DOI: 10.1111/j.1475-679X.2008.00286.x
Journal of Accounting Research
Vol. 46 No. 3 June 2008
*Printed in U.S.A.*

# Regulation Fair Disclosure and the Cost of Adverse Selection

BALJIT SIDHU,* TOM SMITH,† ROBERT E. WHALEY,‡ AND RICHARD H. WILLIS‡

Received 1 July 2005; accepted 17 August 2007

ABSTRACT

Regulation Fair Disclosure (FD), imposed by the Securities and Exchange Commission in October 2000, was designed to prohibit disclosure of material private information to selected market participants. The informational advantage such select participants gain is unclear. If multiple "insiders" receive identical information, private information is immediately incorporated in price and each insider has zero expected profit. If, on the other hand, Regulation FD has curtailed the flow of information from firms, private information becomes longer-lived and more valuable. Hence, market makers will demand increased compensation by widening the adverse selection component of the bid-ask spread. We identify the cost components of the bid-ask spread for a sample of NASDAQ stocks surrounding the implementation of Regulation FD. Controlling for other factors affecting the spread, we find that adverse selection costs increase approximately 36% after Regulation FD. We interpret our finding as Regulation FD failing to achieve one of its desired objectives.

*University of New South Wales; †Australian National University; ‡Owen Graduate School of Management, Vanderbilt University. Comments and suggestions by Peter Clarkson, Patricia Dechow, Neil Fargher, Doug Foster, Lynn Gallagher, Barry Oliver, and Terry Walter as well as seminar participants at the University of Queensland, the University of New South Wales Conference on Information Quality and Markets, the University of Western Australia, the AGSM Accounting and Finance Research Camp, the London Business School, the London School of Economics, the University of Sydney, the University of Tilburg, the University of Otago, and the 2004 Accounting and Finance Association of Australia and New Zealand meetings are gratefully acknowledged.



Copyright ©, University of Chicago on behalf of the Institute of Professional Accounting, 2008

## 1. Introduction

We estimate the probability of informed trading and the cost of adverse selection in the period surrounding the implementation of Regulation Fair Disclosure (FD) by examining the cost components of market maker bid-ask spreads in the NASDAQ market.[1] We focus on NASDAQ stocks to avoid the confounding effects of decimalization for New York Stock Exchange (NYSE) stocks, which occurred in proximity to the effective date of Regulation FD. In contrast to prior research investigating this issue for NYSE-listed securities (Eleswarapu, Thompson, and Venkataraman [2004]), our evidence indicates, after controlling for other factors affecting the market maker's spread, Regulation FD has led to an increase in adverse selection costs.

The Securities and Exchange Commission's (SEC) *Selective Disclosure and Insider Trading Regulation* became effective on October 23, 2000.[2] In a section popularly referred to as *Regulation Fair Disclosure* (Regulation FD), the SEC expressed its intention to create a level playing field for *all* investors in accessing price-sensitive information. Regulation FD prohibits the disclosure of material nonpublic information to selective groups or individuals such as financial analysts or institutional investors. If material disclosures are intended through such briefings, the same information must be disclosed simultaneously to the investing public.[3]

The motivation for imposing Regulation FD was the SEC's view that certain members of the investment community with access to private information had a trading advantage relative to the wider investing public. Economic theory offers little support for the SEC's position. Holden and Subrahmanyam [1992] and Foster and Viswanathan [1996], for example, show that if there are multiple informed traders with identical information then that news is immediately incorporated into share price and insiders' expected profits are zero. Thus, analysts and their clients receive no benefit from the private briefing.[4] Nonetheless, former SEC Chairman Levitt argued that such

---

[1] A number of terms are used interchangeably with "adverse selection" in describing the risk premium that market makers levy to cover losses they realize from trading against individuals who possess superior information regarding the security's value. Bagehot [1971], who originally introduced the concept, called it an "information cost." "Cost of informed trading" provides the clearest description. "Informational asymmetry cost" highlights the difference between the costs of trading with informed versus uninformed market participants.

[2] See http://www.sec.gov/rules/final/33–7881.htm and http://www.sec.gov/news/extra/seldisal.htm.

[3] If an inadvertent selective disclosure of material information occurs, a public announcement is required within 24 hours in a Form 8-K filing or through a medium capable of mass and unbiased distribution (see SEC [2000a]).

[4] Foster and Viswanathan [1996] also show that, if the information is not identical and not perfectly correlated, insiders can exploit the information and earn some of the potential profits—the amount depending upon the degree of correlation of the insiders' information. The SEC, however, in promulgating Regulation FD, appears to define selective disclosure in the vein of multiple informed traders with identical information. In discussing its proposed rule regarding selective disclosure, for example, the Commission stated, "In practice, issuers

selective disclosure delayed the price discovery process, giving undue trading advantage to a favored few and their clients (see SEC [2000a]). He also commented,

> . . . 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 the SEC. See SEC [2000b]).

The SEC argues that Regulation FD will 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" (see SEC [2000a]). Thus, the regulation will improve information flow to the *entire* market and remove the opportunity for select recipients to trade on the private information.[5] Moreover, whereas reliance on private briefings may compromise analysts into issuing favorable reports to maintain access to corporate management, the new regulation forces analysts to do more independent research.[6] Mohanram and Sunder's [2006] findings are consistent with this motivation; they find that analysts invest more in idiosyncratic information search post–Regulation FD and also reduce the number of firms they follow—presumably to compensate for the additional effort they must exert in information gathering and analysis in a post–Regulation FD world.[7]

Critics of Regulation FD, on the other hand, argue that it will have a "chilling effect," with firms reducing the quality and quantity of information flowing to the market. For example, firms may prefer to release information to a selected audience rather than broadly to reduce the proprietary costs of disclosure and limit the litigation risk that may arise from misinterpretation of information releases by less skilled users. In this vein, the Association

---

also retain control over the audience and forum for some important disclosures. If a disclosure is made at a time when no Commission filing is immediately required, the issuer determines how and to whom to make its initial disclosure. As a result, issuers sometimes choose to disclose information selectively—i.e., to a small group of analysts or institutional investors—before making broad public disclosure by a press release or Commission filing" (http://www.sec.gov/rules/proposed/34–42259.htm).

[5] Admati and Pfleiderer [1988] show that informed trading reduces market liquidity and increases price volatility.

[6] Hutton [2004] finds that, pre–Regulation FD, selective disclosure was more common when it was most likely to be useful, in settings where: financial statements were less informative (high market-to-book ratios), accounting earnings were more important to valuation but difficult to predict, and capital market intermediation was high.

[7] Mohanram and Sunder [2006] conclude that, in making higher investments in idiosyncratic information search, analysts reduce (increase) their coverage of previously well (less) followed firms.

for Investment Management and Research (now the Chartered Financial Analyst Institute) argues,

> 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 . . . . (See AIMR [2000])[8]

Such a response could lead to longer-lived, and hence more valuable, management inside information. Moreover, the information that is released would tend to be disseminated in standard or raw form with little value added in terms of management guidance. Without guidance from management (through the financial analyst community), users must make their own inferences (see Weber [2000]).[9]

Direct measures of the cost of information asymmetry are few. One possibility is to infer it from the market maker's bid-ask spread. The market maker's bid-ask spread is a function of order-processing costs, inventory-holding costs, competition, and adverse selection costs. If the first three components are unaffected by Regulation FD, a change in spread surrounding the regulation must be driven by a change in adverse selection costs. Sunder [2002] uses the relative bid-ask spread as a proxy for the level of information asymmetry between informed and uninformed traders of firms hosting conference calls. In the pre–Regulation FD period, he finds firms disclosing information through "restricted" conference calls have higher bid-ask spreads (higher information asymmetry) than firms that use "open" conference calls.[10] These differences do not persist in the post–Regulation FD period, leading him to conclude that the playing field has been leveled. Sunder's [2002] regression model, however, does not explicitly isolate the adverse selection cost component of the bid-ask spread. Thus, his results can also be driven by cross-sectional variation in any of the other components

---

[8] These disparate views are mirrored in survey evidence. For example, the Security Industry Association (SIA) found that 72% of analysts interviewed believe that information flowing to the public from corporations is now of lower quality. Likewise, a March 2001 survey of AIMR members revealed that 57% (14%) of its members believe that Regulation FD has reduced (increased) the *quantity* of information flow to investors; 56% (15%) believe that the *quality* of information has decreased (increased). Furthermore, 71% state that the reduced information flow increases market volatility (see AIMR [2001]). A survey by PricewaterhouseCoopers finds 80% of executives surveyed see a positive or neutral effect through the introduction of Regulation FD (PricewaterhouseCoopers [2001]).

[9] Such a response (a "chilling effect") by itself acts to increase the probability of informed trading post–Regulation FD, regardless of whether prior analysts' briefings involve multiple analysts or not. Thus, the "multiple informed traders with identical information" assumption of the Holden and Subrahmanyam [1992] and Foster and Viswanathan [1996] models is not central to the theoretical argument suggesting the SEC's concerns regarding a trading advantage are unfounded. We are grateful to an anonymous referee for pointing this out to us.

[10] Firms using "restricted" or "closed" conference calls make their calls available to analysts and institutional investors; firms using "open" calls make such calls accessible to all investors.

of the bid-ask spread including order-processing costs, inventory-holding costs, and competition.[11]

Eleswarapu, Thompson, and Venkataraman [2004] proxy for information asymmetry using not only the relative bid-ask spread but also a measure of the order flow imbalance.[12] 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 for less liquid firms. Straser [2002] attempts to focus more directly on information asymmetry by measuring (1) the probability of informed trading based on Easley et al. [1996], and (2) the adverse selection component of the spread derived from a modified version of Huang and Stoll [1997]. He finds that both approaches show that the probability of informed trading does not change significantly between the pre– and post–Regulation FD periods. Aslan [2002] also uses the Easley et al. [1996] model and concludes that the probability of informed trading decreases for medium and large firms but increases for small firms. In summary, prior work presents conflicting evidence regarding changes in information asymmetry surrounding Regulation FD. Some studies note a decrease (e.g., Aslan [2002] for medium and large firms, Eleswarapu, Thompson, and Venkataraman [2004], Sunder [2002]), some work finds an increase (e.g., Aslan [2002] for small firms), and some research documents no change (e.g., Straser [2002].

