily return file, and the daily return standard deviation was annualized using the factor, $\sqrt{252}$. Finally, the inventory-holding premium for each stock was computed using expression (4), where S is the stock's average share price, s is the annualized return volatility, and $E\left(\sqrt{t}\right)$ is the average of the square root of the time between trades[16]. With more than one market maker, this estimate understates the expected inventory-holding premium. If trading volume was uniformly distributed across all dealers, we could multiply the average by the number of dealers. But, this value would cause inventory-holdings to be overstated, since only a handful of dealers account for the lion's share of the trading volume of a stock. We allow the data to infer the square root of the average time between trades later in this section[17]

[16] Since volatility is expressed on an annualized basis, the time between trades must be measured in years. To accomplish this task, we divided the number of minutes between trades by 390 (i.e., the number of minutes in a trading day) and then by 252 (i.e., the number of trading days in a year).

[17] Another approach is to infer the equivalent number of independent market makers by using the modified Herfindahl index. We note that 1-*MHI* is the proportion of market makers who are competitive. Multiplying the

5.2 Regression results

Table 2 contains a summary of the regression results for the at-the-money BSW model versus ad-hoc models previously employed to model the bid/ask spread. All of the *t*-ratios are corrected for heteroscedasticity and autocorrelation in the residuals. Panel A of Table 2 contains the results of the regressions using the equal-weighted quoted spread and Panel B contains the results of the regressions using the volume-weighted effective spread as the dependent variable. The at-the-money BSW model performs very well with adjusted R-squared in the 80 percent range. In contrast the ad hoc model where each of the variables are entered separately on the right hand side of the equation achieves adjusted R-squared only in the 40 to 50 percent range. The single most important explanatory variable appears to be the inventory-holding premium. Its coefficient estimate is greater than one, indicating that, as expected, the average time between trades is a downward biased estimate of the expected length of the market maker's holding period.[18]

We now turn to estimating the probability that a trade was executed by an informed trader. Panel A of Table 3 gives the results of the regression based on expression (10), namely,

$$VWES_i = a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_i + a_4 d_t + a_5 InvTV_i d_t + a_6 MHI_i d_t + a_7 IHP_i d_t + e_i$$

where d_t is a dummy variable whose value is 0 in months preceding October 2000 and 1 in months after October 2000. The coefficient on a_7 shows that there has been no significant change in the IHP.

Recall that IHP can be written as

$$IHP = IHP_U + p_I (IHP_I - IHP_U) .$$

Hence, it possible that the informed option might have changed in one direction and the uninformed option in the opposite direction. Panel B of Table 3 reports the results of the regression based on expression (13),

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average time between trades by 1-*MHI* and then by the number of market makers should produce the average time between trades for a typical market maker.

[18] Indeed, later in this section, we allow the data to identify the average of the square root of the time between trades.

$$VWES_i = a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_{U,i}(t_i) + a_4(IHP_{I,i}(t_i) - IHP_{U,i}(t_i))$$
$$+ a_5 d_t + a_6 InvTV_i d_t + a_7 MHI_i d_t + a_8 IHP_{U,i}(t_i) d_t + a_9(IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) d_t + e_i$$

In place of using a single at-the-money option to value the inventory-holding premium, we use an out-of-the-money option value for uniformed trades and an in-the-money option for informed trades. To value the out-of-the-money option, we assume that the true stock price is the midpoint between the bid and ask prices and that the exercise price is the bid or the ask depending on whether the customer's trade was a sale or a purchase. To value the in-the-money option, however, is more difficult. While we know the option's exercise price (i.e., the ask price on a customer purchase and the bid price on a customer sale), we do not know the true price. All that we know is that the true price exceeds the ask price on an insider purchase and is below the bid price on an insider sale. Consequently, in the regressions whose results are reported in Panel B of Table 3, we allow the true price to have a premium from one percent to fifty percent over the option's exercise price.