Furthermore, these approaches depend on theoretical (or empirical) models that assume that the only time-series variation in spread is driven by informational asymmetry. Temporal movements in order-processing costs, inventory-holding costs, and competition are assumed constant. Without explicitly modeling the effects of these variables, the results must be interpreted cautiously. To overcome these limitations, we adopt the bid-ask spread regression model developed in Bollen, Smith, and Whaley [2004] (hereafter, BSW). This model, summarized in the appendix, decomposes the market maker's spread into costs attributable to order-processing, inventory-holding, adverse selection, and market maker competition. In contrast to Eleswarapu, Thompson, and Venkataraman [2004], our evidence indicates that, after controlling for other factors affecting the market maker's spread, Regulation FD has led to an increase in adverse selection costs. Our results are robust to a number of sensitivity checks. We interpret our finding as market makers responding in a manner inconsistent with the SEC's "level playing field" and "improved investor confidence" objectives in imposing Regulation FD; that is, market makers respond as if information asymmetry is increased, not diminished, after the implementation of Regulation FD.

[11] The use of relative spread in a regression model that includes an intercept is problematic (see Bollen, Smith, and Whaley [2004]).

[12] Following Huang and Stoll [1996], they measure percentage price impact as 200 times the relative movement in the bid-ask midpoint in the 30 minutes following a trade.

The paper proceeds as follows. In section 2, we summarize prior research. We describe the sample in section 3, and section 4 contains the empirical work. In section 5, we assess the robustness of our finding, then conclude in section 6. A brief description of the BSW model is contained in the appendix.

## 2. *Prior Research*

Our study is related to prior research examining changes surrounding Regulation FD in firms' information environments and investors' trading behavior.

### 2.1 CHANGES IN FIRMS' INFORMATION ENVIRONMENTS

Several studies assess the impact on firms' information environments by investigating changes surrounding Regulation FD in the accuracy and dispersion of analysts' earnings forecasts and the market response to analysts' reports. If analysts' access to management is (1) an important source of information and (2) curtailed by Regulation FD, we would expect a reduction (increase) in the accuracy (dispersion) of their earnings forecasts and a reduction in the share price response to their reports. Prior research generally confirms these conjectures.

An early study by Heflin, Subramanyam, and Zhang [2003a] finds no significant change in forecast accuracy and dispersion. Later work, however, suggests that analysts' forecasts have become less accurate and more dispersed[13] in the post–Regulation FD period (Agrawal, Chadha, and Chen [2005]). Furthermore, the deterioration in forecast accuracy tends to (1) be associated with forecasts issued earlier in the quarter (Shane, Soderstrom, and Yoon [2001], Agrawal, Chadha, and Chen [2005]), (2) be more pronounced for smaller companies (Agrawal, Chadha, and Chen [2005], Gomes, Gorton, and Madureira [2006]), (3) increase with the passage of time since Regulation FD's enactment (Agrawal, Chadha, and Chen [2005]), and (4) occur for those analysts thought to have had preferential access to firms (Mohanram and Sunder [2006]).

Again, consistent with Regulation FD reducing information provided by managers to analysts, Gintschel and Markov [2004] find that the absolute price response to information disseminated by financial analysts is 28% lower in the post–Regulation FD period (see also Tehranian and Yalcin [2004]). Moreover, the drop is systematically higher for (1) those constituencies thought to have most benefited from preferential access to management prior to Regulation FD, (2) highly ranked (by *Institutional Investor*) brokerage houses and optimistic analysts, and (3) firms more difficult to value with publicly available information, those with larger idiosyncratic risk. Furthermore, credit analysts, a group exempt from the provisions of Regulation FD,

[13] Irani and Karamanou [2003] and Bailey et al. [2003] also report an increase in forecast dispersion after Regulation FD.

appear to have become "privileged conduits of selective disclosure to the public" (Jorion, Liu, and Shi [2005, p. 329]). Jorion et al. [2005] find that, after Regulation FD, both rating downgrades and upgrades have a large stock price impact. They conclude that Regulation FD confers a strategic advantage to credit ratings agencies.

Research investigating share price responses to earnings announcements surrounding Regulation FD has yielded mixed conclusions. Heflin, Subramanyam, and Zhang [2003a] measure the "information gap," the absolute deviation in stock price between various pre–earnings announcement days and the post–earnings announcement day after controlling for marketwide movements,[14] before and after Regulation FD. Their evidence suggests that the post–Regulation FD information available to the market prior to earnings announcements may have improved.[15] In contrast, Ahmed and Schneible [2007] find that the absolute earnings announcement period returns did *not* change in a post–Regulation FD period relative to a pre–Regulation FD period. Moreover, in cross-section, the absolute announcement period returns significantly increased after Regulation FD for high-tech firms, consistent with a decline in the information environment for these firms. They conclude that, contrary to assertions of the SEC, elimination of selective disclosure has worsened the information environment for some firms (particularly small, high-tech firms) without improving the information environment for other firms.[16]

Last, researchers have studied firms' voluntary disclosure practices, motivated by concerns that Regulation FD would induce managers to withhold information due to factors such as increased litigation risk. Inconsistent with this concern, Heflin, Subramanyam, and Zhang [2003a] find a significant increase in the frequency of voluntary public disclosures after Regulation FD and Gomes, Gorton, and Madureira [2006] report a sharp increase in the use of earnings preannouncements driven by large and mid-sized firms. Meanwhile, Bushee, Matsumoto, and Miller [2004] conclude that the Regulation did not have a significant impact on the disclosure practices of firms potentially most affected by Regulation FD, those holding closed conference calls.

[14] Specifically, they measure absolute cumulative abnormal return from 64 days before to 2 days after an earnings announcement. The smaller the "information gap," the greater the information available to the market before the earnings announcement.

[15] The drivers of Heflin et al's [2003a] finding that the information gap may have shrunk are unclear. Their findings are consistent with there being more information in preannouncement prices due to either increased public (vs. selective) corporate disclosures or a greater production of private information that is also reflected in preannouncement prices.

[16] Gadarowski and Sinha's [2005] findings also are consistent with a curtailment in selective disclosure. They investigate whether certain market participants have an unfair informational advantage at the time of voluntary disclosures by firms in the pre– and post–Regulation FD periods. They document stock price movements in the direction of the news two days prior to announcements in the pre–Regulation FD period consistent with information leakage. The leakage is significantly diminished post–Regulation FD (especially for large firms with bad news), suggesting that the regulation has been successful in reducing selective disclosure.

In summary, prior research generally characterizes the post–Regulation FD information environment as one where analysts' reports are less informative and their forecasts less accurate and more dispersed. Evidence on the association between market returns and earnings announcements is less conclusive. Contrary to early concerns, the incidence of firms engaging in voluntary disclosure in response to Regulation FD has increased or remained unchanged.

### 2.2 CHANGES IN INVESTORS' TRADING BEHAVIOR

The effects of Regulation FD on stock return volatility and trading volume have also been examined. With continuous and complete information flow, stock prices adjust quickly in an unbiased manner to new information. Hence, if Regulation FD results in more continuous and complete information to market participants, stock return volatility should decrease and trading volume should increase after Regulation FD.

The empirical evidence regarding the effect of Regulation FD on return volatility is mixed. Heflin, Subramanyam, and Zhang [2003b] and Shane, Soderstrom, and Yoon [2001] find a significant decrease in return volatility after Regulation FD, but do not account for the reduction in the minimum tick size from sixteenths to decimal that occurred during the investigation periods. Bailey et al. [2003] correct for this problem and find no significant change in return volatility (see also Eleswarapu, Thompson, and Venkataraman [2004]). Bailey et al. [2003] also examine trading volume before and after the implementation of Regulation FD. They report a significant increase in trading volume in the post–Regulation FD period after controlling for the effects of decimalization.

## *3. Sample*

Measuring the effects of Regulation FD is complicated by the shift to decimalization in the months surrounding October 2000, affecting our ability to accurately measure the bid-ask spread and its components.[17] The NYSE began to switch from sixteenths to decimal pricing in August 2000 and did not complete the transition until January 2001. To avoid the confounding effects of decimalization, we focus on NASDAQ stocks, for which the change to decimal pricing did not occur until April 9, 2001.[18] The use of NASDAQ stocks has the additional advantage that monthly information on the number of market makers for each stock used in our empirical models is available (see http://www.Nasdaqtrader.com).

[17] Bailey et al. [2003] argue that studies that document a reduction in return volatility in the post–Regulation FD period are attributable to the move to decimal pricing.

[18] Fifteen NASDAQ stocks began trading in decimal on March 12, 2001, with an additional 177 stocks beginning March 26, 2001. The remaining 4,650 stocks were converted to decimal pricing on April 9, 2001.

We define the pre–Regulation FD period as May 2000 through September 2000 and the post–Regulation FD period as November 2000 through March 2001. For all time-stamped trades available from NYSE's Trade and Quote (TAQ) data files, we matched the quotes prevailing immediately before each trade. From this matched file, we compute five summary statistics for each stock each day:[19] (1) the end-of-day share price, *S* (the last bid-ask midpoint prior to 4:00 p.m. EST), (2) the number of shares traded, *TV*, (3) the average of the square root of the time between trades, *Sqrt t*, (4) the equal-weighted quoted spread, *EWQS*, and (5) the volume-weighted effective spread, *VWES*. We compute two measures of spread to assess the robustness of our results.

We measure the equal-weighted quoted spread (*EWQS*) as the arithmetic average of the prevailing quoted spreads at the time of each transaction $t$ of a particular stock during the trading day:

$$Quoted\ spread_t = ask\ price_t - bid\ price_t. \quad (1)$$

Our second spread measure, volume-weighted effective spread (*VWES*), is a volume-weighted average of the effective spreads of the trades occurring throughout the day. This metric assumes that the trade is only costly to the investor if the trade price deviates from the true price, approximated by the bid-ask price midpoint:

$$Midpoint_t = \frac{(bid\ price_t + ask\ price_t)}{2}. \quad (2)$$

On a round-trip basis, the cost is incurred twice; hence, the measure of the effective spread is:[20]

$$Effective\ spread_t = 2|trade\ price_t - midpoint_t|. \quad (3)$$

With the five summary statistics compiled for each stock each day, we compute average values for each stock across all days in the month and append three measures to each monthly stock record.

First, the modified Herfindahl Index (HI) is computed:

$$HI = \sum_{i=1}^{ND} \left(\frac{V_i}{V}\right)^2, \quad (4)$$

The HI incorporates the numbers of dealers making a market in a particular stock, *ND*, as well as their respective trading volumes, $V_i$.

Second, the rate of return volatility for each stock, $\sigma$, is computed using daily returns over the 60 trading days before the sample month. The returns are obtained from the Center for Research in Security Prices daily return

[19] To mitigate the effects of outliers, we constrain the sample to include only stocks whose shares trade at least five times each day in every day during the month.

[20] If all trades take place at the prevailing bid and ask quotes, the effective spread equals the quoted spread. If some trades take place within the spread, the effective spread is smaller than the quoted spread.

file, and the daily return standard deviation is annualized using the factor $\sqrt{252}$.

Third, the inventory-holding premium for each stock, *IHP*, is computed using

$$IHP = S[2N(.5\sigma E(\sqrt{t})) - 1], \quad (5)$$

where $S$ is the stock's average share price over the month, $\sigma$ is the expected annualized return volatility, and $E(\sqrt{t})$ is the expected value of the square root of the time between trades.[21] With more than one market maker, this estimate causes the expected inventory-holding premium to be understated. If trading volume is uniformly distributed across all dealers, we can multiply the average by the number of dealers. This estimate would overstate the inventory-holding premium because a small number of dealers account for the majority of trading volume for any particular stock. Later, we use the data to infer the square root of the average time between trades.[22]

## 4. *Results*

The analyses provided in this section have three parts. First, we examine descriptive statistics for the bid-ask spread and its determinants in the periods before and after Regulation FD became effective. Second, we estimate the change in the expected cost of informed trading. Third, we partition the bid-ask spread into its basic cost components.

### 4.1 DESCRIPTIVE STATISTICS

Table 1 contains summary statistics of the bid-ask spread and its determinants. The panel on the left contains the pre–Regulation FD results ($N =$ 8,706 stock-month observations); the panel on the right contains the post–Regulation FD results ($N = 7{,}568$ stock-month observations). Focusing first on the pre–Regulation FD results, we see that the average equal-weighted quoted spread, *EWQS*, is 18.14 cents while the average volume-weighted effective spread, *VWES*, is about 13.23 cents. As expected, a large number of trades occur at prices between the bid-ask quotes, so the effective spread is lower. On a relative basis, the bid-ask spreads are 1.8% and 1.3% of share price, respectively. The average share price is $21.64, and the average number of shares traded each day is nearly 450,000. The markets for these NASDAQ stocks appear quite competitive. An average of 89 firms make markets in a typical stock. The modified HI is at the lower end of its zero/one range

[21] Because volatility is expressed on an annualized basis, the time between trades must be measured in years. To do this, we divide the number of minutes between trades by 390 (the number of minutes in a trading day) and then by 252 (the number of trading days in a year).

[22] Another approach is to infer the equivalent number of independent market makers by using the modified Herfindahl Index. $1 - MHI$ is the proportion of market makers who are competitive. Multiplying the 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.

**TABLE 1**

*Summary of Descriptive Statistics of Variables Used in the Cross-sectional Regressions of Spreads for NASDAQ Stocks*

*EWQS* is the equal-weighted quoted bid-ask spread; *VWES* is the volume-weighted effective bid-ask spread; *REWQS* and *RVWES* are the equal-weighted quoted and volume-weighted effective bid-ask spreads divided by share price, respectively; *S* is the share price; *TV* is the number of shares traded in thousands; *ND* is the number of dealers; *MHI* is the modified Herfindahl Index; $\sigma$, the expected volatility rate, is proxied for by the annualized return volatility of the stock computed over the most recent 60 trading days prior to the estimation month; $E(\sqrt{t})$, the expected value of the square root of the time between trades, is proxied for by $\overline{\sqrt{t}}$, the average of the square root of the number of minutes between trades; and *IHP* is expected inventory-holding premium as defined by

$$IHP = S[2N(.5E(\sqrt{t})) - 1].$$

Each observation in the sample is an average of the daily values of the variable across the days in the month. To be included in the sample for a particular month, the stock must have traded at least five times each day in every day during the month.

| | Pre–Regulation FD Period: May 2000–September 2000 No. of observations = 8,706 | | | | Post–Regulation FD Period: November 2000–March 2001 No. of observations = 7,568 | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Mean | 25% | Median | 75% | Mean | 25% | Median | 75% |
| Spread measures | | | | | | | | |
| *EWQS* | 0.1814 | 0.1004 | 0.1465 | 0.2208 | 0.1515 | 0.0852 | 0.1252 | 0.1843 |
| *VWES* | 0.1323 | 0.0772 | 0.1076 | 0.1577 | 0.1143 | 0.0681 | 0.0948 | 0.1360 |
| *REWQS* | 0.0181 | 0.0069 | 0.0128 | 0.0238 | 0.0217 | 0.0064 | 0.0125 | 0.0267 |
| *RVWES* | 0.0136 | 0.0050 | 0.0093 | 0.0178 | 0.0170 | 0.0049 | 0.0095 | 0.0207 |
| Determinants of spread | | | | | | | | |
| *S* | 21.64 | 5.65 | 13.41 | 28.11 | 17.48 | 4.44 | 12.13 | 25.06 |
| *TV* | 449.74 | 47.22 | 106.93 | 280.97 | 688.22 | 47.50 | 119.38 | 322.67 |
| *ND* | 89.06 | 43 | 67 | 110 | 79.41 | 33.75 | 56 | 97 |
| *MHI* | 0.1194 | 0.0772 | 0.1077 | 0.1454 | 0.1076 | 0.0666 | 0.0941 | 0.1306 |
| *a* | 0.9063 | 0.6222 | 0.8531 | 1.1426 | 1.0074 | 0.6496 | 0.9362 | 1.2628 |
| *Sqrt t* | 1.285 | 0.668 | 1.179 | 1.829 | 1.227 | 0.598 | 1.088 | 1.793 |
| *IHP* | 0.0181 | 0.0071 | 0.0129 | 0.0231 | 0.0144 | 0.0056 | 0.0109 | 0.0187 |

(zero reflecting perfect competition and one reflecting a monopoly). The annualized standard deviation of stock return exceeds 90%, which is high relative to historical standards. This result is expected because 2000 and 2001 were volatile years for the U.S. stock market in general, and the heavily tech-laden NASDAQ market in particular.

Comparing the results of the pre– and post–Regulation FD periods indicates that the bid-ask spread measures decrease after Regulation FD. The average *VWES* is 13.23 cents during the pre–Regulation FD period and is 11.43 cents afterward. At this juncture, it is impossible to determine the cause of the reduction. One possible explanation is that Regulation FD lowers the information asymmetry cost component of the bid-ask spread. Another explanation is that the order-processing cost per share fell as reflected by the 53% increase in average daily trading volume—from 450 thousand shares in the first period to 688 thousand in the second—and the reduction in the average of the square root of the time between trades—from 1.285 to

**TABLE 2**

*Pairwise Cross-correlations among Regression Variables for NASDAQ Stocks*

*EWQS* is the equal-weighted quoted spread, *VWES* is the volume-weighted effective spread, *InvTV* is the inverse of the number of shares traded, *MHI* is the modified Herfindahl Index, *IHP* is the expected inventory-holding premium, *TV* is the number of shares traded, *S* is the closing bid–ask price midpoint, and *PIN* is the probability of informed trading. The value of each variable (except *IHP*, *MHI*, and *PIN*) is computed each trading day and averaged across all days during the five-month period preceding Regulation FD (May 2000 through September 2000) and the five-month period after Regulation FD (November 2000 through March 2001). The values of *IHP* and *MHI* are averages across the five months in each period.

**Panel A: Pre–Regulation FD period: May 2000–September 2000**
**(No. of observations = 8,706)**

| Variable | *EWQS* | *VWES* | *InvTV* | *MHI* | *IHP* | *TV* | *S* |
|---|---|---|---|---|---|---|---|
| *EWQS* | 1 | | | | | | |
| *VWES* | 0.989 | 1 | | | | | |
| *InvTV* | 0.330 | 0.358 | 1 | | | | |
| *MHI* | 0.089 | 0.084 | 0.361 | 1 | | | |
| *IHP* | 0.889 | 0.868 | 0.239 | 0.045 | 1 | | |
| *TV* | −0.130 | −0.114 | −0.178 | −0.228 | −0.135 | 1 | |
| *S* | 0.434 | 0.414 | −0.199 | −0.315 | 0.445 | 0.258 | 1 |

**Panel B: Post–Regulation FD period: November 2000–March 2001**
**(No. of observations = 7,568)**

| *Variable* | *EWQS* | *VWES* | *InvTV* | *MHI* | *IHP* | *TV* | *S* |
|---|---|---|---|---|---|---|---|
| *EWQS* | 1 | | | | | | |
| *VWES* | 0.990 | 1 | | | | | |
| *InvTV* | 0.501 | 0.519 | 1 | | | | |
| *MHI* | 0.187 | 0.187 | 0.340 | 1 | | | |
| *IHP* | 0.862 | 0.848 | 0.430 | 0.135 | 1 | | |
| *TV* | −0.124 | −0.110 | −0.145 | −0.175 | −0.150 | 1 | |
| *S* | 0.441 | 0.425 | −0.095 | −0.232 | 0.443 | 0.166 | 1 |

1.227. Yet another possibility is that the market making in NASDAQ stocks became more competitive, with the average value of the modified HI, our measure of market competition, falling from 0.1194 before Regulation FD to 0.1076 afterward. The fact that there are competing explanations for the reduction in spread shows the danger in using changes in the level of the bid-ask spread (or relative bid-ask spread) to gauge whether Regulation FD affects adverse selection costs. In order to make such an assessment, the cost components of the spread must be separated.