The results reported in the Panel B of Table 3 are interesting in a number of respects. First, as the insider's "true" price rises relative to the exercise price, the probability that the trade was executed by an insider falls. This stands to reason since the product of the insider inventory-holding premium and the probability of an informed trade is nearly constant, as was illustrated in Table 1. Indeed, the probabilities reported in Table 3 are very similar to Table 1 simulated values using plausible parameter settings. Second, note that the adjusted R-squared values do not move around much as the true price changes. Again, this is a reflection of the fact the adverse selection component in the inventory-holding premium is relatively constant. Third, the coefficient a_9 is significantly positive no matter what level of ITM for the informed option thus indicating an increase in the probability of informed trading after the introduction of Regulation FD. The value of ITM that maximizes the regressions adjusted R-squared is 42 percent.

The results reported in Table 4 show that the cost components of the spread using the method of BSW. Irrespective of the level of of ITM for the informed option they show an increase in adverse selection costs. The level of the costs are also the same across the various levels of ITM. The cost of adverse selection increases from 22 percent pre-regulation FD to 27 percent post-regulation FD.

Finally Table 5 reports results of a sub-period analysis. Panel A reports the results for 3 months apart and surrounding the intervention month. The first row shows the results for August 2000 as the first month and November 2000 as the second month. The second row shows the results for September 2000 as the first month and December 2000 as the second month. Both sets of results show a significant increase in the probability of informed trading. Panel B reports the results for 3 months apart and on either side of the intervention month. Since the results are on either side of the intervention month we would not expect to see a change in the probability of informed trading. The first row shows June 2000 as the first month and September 2000 as the second month. The second row shows November 2000 as the first month and February 2001 as the second month. Neither set of results reveals a significant increase in the probability of informed trading.

6. SUMMARY

Regulation FD, which became effective in October 2000, is designed to create a level playing field by prohibiting selective disclosure of material private information. It is intended to prevent opportunities for select investors having a trading advantage through their privileged information set. Several studies have concluded that Regulation FD has led to a 'chilling effect' whereby corporations disclose less information. Such a chilling effect implies that inside information becomes long lived and therefore more valuable to insiders. Hence leading to an increase in the cost of adverse selection and the probability of informed trading. Previous studies have found mixed results with respect to these issues. We attribute this to their use of incomplete specifications of the bid/ask spread which reflects, among other costs, the costs of adverse selection and the probability of informed trading.

We employ the bid/ask spread model of Bollen Smith and Whaley (2004) which allows us to directly estimate each of the components of the bid/ask spread as well as the probability of informed trading. In evidence consistent with a chilling effect, we find that the cost of adverse selection and the probability of informed trading have increased after the introduction of Regulation FD.

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Table 1. Simulated probability of informed trade given percent premium of true price over ask price for informed traders. Stock price is set equal to $27.50, bid/ask spread is $.10, and the volatility rate is 50 percent. Spread is assumed to be equal to

$$SPRD = (1 - p_I)IHP_U + p_I IHP_I ,$$

where p_I $(1 - p_I)$ is the probability of an informed (uniformed) trade, and IHP_I (IHP_U) is the expected inventory holding premium for informed (uninformed) trades. IHP_U is an out-of-the-money call option with the stock price equal to the bid/ask midpoint and an exercise price equal to the ask price. IHP_I is an in-the-money call option with an exercise price equal to the ask price, and a stock price equal to the exercise price plus a "Percent ITM" premium.

Percent	**Number of minutes between trades**					
ITM	5	10	15	20	25	30
1%	31.53%	27.20%	23.22%	19.45%	15.85%	12.40%
2%	15.20%	12.78%	10.74%	8.91%	7.23%	5.64%
3%	10.02%	8.34%	6.95%	5.73%	4.62%	3.58%
4%	7.47%	6.19%	5.14%	4.22%	3.39%	2.62%
5%	5.95%	4.92%	4.07%	3.34%	2.68%	2.07%
6%	4.95%	4.08%	3.38%	2.76%	2.21%	1.71%
7%	4.24%	3.49%	2.88%	2.36%	1.89%	1.46%
8%	3.70%	3.04%	2.51%	2.06%	1.64%	1.27%
9%	3.29%	2.70%	2.23%	1.82%	1.46%	1.12%
10%	2.96%	2.43%	2.00%	1.64%	1.31%	1.01%