The descriptive statistics in table 1 also suggest that other components of the spread have changed. The reduction in share price from the first period to the second suggests that inventory-holding costs have fallen. On the other hand, the return volatility of stocks increased on average from 90.63% to 100.74%, which means inventory-holding costs may have increased. The investor-holding premium, *IHP*, the sum of the inventory holding cost and adverse selection cost components of the spread, fell by about 20%, from 0.0181 to 0.0144.

Table 2 contains Pearson correlations for our variables of interest from which we draw the following conclusions. First, the correlation between the spread measures, *EWQS* and *VWES*, is 0.989 and 0.990 in the pre– and post–Regulation FD periods, respectively. Thus, models explaining the variation in *EWQS* also explain the variation in *VWES*. In the tests that follow, we focus on *VWES* because it is a better reflection of actual trading costs. Second, the correlations between the spread measures and the inverse of trading volume, *InvTV*, are stronger than the correlations between the spread measures and trading volume, *TV*. In the post–Regulation FD period, for example, they are 0.501 and 0.519 for the *EWQS* and *VWES*, and –0.124 and –0.110, respectively. This result is expected because this variable is intended to capture order-processing costs, which are largely fixed. Hence, their contribution to the bid-ask spread is amortized over the number of shares traded. Consequently, we use the inverse of trading volume to proxy for order-processing costs in our regression models. Third, the spread measures are strongly positively correlated with the inventory-holding premium variable *IHP*. In the pre–Regulation FD period, they are 0.889 and 0.868 for *EWQS* and *VWES*, and, in the post–Regulation FD period, they are 0.862 and 0.848. Hence, we expect that *IHP* plays an important role in explaining the variation in spread.

### 4.2 PRELIMINARY REGRESSION RESULTS

The ability to measure the adverse selection cost component of the bid-ask spread depends critically on the structural model of the spread. For this purpose, we use the BSW regression model,

$$SPRD_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_i + \varepsilon_i, \tag{6}$$

where $SPRD_i$ is the bid-ask spread of stock $i$, $InvTV_i$ is the inverse of trading volume, $MHI_i$ is the modified HI, and $IHP_i$ is the inventory-holding premium. In this model, the specific components of the bid-ask spread are: $\alpha_0$, the minimum tick size; $\alpha_1 InvTV_i$, order-processing costs; $\alpha_2 MHI_i$, competition; and $\alpha_3 IHP_i$, the sum of the inventory holding and informational asymmetry components of the spread. The BSW model includes proxies for order-processing costs, competition, inventory-holding risk, and adverse selection. Table 3 contains the estimation results of the BSW model for our sample. All *t*-statistics are corrected for heteroskedasticity and autocorrelation in the residuals. Panel A contains the estimation using equal-weighted quoted spread as the dependent variable; panel B contains the results using volume-weighted effective spread. Within each panel, the BSW model is estimated separately for the pre–Regulation FD period (May 2000 through September 2000) and the post–Regulation FD period (November 2000 through March 2001).

The estimation results in panels A and B of table 3, with one minor exception, are qualitatively similar, so we focus our discussion on the volume-weighted effective spread results (panel B). The results show that all cost components are important determinants of the effective bid-ask spread. The single most important explanatory variable appears to be the inventory-holding premium. Its coefficient estimate is greater than one, indicating

**TABLE 3**

*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, $MHI_i$ is the modified Herfindahl Index, and $IHP_i$ is the expected inventory-holding premium. The value of each variable is computed each trading day, and then the values are averaged across all days during a month to form a variable observation. The value of $IHP_i$ is computed using

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

where $S_i$ is the average share price; $\sigma_i$, the expected volatility rate, is proxied for by the annualized return volatility of the stock computed over the most recent 60 trading days prior to the estimation month; $E(\sqrt{t_i})$, the expected value of the square root of the time between trades, is proxied for by $\overline{\sqrt{t_i}}$, the average of the square root of the number of minutes between trades. To be included in the sample in either the five-month period preceding Regulation FD (May 2000 through September 2000) and the five-month period after Regulation FD (November 2000 through March 2001), the stock must have traded at least five times each day in every day during the period. 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 regression model is

$$BSW: SPRD_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_i + \varepsilon_i.$$

| Period | Model | No. of. Obs. | Adjusted $R$-Squared | Coefficient Estimates/$t$-Ratios | | | |
|---|---|---|---|---|---|---|---|
| | | | | $\hat{\alpha}_0/t(\hat{\alpha}_0)$ | $\hat{\alpha}_1/t(\hat{\alpha}_1)$ | $\hat{\alpha}_2/t(\hat{\alpha}_2)$ | $\hat{\alpha}_3/t(\hat{\alpha}_3)$ |
| **Panel A: Equal-weighted quoted spread** | | | | | | | |
| Pre-FD | *BSW* | 8, 706 | 0.8049 | 0.0517 | 806.49 | 0.0122 | 6.3746 |
| | | | | 16.66 | 12.24 | 0.81 | 38.16 |
| Post-FD | *BSW* | 8, 706 | 0.7772 | 0.0412 | 786.57 | −0.0194 | 4.4633 |
| | | | | 12.58 | 13.71 | −1.68 | 23.53 |
| **Panel B: Volume-weighted effective spread** | | | | | | | |
| Pre-FD | *BSW* | 7, 568 | 0.7646 | 0.0419 | 788.10 | 0.0525 | 6.3376 |
| | | | | 20.28 | 9.98 | 3.55 | 37.19 |
| Post-FD | *BSW* | 7, 568 | 0.7484 | 0.0347 | 708.98 | 0.0287 | 4.5269 |
| | | | | 19.30 | 11.01 | 2.47 | 30.28 |

that, as expected, the average time between trades is a downward-biased estimate of the expected length of the market maker's holding period.[23] The sign and the significance of the coefficient estimate $\alpha_2$ indicate that competition among market makers also plays an important role in determining the absolute level of the bid-ask spread. The higher the modified HI (the lower the competition), the greater the spread. The coefficient estimate of 0.0287 in the post–Regulation FD period, for example, implies that the effective bid-ask spread is about three cents higher in a market with a monopolist than in a market with perfect competition. The coefficient of competition in the first period is 0.0525. The inverse of trading volume also enters significantly.

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

Its magnitude is smaller in the second period than in the first, indicating perhaps that the fixed cost per share of market making has fallen. Finally, recall that equation (6) is structured so that the level of the intercept term equals the minimum tick size. The estimate of the intercept term $\alpha_0$ in the first period is 0.0419, which is less than the exchange-mandated 0.0625 (one-sixteenth). The intercept is 0.0347 in the second period. The difference between the estimates represents the reduction in revenue per share for a market maker providing liquidity in an extremely active stock.

The results of the quoted spread regressions reported in panel B are similar to those of the effective spread regressions. The variable with the greatest explanatory power is the expected inventory-holding premium, and its coefficient estimate is the same order of magnitude. The *InvTV* variable is also highly significant and has similar coefficient magnitudes. The only exception appears to be the competition variable, which does not enter significantly in either quoted spread regression. But, even in the effective spread regression, the effect of competition is small from an economic standpoint. The intercept estimates are slightly higher for the quoted spread regressions than for the effective spread. This finding is not surprising because the effective spread can have values as low as zero.

### 4.3 ESTIMATING THE PROBABILITY AND EXPECTED COST OF INFORMED TRADES

We now estimate the probability and expected cost of informed trading surrounding Regulation FD. As a preliminary investigation, we estimate the regression model:

$$SPRD_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_i + \alpha_4 d_t + \alpha_5 InvTV_i d_t + \alpha_6 MHI_i d_t + \alpha_7 IHP_i d_t + \varepsilon_i \quad (7)$$

where $d_t$ is a dummy variable whose value is zero in the months preceding October 2000 and one in the months after October 2000. The coefficients $\alpha_4$ through $\alpha_7$, therefore, measure changes in the cost components of the bid-ask spread after the implementation of Regulation FD.

Panel A of table 4 contains the results. In general, the cost components do not appear to have been affected by Regulation FD, with no significant changes reported for minimum tick size $\alpha_4$, order-processing costs $\alpha_5$, and inventory-holding premium $\alpha_7$. The only variable whose coefficient changes significantly is competition, $\alpha_6$. One possible explanation for this result is that market makers in less competitive markets increase spreads post–Regulation FD to compensate for the increased prospect of informed trading. In more competitive markets, this shift may not have been possible.

To further isolate the effect of informed trading on the bid-ask spread, we focus on the components of the inventory-holding premium. Recall that the inventory-holding premium, modeled in equation (5), incorporates the trades of both uninformed and informed traders (see appendix.) While the results in panel A show no change in the contribution of *IHP* to the

**TABLE 4**

*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, $MHI_i$ is the modified Herfindahl Index, and $IHP_i$ is the expected inventory-holding premium. The value of each variable, except $IHP_i$ and $MHI_i$, 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

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

where $S_i$ is the average share price; $\sigma_i$, the expected volatility rate, is proxied for by the annualized return volatility of the stock computed over the most recent 60 trading days prior to the estimation month; $E(\sqrt{t_i})$, the expected value of the square root of the time between trades, is proxied for by $\overline{\sqrt{t_i}}$, the average of the square root of the number of minutes 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. The regression model is

$$VWES_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_{U,i}(\tau_i) + \alpha_4(IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) + \alpha_5 d_t + \alpha_6 InvTV_i d_t$$
$$+\alpha_7 MHI_i d_t + \alpha_8 IHP_{U,i}(\tau_i) d_t + \alpha_9 (IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) d_t + \varepsilon_i,$$

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. For a trade at the ask, the value of $IHP_{k,i}$ is computed using

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

$IHP_{U,i}$ 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.

| | | | Coefficient Estimates/$t$-Ratios | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percent ITM | No. of Obs. | Adjusted $R$-Squared | $\hat{\alpha}_0/t(\hat{\alpha}_0)$ | $\hat{\alpha}_1/t(\hat{\alpha}_1)$ | $\hat{\alpha}_2/t(\hat{\alpha}_2)$ | $\hat{\alpha}_3/t(\hat{\alpha}_3)$ | $\hat{\alpha}_4/t(\hat{\alpha}_4)$ | $\hat{\alpha}_5/t(\hat{\alpha}_5)$ | $\hat{\alpha}_6/t(\hat{\alpha}_6)$ | $\hat{\alpha}_7/t(\hat{\alpha}_7)$ | $\hat{\alpha}_8/t(\hat{\alpha}_8)$ | $\hat{\alpha}_9/t(\hat{\alpha}_9)$ |
| **Panel A: Single composite inventory-holding premium** | | | | | | | | | | | | |
| | 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**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16,274 | 0.6690 | 0.0357 | 1267.90 | 0.0653 | 1.0921 | 0.0951 | −0.0114 | 46.70 | 0.0525 | −0.1597 | 0.0497 |
| | | | 8.43 | 12.62 | 3.10 | 12.80 | 8.59 | −2.35 | 0.36 | 2.34 | −1.58 | 3.86 |
| 2 | 16,274 | 0.7796 | 0.0303 | 905.30 | 0.0252 | 0.9419 | 0.0218 | −0.0077 | −33.36 | 0.0490 | −0.0274 | 0.0144 |
| | | | 10.28 | 11.87 | 1.50 | 17.55 | 6.78 | −2.01 | −0.34 | 2.53 | −0.42 | 3.28 |
| 3 | 16,274 | 0.7798 | 0.0302 | 908.57 | 0.0256 | 0.9378 | 0.0144 | −0.0078 | −31.27 | 0.0493 | −0.0314 | 0.0097 |
| | | | 10.49 | 11.88 | 1.51 | 17.14 | 6.50 | −2.05 | −0.31 | 2.52 | −0.48 | 3.21 |
| 4 | 16,274 | 0.7799 | 0.0301 | 909.92 | 0.0257 | 0.9350 | 0.0108 | −0.0078 | −30.09 | 0.0495 | −0.0340 | 0.0074 |
| | | | 10.59 | 11.88 | 1.51 | 16.89 | 6.36 | −2.07 | −0.30 | 2.52 | −0.51 | 3.19 |
| 5 | 16,274 | 0.7800 | 0.0301 | 910.54 | 0.0259 | 0.9332 | 0.0086 | −0.0078 | −29.41 | 0.0496 | −0.0357 | 0.0059 |
| | | | 10.64 | 11.88 | 1.51 | 16.74 | 6.29 | −2.08 | −0.29 | 2.52 | −0.53 | 3.19 |
| 6 | 16,274 | 0.7801 | 0.0301 | 910.84 | 0.0259 | 0.9318 | 0.0072 | −0.0079 | −28.96 | 0.0497 | −0.0368 | 0.0050 |
| | | | 10.67 | 11.88 | 1.51 | 16.64 | 6.26 | −2.09 | −0.29 | 2.52 | −0.55 | 3.19 |
| 7 | 16,274 | 0.7801 | 0.0301 | 911.01 | 0.0260 | 0.9308 | 0.0062 | −0.0079 | −28.72 | 0.0497 | −0.0376 | 0.0043 |
| | | | 10.67 | 11.88 | 1.52 | 16.58 | 6.25 | −2.09 | −0.29 | 2.52 | −0.56 | 3.19 |
| 8 | 16,274 | 0.7801 | 0.0301 | 911.11 | 0.0260 | 0.9300 | 0.0054 | −0.0079 | −28.59 | 0.0498 | −0.0382 | 0.0037 |
| | | | 10.68 | 11.88 | 1.52 | 16.53 | 6.24 | −2.09 | −0.29 | 2.52 | −0.57 | 3.19 |
| 9 | 16,274 | 0.7801 | 0.0301 | 911.17 | 0.0260 | 0.9294 | 0.0048 | −0.0079 | −28.52 | 0.0497 | −0.0387 | 0.0033 |
| | | | 10.68 | 11.88 | 1.52 | 16.50 | 6.24 | −2.09 | −0.29 | 2.52 | −0.57 | 3.19 |
| 10 | 16,274 | 0.7801 | 0.0301 | 911.19 | 0.0260 | 0.9289 | 0.0043 | −0.0079 | −28.46 | 0.0497 | −0.0390 | 0.0030 |
| | | | 10.68 | 11.88 | 1.52 | 16.47 | 6.24 | −2.10 | −0.28 | 2.52 | −0.58 | 3.19 |

bid-ask spread, it is possible that the informed trader $IHP_I$ changes in one direction and the uninformed trader $IHP_U$ changes in the other. To test this proposition, we substitute the relation

$$IHP = IHP_U + p_I(IHP_I - IHP_U) \quad (8)$$

into equation (7):

$$\begin{aligned} SPRD_i = \alpha_0 &+ \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_{U,i} + \alpha_4(IHP_{I,i} - IHP_{U,i}) \\ &+ \alpha_5 d_t + \alpha_6 InvTV_i d_t + \alpha_7 MHI_i d_t + \alpha_8 IHP_{U,i} d_t \\ &+ \alpha_9(IHP_{I,i} - IHP_{U,i}) d_t + \varepsilon_i. \end{aligned} \quad (9)$$

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 uninformed trades and an in-the-money option for informed trades. Valuing 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. Valuing the in-the-money (ITM) 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 except that it exceeds the ask price for an informed buy and is below the bid price for an informed sell. Consequently, in the estimation of regression model (9), we allow the true price to have a premium from 1% to 10% over the option's exercise price (column "Percent ITM" in panel B).

The results are reported in panel B of table 4. We conclude the following. First, as the insider's "true" price rises relative to the exercise price, the probability that the trade is executed by an insider falls. This finding is intuitive because the product of the probability of an informed trade and the insider inventory-holding premium is nearly constant, as discussed in the appendix. Second, once $IHP_I$ is 6% in the money, the adjusted $R^2$ value reaches its maximum value of 0.7801. This finding indicates that, while we should be comfortable with models in which $IHP_I$ is at least 6% in the money, we cannot partition the expected adverse selection cost into its probability of informed trading and expected loss from informed trading components. Third, over this maximal adjusted $R^2$ range, the estimate of the probability of an informed trade $\alpha_4$ is significant but has a value of less than 1%. When one considers how little informed trading occurs in a single stock on any given day, the estimate seems plausible. Fourth, the coefficient $\alpha_9$ is significantly positive independent of the degree to which $IHP_I$ is in the money. The evidence indicates the probability of informed trading rose after the introduction of Regulation FD.

The significance of the coefficient estimate $\alpha_9$ in the regression results of table 4 indicates that the probability of informed trading has increased significantly since the implementation of Regulation FD. This coefficient estimate also allows us to estimate the dollar size of the increase in the expected cost of adverse selection. Moreover, we can calculate the relative size

**TABLE 5**

*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, $MHI_i$ is the modified Herfindahl Index , and $IHP_i$ is the expected inventory holding premium. The value of each variable, except $IHP_i$ and $MHI_i$, 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,

$$SPRD_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + IHP_{U,i}(\tau_i) + \alpha_4(IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) + \varepsilon_i,$$

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–Regulation FD period (May 2000 through September 2000) and the post–Regulation FD period (November 2000 through March 2001). Cost components are computed using the method outlined in Bollen, Smith, and Whaley [2004].

| Percent ITM | Period | Minimum Tick Size | Order Processing Costs | Competition | Inventory Holding Costs | Adverse Selection Costs |
|---|---|---|---|---|---|---|
| 1 | Pre-FD | 26.97% | 15.46% | 5.89% | 37.26% | 14.41% |
| | Post-FD | 21.23% | 18.32% | 11.08% | 28.72% | 20.65% |
| 2 | Pre-FD | 22.91% | 11.04% | 2.27% | 57.80% | 5.98% |
| | Post-FD | 19.77% | 12.15% | 6.98% | 51.78% | 9.33% |
| 3 | Pre-FD | 22.81% | 11.08% | 2.31% | 57.55% | 6.25% |
| | Post-FD | 19.60% | 12.22% | 7.05% | 51.32% | 9.81% |
| 4 | Pre-FD | 22.77% | 11.10% | 2.32% | 57.38% | 6.42% |
| | Post-FD | 19.51% | 12.26% | 7.08% | 51.02% | 10.13% |
| 5 | Pre-FD | 22.75% | 11.11% | 2.33% | 57.27% | 6.54% |
| | Post-FD | 19.46% | 12.28% | 7.10% | 50.82% | 10.34% |
| 6 | Pre-FD | 22.74% | 11.11% | 2.34% | 57.18% | 6.63% |
| | Post-FD | 19.43% | 12.29% | 7.12% | 50.68% | 10.49% |
| 7 | Pre-FD | 22.73% | 11.11% | 2.34% | 57.12% | 6.69% |
| | Post-FD | 19.41% | 12.29% | 7.12% | 50.57% | 10.60% |
| 8 | Pre-FD | 22.73% | 11.11% | 2.34% | 57.08% | 6.74% |
| | Post-FD | 19.40% | 12.30% | 7.13% | 50.50% | 10.68% |
| 9 | Pre-FD | 22.72% | 11.11% | 2.35% | 57.04% | 6.78% |
| | Post-FD | 19.40% | 12.30% | 7.13% | 50.44% | 10.74% |
| 10 | Pre-FD | 22.72% | 11.11% | 2.35% | 57.01% | 6.81% |
| | Post-FD | 19.40% | 12.30% | 7.13% | 50.39% | 10.78% |

of each of the cost components of the spread before and after Regulation FD by computing the average value of each independent variable in the regression, multiplying by its respective coefficient, and dividing by the average spread.