Table 2

Summary of cross-sectional regression results of absolute quoted and effective bid/ask spreads of Nasdaq stocks. $EWQS_i$ is the equal-weighted quoted spread of stock *i*, $VWES_i$ is the volume-weighted effective spread, $InvTV_i$ is the inverse of the number of shares traded, *MHI* is the modified Herfindahl index, and IHP_i is the expected inventory-holding premium. The value of each variable, except IHP_i and *MHI*, is computed each trading day, and then the values are averaged across all days during the month. All months during the five-month period preceding Regulation FD (May 2000 through September 2000) and during the five-month period after Regulation FD (November 2000 through March 2001) are included. The value of IHP_i is computed using

$$IHP_i = S_i\left[2N\left(.5s_i\sqrt{t_i}\right)-1\right],$$

where S_i is the average share price, s_i is the annualized return volatility of the stock computed over the most recent 60 trading days prior to the estimation month, and $\overline{\sqrt{t_i}}$ is the average of the square root of the time between trades. To be included in the sample in a particular month, the stock must have traded at least five times each day in every day during the month. Panel A contains the regression results where the equal-weighted quoted spread is used as the dependent variable, and Panel B contains the results for the volume-weighted effective spread. The Bollen-Smith-Whaley regression specification is

$$BSW: SPRD_i = a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_i + e_i\,,$$

and the ad hoc regression specification is

$$Ad\ hoc: SPRD_i = a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 S_i + a_4 s_i + a_5 \overline{t_i} + e_i\,.$$

Period	Model	No. of obs.	Adjusted R-squared	Coefficient estimates/t-ratios $\hat{a}_0 / t(\hat{a}_0)$	$\hat{a}_1 / t(\hat{a}_1)$	$\hat{a}_2 / t(\hat{a}_2)$	$\hat{a}_3 / t(\hat{a}_3)$	$\hat{a}_4 / t(\hat{a}_4)$	$\hat{a}_5 / t(\hat{a}_5)$
Panel A: Equal-weighted quoted spread									
Pre	*BSW*	8,706	0.8049	0.0517	806.49	0.0122	6.3746		
				14.12	9.82	0.62	32.02		
Post	*BSW*	7,568	0.7646	0.0419	788.08	0.0525	6.3376		
				16.56	9.23	3.27	32.26		
Full	*BSW*	16,274	0.7923	0.0462	784.05	0.0362	6.3882		
				20.14	11.73	2.58	42.09		
Pre	*Ad hoc*	8,706	0.4002	0.0344	3885.92	0.3636	0.0027	0.0189	-541.33
				2.58	11.09	10.15	8.45	3.91	-6.16
Post	*Ad hoc*	7,568	0.5199	0.0394	3400.80	0.3319	0.0029	-0.0052	-377.31
				3.59	12.80	11.79	9.67	-1.36	-6.08
Full	*Ad hoc*	16,274	0.4465	0.0375	3628.91	0.3722	0.0028	0.0032	-464.89
				3.31	14.61	14.16	9.62	0.83	-7.30
Panel B: Volume-weighted effective spread									
Pre	*BSW*	8,706	0.7772	0.0412	786.57	-0.0194	4.4632		
				11.39	10.61	-1.28	21.16		
Post	*BSW*	7,568	0.7484	0.0347	708.98	0.0287	4.5269		
				14.81	10.58	2.32	24.47		
Full	*BSW*	16,274	0.7682	0.0379	749.86	0.0042	4.4893		
				16.37	13.57	0.39	28.1		
Pre	*Ad hoc*	8,706	0.4029	0.029	3026.07	0.2335	0.0019	0.014	-415.80
				2.99	10.24	9.48	8.11	4.15	-6.11
Post	*Ad hoc*	7,568	0.5231	0.0324	2624.86	0.2341	0.002	-0.0032	-292.39
				3.81	12.74	11.48	8.99	-1.11	-6.28
Full	*Ad hoc*	16,274	0.4496	0.0315	2824.90	0.2479	0.0019	0.0029	-361.06
				3.78	14.08	13.67	9.18	1.07	-7.53