Table 5 contains these estimation results, which indicate that there is a shift in the weighting assigned to each cost category. Focusing on the results that maximize the adjusted $R^2$, (ITM $\geq$ 6%), we see that the order-processing component of the volume-weighted effective spread does not change much after Regulation FD—from 11.1 beforehand to 12.3 afterward. The premium attached to competition, however, increases from about 2.3% of the spread to about 7.1%. Inventory-holding costs are the single largest cost component of spread, and fall in the post–Regulation FD period. The adverse selection component rises from about 6.6% to about 10.5% of the volume-weighted effective spread. In dollar terms, this increase amounts to 0.0663 × \$0.1323 or \$.0088 per share pre–Regulation FD, and 0.1049 × \$0.1143 or \$.0120 post–Regulation FD—an increase of 36%. We conclude that Regulation FD has an economically significant chilling effect, causing inside information to become longer-lived and more valuable and market makers to demand a larger adverse selection risk premium.

## 5. *Robustness*

We assess the robustness of our results along four dimensions. For brevity, we present our results in table 6 and discuss them in sections 5.1 through 5.4 for cases where ITM = 6% (the value for which the adjusted $R^2$ in equation (9) is maximized). All our conclusions are unchanged regardless of the value we use for percent ITM.

### 5.1 INCLUSION OF AMERICAN DEPOSITORY RECEIPTS

American Depository Receipts (ADRs), which constitute 2% of our sample of stock-months, are exempt from Regulation FD.[24] Thus, we expect no change in the probability of informed trading for ADRs. An analysis based on subsets of our sample representing non-ADRs and ADRs is presented in panels A and B, respectively, of table 6. Panel A indicates that the main results from table 4 are unaffected for our sample of non-ADRs; $\alpha_4$ and $\alpha_9$ are both significantly positive. For non-ADRs, the probability of informed trading is 0.81% pre–Regulation FD and increases by 0.42% post–Regulation FD; this statistically significant increase is consistent with our main results in table 4. Interestingly, for the ADR sample, neither $\alpha_4$ nor $\alpha_9$ is significantly different from zero. While no change in the probability of informed trading is expected, the probability of informed trading in ADRs appears negligible even before the implementation of Regulation FD. Our results are consistent with those of Francis, Nanda, and Wang [2006], who find that the informativeness of analyst reports for U.S.-based firms declines relative to analyst reports for ADRs after the Regulation is in place. They interpret this result as a signal that the intention of the Regulation to stem private information flow to analysts is achieved.[25] This is consistent with a chilling effect for U.S.-based firms.

Because ADRs are exempt from Regulation FD, and we find no change in adverse selection costs for these firms, we conduct the remaining sensitivity checks on the non-ADR sample.

---

[24] Rule 243.101(b) of Regulation FD explicitly excludes foreign issuers trading on U.S. exchanges (see http://www.sec.gov/news/testimony/051701wssec.htm and Page and Yang [2005]).

[25] However, they find no differences between their U.S.-based and ADR subsets pre– and post–Regulation Regulation FD, with respect to changes in either their public information metrics (returns volatility, trading volume, and informational efficiency) or their analyst information metrics (forecast dispersion and accuracy).

**TABLE 6**

*Summary of Cross-sectional Regression Results of Absolute Effective Bid-Ask Spreads of NASDAQ Stocks, Partitioned on Whether (1) Sample Firms Are ADRs (American Depositary Receipts) or Not, (2) Sample Observations Are from Periods Proximate to Quarterly Earnings Announcements, and (3) Sample Firms Are Followed by Analysts Post– versus Pre–Regulation FD*

$VWES_i$ is the volume-weighted effective spread, $InvTV_i$ is the inverse of the number of shares traded, $MHI_i$ is the modified Herfindahl Index, and $IHP_i$ is the expected inventory-holding premium. The value of each variable, except $IHP_i$ and $MHI_i$, 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

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

where $S_i$ is the average share price; $\sigma_i$, the expected volatility rate, is proxied for by the annualized return volatility of the stock computed over the most recent 60 trading days prior to the estimation month; $E(\sqrt{t_i})$, the expected value of the square root of the time between trades, is proxied for by $\overline{\sqrt{t_i}}$, the average of the square root of the number of minutes 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. The regression model is

$$VWES_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_{U,i}(\tau_i) + \alpha_4(IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) + \alpha_5 d_t$$
$$+ \alpha_6 InvTV_i d_t + \alpha_7 MHI_i d_t + \alpha_8 IHP_{U,i}(\tau_i) d_t + \alpha_9(IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) d_t + \varepsilon_i,$$

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. For a trade at the ask, the value of $IHP_{k,i}$ is computed using

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

$IHP_{U,i}$ 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 a 6% in-the-money (ITM) call option with an exercise price equal to the ask 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.

| No. of | Adjusted | Coefficient Estimates/$t$-Ratios | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Obs. | $R$-Squared | $\alpha_0/t(\alpha_0)$ | $\alpha_1/t(\alpha_1)$ | $\alpha_2/t(\alpha_2)$ | $\alpha_3/t(\alpha_3)$ | $\alpha_4/t(\alpha_4)$ | $\alpha_5/t(\alpha_5)$ | $\alpha_6/t(\alpha_6)$ | $\alpha_7/t(\alpha_7)$ | $\alpha_8/t(\alpha_8)$ | $\alpha_9/t(\alpha_9)$ |
| **Panel A: Non-ADRs** | | | | | | | | | | | |
| 15,971 | 0.7726 | 0.0350 | 831.72 | 0.0334 | 0.8997 | 0.0081 | −0.0109 | 23.833 | 0.0411 | 0.0158 | 0.0042 |
| | | 20.46 | 15.45 | 3.57 | 42.83 | 14.24 | −4.02 | 0.27 | 2.79 | 0.34 | 3.48 |

*(Continued)*

**TABLE 6**—*Continued*

| No. of Obs. | Adjusted $R$-Squared | Coefficient Estimates/$t$-Ratios | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\alpha_0/t(\alpha_0)$ | $\alpha_1/t(\alpha_1)$ | $\alpha_2/t(\alpha_2)$ | $\alpha_3/t(\alpha_3)$ | $\alpha_4/t(\alpha_4)$ | $\alpha_5/t(\alpha_5)$ | $\alpha_6/t(\alpha_6)$ | $\alpha_7/t(\alpha_7)$ | $\alpha_8/t(\alpha_8)$ | $\alpha_9/t(\alpha_9)$ |
| **Panel B: ADRs** | | | | | | | | | | | |
| 303 | 0.8938 | −0.0012 | 1702.6 | 0.1591 | 1.1042 | −0.0203 | 0.0048 | 338.92 | −0.0543 | −0.3011 | 0.0288 |
| | | −0.09 | 1.77 | 2.25 | 5.94 | −1.26 | 0.26 | 0.28 | −0.57 | −1.30 | 1.5377 |
| **Panel C: Within earnings announcement period** | | | | | | | | | | | |
| 8,369 | 0.6814 | 0.039 | 561.2881 | 0.0643 | 0.8892 | 0.0082 | −0.0121 | −30.7319 | 0.0003 | 0.0438 | 0.0045 |
| | | 14.16 | 8.96 | 4.19 | 26.30 | 10.05 | −3.03 | −0.37 | 0.01 | 0.79 | 2.58 |
| **Panel D: Outside earnings announcement period** | | | | | | | | | | | |
| 13,047 | 0.8321 | −0.0223 | 661.6245 | −0.0087 | 1.0776 | 0.0005 | 0.0166 | −266.0263 | 0.1194 | −0.1851 | 0.0104 |
| | | −1.19 | 7.05 | −0.22 | 5.71 | 0.12 | 0.73 | −1.51 | 2.78 | −0.75 | 2.06 |
| **Panel E: Increase in analyst following** | | | | | | | | | | | |
| 3,764 | 0.7867 | 0.0358 | 754.05 | 0.0423 | 0.9356 | 0.0077 | −0.0051 | 0.22 | 0.0499 | −0.0689 | 0.0023 |
| | | 12.9436 | 7.54 | 2.06 | 33.40 | 11.78 | −1.42 | 0.00 | 1.73 | −1.56 | 2.29 |
| **Panel F: No change in analyst following** | | | | | | | | | | | |
| 5,933 | 0.7929 | 0.0317 | 776.00 | 0.0429 | 0.8511 | 0.0127 | −0.019 | 105.718 | 0.0739 | 0.0115 | 0.0096 |
| | | 9.84 | 8.54 | 2.49 | 19.22 | 6.47 | −3.65 | 0.67 | 2.66 | 0.12 | 1.89 |
| **Panel G: Reduction in analyst following** | | | | | | | | | | | |
| 6,274 | 0.7279 | 0.0379 | 1019.07 | 0.0325 | 0.9091 | 0.0069 | −0.0053 | −160.45 | 0.0166 | 0.0224 | 0.0029 |
| | | 19.85 | 16.01 | 2.60 | 26.19 | 8.60 | −2.06 | −1.58 | 0.91 | 0.40 | 2.23 |

## 5.2 INCLUSION OF EARNINGS ANNOUNCEMENTS

Prior work (e.g., Kim and Verrecchia [1994]) suggests that information asymmetry is more pronounced surrounding earnings announcements. Eleswarapu, Thompson, and Venkataraman [2004] focus their investigation of changes in their measures of information asymmetry during earnings announcement periods, asserting that this period is where they expect to find the sharpest impact of Regulation FD. Other research suggests that expectations of higher adverse selection costs during earnings announcement periods are less obvious. Venkatesh and Chiang [1986], for example, show that information asymmetry before earnings announcements is normal on average. Other studies examining adverse selection costs surrounding earnings announcement periods find that these costs increase for firms with low, but not high, earnings predictability (Affleck-Graves et al. [2002], Ng [2006]).[26] Hence, it is unclear how the inclusion of earnings announcement and non–earnings announcement periods in our pre– and post–Regulation FD sample periods would bias our results.