Table 3

Summary of cross-sectional regression results of absolute effective bid/ask spreads of Nasdaq stocks. $VWES_i$ is the volume-weighted effective spread, $InvTV_i$ is the inverse of the number of shares traded, *MHI* is the modified Herfindahl index, and IHP_i is the expected inventory-holding premium. The value of each variable, except IHP_i and *MHI*, is computed each trading day, and then the values are averaged across all days during the month. The value of IHP_i is computed using

$$IHP_i = S_i \left[2N\left(.5s_i \overline{\sqrt{t_i}} \right) - 1 \right],$$

where S_i is the average share price, s_i is the annualized return volatility of the stock computed over the most recent 60 trading days prior to the estimation month, and $\overline{\sqrt{t_i}}$ is the average of the square root of the time between trades. To be included in the sample, the stock must have traded at least five times each day in every day during the month. All months during the five-month period preceding Regulation FD (May 2000 through September 2000) and during the five-month period after Regulation FD (November 2000 through March 2001) are included. Panel A contains the results from the estimation of

$$VWES_i = a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_i + a_4 d_t + a_5 InvTV_i d_t + a_6 MHI_i d_t + a_7 IHP_i d_t + e_i,$$

where d_t is a dummy variable whose value is 0 in months preceding October 2000 and 1 in months after October 2000. Panel B contains the results from the estimation of

$$\begin{aligned} VWES_i = {} & a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_{U,i}(t_i) + a_4 (IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) \\ & + a_5 d_t + a_6 InvTV_i d_t + a_7 MHI_i d_t + a_8 IHP_{U,i}(t_i) d_t + a_9 (IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) d_t + e_i, \end{aligned}$$

where $IHP_{U,i}$ is the expected inventory-holding premium for trades with uninformed traders and $IHP_{I,i}$ is the expected inventory-holding premium for trades with informed traders. For a trade at the ask, the value of $IHP_{k,i}$ is computed using

$$IHP_{k,i} = S_{k,i} N\left(\frac{\ln\left(S_{k,i}/X_i\right)}{s_i \overline{\sqrt{t_i}}} + .5s_i \overline{\sqrt{t_i}} \right) - X_i N\left(\frac{\ln\left(S_{k,i}/X_i\right)}{s_i \overline{\sqrt{t_i}}} - .5s_i \overline{\sqrt{t_i}} \right).$$

$IHP_{U,i}$ is valued as an out-of-the-money call option with an exercise price equal to the ask price and a stock price equal to the bid/ask midpoint. $IHP_{I,i}$ is valued as an in-the-money (ITM) call option with an exercise price equal to the ask price and a stock price Percent ITM above the exercise price. For a trade at the bid, the *IHP* is valued using a put option formula with an exercise price equal to the bid price.

Panel A: Single composite inventory -holding premium

No. of obs.	Adjusted R-squared	Coefficient estimates/t-ratios							
		$\hat{\alpha}_0/(t)$	$\hat{\alpha}_1/(t)$	$\hat{\alpha}_2/(t)$	$\hat{\alpha}_3/(t)$	$\hat{\alpha}_4/(t)$	$\hat{\alpha}_5/(t)$	$\hat{\alpha}_6/(t)$	$\hat{\alpha}_7/(t)$
16,274	0.7685	0.0412	786.56	-0.0194	4.4632	-0.0065	-77.56	0.0481	0.0637
		11.39	10.67	-1.28	21.18	-1.61	-0.85	2.72	0.24

Panel B: Separate inventory-holding premia for uninformed and informed traders

Percent ITM	No. of obs.	Adjusted R-squared	Coefficient estimates/t-ratios									
			$\hat{\alpha}_0/(t)$	$\hat{\alpha}_1/(t)$	$\hat{\alpha}_2/(t)$	$\hat{\alpha}_3/(t)$	$\hat{\alpha}_4/(t)$	$\hat{\alpha}_5/(t)$	$\hat{\alpha}_6/(t)$	$\hat{\alpha}_7/(t)$	$\hat{\alpha}_8/(t)$	$\hat{\alpha}_9/(t)$
1	16,274	0.7142	0.0431	740.69	0.0080	1.3170	0.1384	-0.0170	168.23	0.0761	-0.1292	0.0431
			10.15	7.92	0.34	13.77	10.83	-4.08	1.33	3.22	-1.10	3.63
5	16,274	0.7167	0.0424	748.38	0.0097	1.3221	0.0278	-0.0168	163.28	0.0754	-0.1270	0.0086
			10.00	7.99	0.42	13.76	10.98	-4.03	1.29	3.18	-1.08	3.63
10	16,274	0.7173	0.0423	749.38	0.0101	1.3097	0.0139	-0.0168	163.10	0.0753	-0.1306	0.0043
			9.98	8.00	0.43	13.57	10.98	-4.03	1.29	3.18	-1.11	3.64
20	16,274	0.7173	0.0423	749.49	0.0101	1.3028	0.0070	-0.0169	163.16	0.0754	-0.1327	0.0022
			9.98	8.00	0.43	13.48	10.98	-4.03	1.30	3.18	-1.13	3.64
30	16,274	0.7173	0.0423	749.46	0.0101	1.3004	0.0046	-0.0169	163.23	0.0754	-0.1335	0.0014
			9.98	8.00	0.43	13.45	10.98	-4.03	1.30	3.18	-1.13	3.65
40	16,274	0.7173	0.0423	749.48	0.0101	1.2993	0.0035	-0.0169	163.18	0.0754	-0.1338	0.0011
			9.98	8.00	0.43	13.43	10.98	-4.03	1.30	3.18	-1.13	3.64
50	16,274	0.7173	0.0423	749.50	0.0101	1.2986	0.0028	-0.0169	163.13	0.0753	-0.1340	0.0009
			9.98	8.00	0.43	13.43	10.98	-4.03	1.29	3.18	-1.14	3.64
42	16,274	0.7173	0.0423	749.49	0.0101	1.2991	0.0033	-0.0169	163.16	0.0753	-0.1338	0.0010
			9.98	8.00	0.43	13.43	10.98	-4.03	1.30	3.18	-1.13	3.64

Table 4

Summary of cost components of absolute effective bid/ask spreads of NASDAQ stocks. The notation is defined as follows: $VWES_i$ is the volume-weighted effective spread, $InvTV_i$ is the inverse of the number of shares traded, MHI is the modified Herfindahl index , and IHP_i is the expected inventory holding premium. The value of each variable, except IHP_i and MHI, is computed each trading day and then the values are averaged across all days during the month. To be included in the sample, the stock must have traded at least five times each day in every day during the month. The estimates are for the regression,

$$SPRD_i = a_0 + a_1 InvTV_i + a_2 MHI_i + IHP_{U,i}(t_i) + a_4(IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) + e_i,$$

where $IHP_{U,i}$ is the expected inventory holding premium for trades with uninformed traders and $IHP_{I,i}$ is the expected inventory holding premium for trades with informed traders. The regression is run in both the pre period (May 2000 – September 2000) and the post period (November 2000 – March 2001). Cost components are computed using the method outlined in Bollen Smith and Whaley (2003).

% ITM	Period	Minimum tick size	Order processing cost	Competitio	Inventory holding costs	Adverse selection costs
1	PRE	32.63%	9.04%	0.72%	35.54%	22.07%
1	POST	22.79%	12.63%	7.89%	29.74%	26.95%
5	PRE	32.09%	9.13%	0.88%	35.67%	22.23%
5	POST	22.33%	12.67%	7.99%	29.93%	27.07%
10	PRE	32.01%	9.14%	0.91%	35.34%	22.59%
10	POST	22.24%	12.68%	8.02%	29.52%	27.53%
20	PRE	32.00%	9.14%	0.92%	35.16%	22.78%
20	POST	22.23%	12.69%	8.03%	29.29%	27.76%
30	PRE	32.00%	9.14%	0.92%	35.09%	22.84%
30	POST	22.23%	12.69%	8.03%	29.22%	27.84%
40	PRE	32.00%	9.14%	0.92%	35.06%	22.88%
40	POST	22.23%	12.69%	8.03%	29.18%	27.88%
50	PRE	32.00%	9.14%	0.92%	35.04%	22.89%
50	POST	22.23%	12.69%	8.03%	29.16%	27.90%