Nonetheless, to investigate this possibility, we obtain quarterly earnings announcement dates from Compustat and replicate our analysis separately for earnings announcement and non–earnings announcement periods before and after Regulation FD. We specify the announcement period as trading days $t = -20$ to $t = 0$ where $t = 0$ is the quarterly earnings announcement date.[27] Since the observations in our tests are averages across days of the month, we impose the conditions that the number of days on which a stock is traded be (1) greater or equal to five to be included in the earnings announcement sample and (2) greater than or equal to the number of trading days in the month less five to be included in the non–earnings announcement sample. While these conditions are complements (i.e., a stock-month is assigned to one sample or the other), the total across subsamples increases from 15,971 (total firm-months in non-ADR sample in panel A of table 6) to 21,416 (total stock-months in earnings/non–earnings announcement samples in panels C and D of table 6) since we are no longer imposing the constraint that the firm must trade in all days during the month to be included in the overall sample.

The results reported in panels C and D of table 6 are interesting in a number of respects. First, consistent with our main findings, $\alpha_4$ is significantly positive in the earnings announcement sample (panel C), which

[26] The former measure the adverse selection component as the difference between the actual bid-ask spread and a predicted spread estimated from historical data, while Ng [2007] uses the probability of informed trading (PIN) measure of Easley et al. [1996].

[27] Our choice of an announcement window of −20, 0 days is motivated by recent papers that find that insiders tend to limit their trades nearer earnings announcements to avoid litigation (Huddart, Ke, and Shi [2007], Jagolinzer and Roulstone [2007]). Huddart, Ke, and Shi [2007], for example, find that insiders tend to shift trades from a −21, −1 day window around the earnings announcement to a period (more than one day after the announcement) when litigation risk is lower.

means that in the pre–Regulation FD period, the probability of informed trading is 0.82%. Second, also consistent with our main findings, $\alpha_9$ is significantly positive. In other words, the probability of informed trading increases by 0.45% from the pre–Regulation FD to the post–Regulation FD periods. Third, $\alpha_4$ is insignificantly different from zero in the non–earnings announcement sample (panel D). Apparently, during the pre–Regulation FD period, the implied degree of informed trading during non–earnings announcement periods appears to be small. Interestingly, $\alpha_9$ is significantly positive, which means that in the post–Regulation FD period, market makers are more concerned about trading with insiders, even during non–earnings announcement periods. Thus, in contrast to Eleswarapu, Thompson, and Venkataraman [2004], who find a decline in adverse selection costs in the days before and including the announcement date, our results indicate a chilling effect.

### 5.3 CHANGE IN ANALYST COVERAGE SURROUNDING REGULATION FD

Our finding of an increased probability of informed trading post–Regulation FD could (potentially) be an artifact of a contemporaneous reduction in analyst following post–Regulation FD (e.g., Mohanram and Sunder [2006]) or an increasing trend of analysts being reassigned to trading desks (Urlocker [2007]). A reduction in analyst following, coupled with Frankel and Li's [2004] finding that the number of analysts plays a role in reducing company insiders' ability to profit from their trades, could be associated with an increase in adverse selection costs. In other words, our documented increase in adverse selection costs might *not* be attributable to Regulation FD per se, but rather a decrease in analyst following in response, and hence, enhanced profitability of insider trades after Regulation FD. To test this proposition, we create three subsamples from the 15,971 stock-months in the non-ADR sample—firms with increased analyst following after Regulation FD, firms with no change in analyst following, and firms with decreased analyst following. Our objective is to isolate any potentially confounding association between adverse selection and changes in analyst following.

We obtain analyst following data from I/B/E/S. We define an analyst as following a firm during the pre– (post–)Regulation FD period if s/he issued one or more annual or quarterly earnings forecasts for the firm during the 12-month period ending October 31, 2000 (October 31, 2001). We replicate our analysis on the above subsamples (of an increase, no change, and a reduction in analyst following) and summarize the results in panels E, F, and G of table 6. All three panels show positive and statistically significant coefficients $\alpha_4$ and $\alpha_9$.[28] Interestingly, even the firms with an *increase* in analyst-following (in panel E) experience an increase in the probability of

[28] Note that the coefficient $\alpha_9$ for the "no change" in coverage group is statistically significant in a one-tailed test.

informed trading post–Regulation FD, that is, $\alpha_9$ is statistically significant.[29] We conclude that our results are generally robust with respect to changes in analyst following surrounding Regulation FD.

### 5.4 POTENTIAL SEASONAL EFFECTS IN INFORMATION FLOW

The results in table 4 are based on a comparison of average spreads five months before and after the implementation of Regulation FD. A potential problem with this approach is that the months comprising our pre– and post–Regulation FD periods occur at different points in the calendar year. To investigate whether a potential seasonal component in information flow could drive our results, we compare spreads in months separated by a quarter. Two of the comparisons, summarized in table 7, panel A, straddle the month in which Regulation FD was implemented—August 2000 versus November 2000 and September 2000 versus December 2000. Two of the comparisons, presented in panel B, are confined to either the period before or the period after Regulation FD—June 2000 versus September 2000 (before Regulation FD) and November 2000 versus February 2001 (after Regulation FD). If Regulation FD affects the adverse selection component of the spread, there should be a significant difference detected in the panel A comparisons but not in the panel B comparisons. Table 7 contains a summary of the results (again setting the percent ITM of the $IHP_I$ equal to 6%). Focusing on the coefficient $\alpha_9$, and consistent with our predictions, we find that the probability of informed trading increases significantly in the quarter-to-quarter comparisons that include the implementation of Regulation FD, and stays the same in the quarter-to-quarter comparisons that do not include the implementation date of Regulation FD. We conclude that our finding regarding an increase in adverse selection costs surrounding Regulation FD is unaffected by potential seasonality in information flow.

In summary, our principal finding of an increase in adverse selection costs after the implementation of Regulation FD is unaffected by the inclusion of ADR firms in our sample, a change in analyst following surrounding the implementation of Regulation FD, the inclusion of earnings announcements, or potential seasonality in information flow.

## 6. *Conclusion*

Regulation FD, imposed by the SEC in October 2000, was designed to create a level playing field by prohibiting disclosure of material private information to select recipients such as financial analysts. What advantage

[29] While we might expect firms that were previously covered by analysts would be affected by the regulation, it does not follow that previously "unfollowed" firms are not affected by it. It is not clear that the latter did not also provide private briefings to selected major institutional or other investors pre–Regulation FD. Nevertheless, we also investigate this set of firms, and our (untabulated) results indicate that these too experience an increase in the probability of informed trading.

**TABLE 7**

*Summary of Cross-sectional Regression Results of Absolute Quoted and Effective Bid-Ask Spreads of NASDAQ Stocks Estimated over Months (1) Surrounding (and Including) the Effective Date and (2) on Either Side of (Not Including) the Effective Date of Regulation FD*

$VWES_i$ is the volume-weighted effective spread, $InvTV_i$ is the inverse of the number of shares traded, $MHI_i$ is the modified Herfindahl Index, and $IHP_i$ is the expected inventory-holding premium. The value of each variable, except $IHP_i$ and $MHI_i$, 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

$$VWES_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_{U,i}(\tau_i) + \alpha_4 (IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) + \alpha_5 d_t + \alpha_6 InvTV_i d_t$$
$$+ \alpha_7 MHI_i d_t + \alpha_8 IHP_{U,i}(\tau_i) d_t + \alpha_9 (IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) d_t + \varepsilon_i,$$

where $d_t$ is a dummy variable whose value is zero in months preceding October 2001 and one in months after October 2001. $IHP_{U,i}$ 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

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

where $\sigma_i$ 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 6% in-the-money (ITM) call option with an exercise price equal to the ask 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.

| First Month | Second Month | No. of Obs. | Adjusted $R$-Squared | $\alpha_0/t(\alpha_0)$ | $\alpha_1/t(\alpha_1)$ | $\alpha_2/t(\alpha_2)$ | $\alpha_3/t(\alpha_3)$ | $\alpha_4/t(\alpha_4)$ | $\alpha_5/t(\alpha_5)$ | $\alpha_6/t(\alpha_6)$ | $\alpha_7/t(\alpha_7)$ | $\alpha_8/t(\alpha_8)$ | $\alpha_9/t(\alpha_9)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Coefficient Estimates/$t$-Ratios | | | | | | | | | |
| **Panel A: Three months apart and surrounding the intervention month** | | | | | | | | | | | | | |
| Aug-00 | Nov-00 | 3,215 | 0.6749 | 0.0414 | 1367.8324 | 0.0254 | 1.0538 | 0.0123 | −0.0081 | 252.5376 | 0.0626 | 0.0342 | 0.0065 |
| | | | | 7.73 | 10.03 | 0.66 | 10.52 | 6.2 | −1.85 | 1.39 | 1.67 | 0.23 | 2.84 |
| Sep-00 | Dec-00 | 3,292 | 0.6796 | 0.041 | 1062.4615 | 0.0875 | 1.0835 | 0.0111 | −0.0045 | 691.3172 | −0.0205 | −0.0558 | 0.0067 |
| | | | | 7.24 | 6.61 | 3.23 | 12.06 | 8.11 | −0.69 | 2.9 | −0.52 | −0.29 | 2.24 |
| **Panel B: Three months apart and on either side of the intervention month** | | | | | | | | | | | | | |
| Jun-00 | Sep-00 | 3,499 | 0.6558 | 0.0386 | 1359.5182 | 0.0415 | 1.0383 | 0.0141 | 0.003 | −261.6487 | 0.0496 | 0.1896 | −0.0024 |
| | | | | 9.04 | 7.44 | 1.44 | 12.15 | 8.45 | 0.45 | −1.14 | 1.34 | 1.52 | −1.65 |
| Nov-00 | Feb-01 | 3,023 | 0.6709 | 0.0335 | 1659.5269 | 0.091 | 1.1941 | 0.0196 | −0.0022 | −702.9121 | −0.0314 | −0.3486 | −0.0029 |
| | | | | 7.55 | 10.87 | 3.34 | 6.16 | 7.26 | −0.47 | −4.12 | −0.97 | −1.78 | −1.03 |

analysts gain from selective disclosure is unclear. If multiple insiders receive identical information, information is immediately incorporated in the share price and the expected profit of each insider is zero. If, on the other hand, Regulation FD has curtailed the flow of information from firms to the investment public, private information becomes longer-lived, yielding higher adverse selection costs. With increased risk of providing immediacy to informed traders, market makers will demand increased compensation, widening the adverse selection component of the bid-ask spread. To test this proposition, we identify the cost components of the bid-ask spread for a sample of NASDAQ stocks in the period surrounding the implementation of Regulation FD. Inconsistent with the SEC's objective, our evidence indicates that Regulation FD has led to an increase in the expected cost of information asymmetry. Our results are robust to a variety of sensitivity checks such as the inclusion of ADRs, changing levels of analyst coverage, potential seasonal effects in the flow of information, and the calculation of our measurements inside or outside earnings announcement periods.