Table 5

Summary of cross-sectional regression results of absolute quoted and effective bid/ask spreads of Nasdaq stocks. $VWES_i$ is the volume-weighted effective spread, $InvTV_i$ is the inverse of the number of shares traded, *MHI* is the modified Herfindahl index, and IHP_i is the expected inventory-holding premium. The value of each variable, except IHP_i and *MHI*, is computed each trading day, and then the values are averaged across all days during the month. All months during the five-month period preceding Regulation FD (May 2000 through September 2000) and during the five-month period after Regulation FD (November 2000 through March 2001) are included. The regression specification is

$$\begin{aligned} VWES_i = {} & a_0 + a_1 InvTV_i + a_2 MHI_i + a_3 IHP_{U,i}(t_i) + a_4 (IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) \\ & + a_5 d_t + a_6 InvTV_i d_t + a_7 MHI_i d_t + a_8 IHP_{U,i}(t_i) d_t + a_9 (IHP_{I,i}(t_i) - IHP_{U,i}(t_i)) d_t + e_i \end{aligned}$$

where d_t is a dummy variable whose value is 0 in months preceding October 2000 and 1 in months after October 2000. $IHP_{U,i}$ is the expected inventory-holding premium for trades with uninformed traders and $IHP_{I,i}$ is the expected inventory-holding premium for trades with informed traders. The value of $IHP_{k,i}$ is computed using

$$IHP_{k,i} = S_{k,i} N\left(\frac{\ln\left(S_{k,i}/X_i\right)}{s_i \overline{\sqrt{t_i}}} + .5 s_i \overline{\sqrt{t_i}} \right) - X_i N\left(\frac{\ln\left(S_{k,i}/X_i\right)}{s_i \overline{\sqrt{t_i}}} - .5 s_i \overline{\sqrt{t_i}} \right),$$

where s_i is the annualized return volatility of the stock computed over the most recent 60 trading days prior to the estimation month, $\overline{\sqrt{t_i}}$ is the average of the square root of the time between trades. $IHP_{U,i}$ is valued as an out-of-the-money call option with an exercise price equal to the ask price and a stock price equal to the bid/ask midpoint. $IHP_{I,i}$ is valued as a 5% in-the-money (ITM) call option with an exercise price equal to the ask price and a stock price.

First month	*Second month*	*No. of obs.*	*Adjusted R-squared*	$\hat{a}_0/(t)$	$\hat{a}_1/(t)$	$\hat{a}_2/(t)$	$\hat{a}_3/(t)$	$\hat{a}_4/(t)$	$\hat{a}_5/(t)$	$\hat{a}_6/(t)$	$\hat{a}_7/(t)$	$\hat{a}_8/(t)$	$\hat{a}_9/(t)$
Panel A: Three months apart and surrounding intervention month													
Aug-00	Nov-00	3,215	0.6748	0.0414	1367.42	0.0253	1.0561	0.0148	-0.0081	252.48	0.0625	0.0355	0.0078
				7.73	10.03	0.66	10.56	6.20	-1.85	1.39	1.67	0.24	2.85
Sep-00	Dec-00	3,292	0.6796	0.0410	1062.24	0.0875	1.0856	0.0133	-0.0045	691.32	-0.0206	-0.0548	0.0081
				7.24	6.61	3.23	12.10	8.11	-0.68	2.90	-0.52	-0.29	2.24
Panel B: Three months apart and on either side of intervention month													
Jun-00	Sep-00	3,499	0.6558	0.0386	1358.69	0.0413	1.0411	0.0170	0.0030	-261.00	0.0497	0.1891	-0.0029
				9.05	7.44	1.44	12.20	8.45	0.44	-1.14	1.34	1.52	-1.65
Nov-00	Feb-01	3,023	0.6708	0.0336	1659.17	0.0908	1.1978	0.0236	-0.0022	-703.22	-0.0313	-0.3494	-0.0035
				7.56	10.86	3.34	6.18	7.27	-0.47	-4.13	-0.96	-1.79	-1.02