## APPENDIX

## *Bollen, Smith, and Whaley [2004] Bid-Ask Spread Model*

### A.1 THE BASIC MODEL

The regression model developed in BSW specifies the market maker's bid-ask spread as:

$$SPRD_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + \alpha_3 IHP_i + \varepsilon_i, \tag{A1}$$

where $SPRD_i$ is the bid-ask spread of stock $i$, $InvTV_i$ is the inverse of trading volume, $MHI_i$ is the modified Herfindahl Index, and $IHP_i$ is the inventory-holding premium. In this model, the specific components of the bid-ask spread are: $\alpha_0$, the minimum tick size; $\alpha_1 InvTV_i$, order-processing costs; $\alpha_2 MHI_i$, competition; and $\alpha_3 IHP_i$, the sum of the inventory holding and informational asymmetry components of the spread.

The first term on the right-hand side of equation (A1), $\alpha_0$, is the exchange-mandated minimum tick size. It serves as the lower bound for the bid-ask spread. The second term models the effects of order-processing costs (e.g., the exchange seat, floor space rent, computer costs, informational service costs, labor costs, and the opportunity cost of the market maker's time). Because these costs are largely fixed, at least in the short run, their contribution to the size of the bid-ask spread should fall with trading volume—the higher the trading volume, the lower the bid-ask spread. The third term captures the effects of competition among market makers, measured by a modified Herfindahl Index ($MHI_i$), as:

$$MHI_i = \frac{HI_i - 1/NM_i}{1 - 1/NM_i}, \tag{A2}$$

where $HI_i$ is the Herfindahl Index and $NM_i$ is the number of market makers. $MHI_i$ ranges from zero to one; when $MHI_i = 1$, the coefficient is an estimate of the rent per share charged by a monopolistic market maker; when $MHI_i = 0$, the rent is zero.

The fourth term on the right-hand side of equation (A1) is the market maker's "inventory-holding premium." This premium is demanded by the market maker to cover the expected cost of accommodating a customer order and then having the stock price move against him, independent of whether the trade is initiated by an informed or an uninformed customer. $IHP_i$ is estimated as a single at-the-money option, with no distinction drawn between informed and uninformed traders.

Assuming that the market maker sets his inventory-holding premium ($IHP$) component of the bid-ask spread such that he minimizes the risk of losing money should the market move against him, his demanded compensation is:

$$IHP = -E(\Delta S \mid \Delta S < 0) \Pr(\Delta S < 0). \tag{A3}$$

According to equation (A3), the minimum $IHP$ equals the expected loss on the trade conditional on an adverse stock price movement times the probability of an adverse stock price movement. BSW show that under the Black and Scholes [1973] and Merton [1973] (hereafter, BSM) option valuation framework, the expected inventory-holding premium is an at-the-money option whose value may be written

$$E(IHP) = S[2N(.5\sigma E(\sqrt{t})) - 1], \tag{A4}$$

where $S$ is the true stock price at the time at which the market maker opens his position, $\sigma$ is the standard deviation of security return, $E(\sqrt{t})$ is the expected value of the square root of the time between offsetting trades, and $N(\cdot)$ is the cumulative unit normal density function. Because the expected time until an offsetting order arrives is assumed to be small, the interest rate term in the BSM model is ignored.

To summarize, in estimating equation (A1), the coefficient $\alpha_1$ is expected to be positive and may be large because it represents the market maker's total order-processing costs.[30] If the market is extremely competitive, however, the market maker may not have the ability to recover fixed costs, in which case the coefficient is indistinguishable from zero.[31] The coefficient $\alpha_2$ 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 $\alpha_3$ 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

[30] This is somewhat misleading in the sense that it implicitly assumes that the market maker deals in a single stock. In general, maker makers may handle hundreds of different stocks, in which case order-processing costs are spread across that trading volume across all stocks.

[31] In the empirical tests that follow, total trading volume across dealers, not trading volume for a particular dealer, is used in the cross-sectional regressions. This, too, downward biases the estimate of $\alpha_1$.

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.

### A.2 INFORMED VERSUS UNINFORMED TRADERS

A market maker demands different inventory-holding premia for trades with informed and uninformed traders. Assume that the market maker currently has no inventory, and 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. 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 either case, the valuation of the $IHP$ is

$$IHP_i = S_i N\left(\frac{\ln(S_i/X)}{\sigma\sqrt{t}} + .5\sigma\sqrt{t}\right) - XN\left(\frac{\ln(S_i/X)}{\sigma\sqrt{t}} - .5\sigma\sqrt{t}\right), \quad \text{(A5)}$$

where $i = U, I$ depending upon whether the trade was with an uninformed or an informed trader. From the market maker's perspective, the required inventory-holding premium, $IHP$, equals the sum of the expected inventory-holding cost and expected adverse selection cost components of the spread, that is,

$$IHP = (1 - p_I)IHP_U + p_I IHP_I, \quad \text{(A6)}$$

where $p_I$ $(1 - p_I)$ is the probability of an informed (uninformed) trade and the expectations operator has been dropped for expositional convenience.

The expected inventory-holding premium, as specified by equation (A6), has intuitive appeal. As the time between offsetting trades approaches zero, the expected $IHP$ converges to the expected cost of an informed trade. To see this point, consider the market maker's demanded compensation for the two types of traders. If the market is highly active (i.e., $t \to 0$), the market maker does not require compensation for the inventory-holding costs of the uninformed trader since the position acquired from providing the market with immediacy is immediately unwound (i.e., the inventory-holding premium of an uninformed trade, $IHP_U$, goes to zero as $t \to 0$ because the option is out of the money). The inventory-holding premium of an informed trade, $IHP_I$, however, approaches the dollar amount the option is in the money (i.e., the difference between the true price and the ask price in the case of a buy, and the difference between the bid price and the true price in the case of a sell). In a highly active market, the market maker immediately realizes the full cost of providing immediacy to an informed trader. Thus, when the time between offsetting trades is zero, the market maker's demanded compensation is $IHP = p_I IHP_I$.

The market maker's inventory-holding premium (A6) may be rearranged to yield

$$IHP = IHP_U + p_I(IHP_I - IHP_U). \tag{A7}$$

Equation (A7) illustrates that an expected inventory-holding premium of $IHP_U$ exists for all trades, uninformed and informed alike, as a result of the price risk associated with having the security in inventory. For informed trades, however, there is an incremental expected cost associated with adverse selection, that is, $p_I(IHP_I - IHP_U)$. The structure of equation (A7) also provides a means of estimating the probability of informed trades (summarized next).

### A.3 Regression estimation

With the model of the *IHP* in hand, we return to estimating equation (A1). Where values of the explanatory variables are, by and large, easy to estimate, the expected time between offsetting trades needs special attention. In estimating the inventory-holding premium, we use the average time between trades as a proxy for the market maker's expected holding period. But, because trades appearing in the database are executed by many market makers, our proxy dramatically understates the length of the holding period. To estimate the length of the holding period across market makers, we set the coefficient $\alpha_3$ to one in equation (A1) and allow the data to estimate the length of the holding period $\tau_i$ by scaling each individual stock's average square root of time between trades by a constant factor. The regression specification is, therefore,

$$SPRD_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + IHP_i(\tau_i) + \varepsilon_i. \tag{A8}$$

With the time between trades, $\tau_i$, set so as to create a coefficient value equal to one, we can estimate the probability of informed versus uninformed trades across stocks. In equation (A7), we show that the inventory-holding premium consists of a common expected cost across trades, $IHP_U$, plus an incremental expected cost associated with informed trades, $p_I(IHP_I - IHP_U)$. Substituting equation (A7) into equation (A8) provides the regression specification,

$$\begin{aligned} SPRD_i = \alpha_0 + \alpha_1 InvTV_i + \alpha_2 MHI_i + IHP_{U,i}(\tau_i) \\ + \alpha_4(IHP_{I,i}(\tau_i) - IHP_{U,i}(\tau_i)) + \varepsilon_i, \end{aligned} \tag{A9}$$

where the coefficient $\alpha_4$ represents the probability of an informed trade. Specifying the regression in this manner has two important advantages. First, it removes a serious collinearity problem that likely exists between $IHP_{I,i}$ and $IHP_{U,i}$. Second, it allows us to test the null hypothesis that the probability of an informed trade is equal to zero.

## REFERENCES

Admati, A., and P. Pfleiderer. "A Theory of Intraday Patterns: Volume and Price Variability." *The Review of Financial Studies* 1 (1988): 3–40.

AFFLECK-GRAVES, J.; C. CALLAHAN; AND N. CHIPALKATTI. "Earnings Predictability, Information Asymmetry, and Market Liquidity." *Journal of Accounting Research* 40 (2002): 561–83.

AGRAWAL, A.; S. CHADHA; AND M. CHEN. "Who Is Afraid of Reg FD? The Behavior and Performance of Sell-Side Analysts Following the SEC's Fair Disclosure Rules." Working paper, University of Alabama, 2005.

AHMED, A., AND R. SCHNEIBLE, JR. "The Impact of Regulation Fair Disclosure on Investors' Prior Information Quality—Evidence from an Analysis of Changes in Trading Volume and Stock Price Reactions to Earnings Announcements." *Journal of Corporate Finance* 13 (2007): 282–99.

ASLAN, H. "The Effect of Regulation Fair Disclosure on the Information Environment." Working paper, Cornell University, 2002.

Association for Investment Management and Research (AIMR). Press Release: August 11, 2000. Charlottesville, VA: AIMR, 2000

Association for Investment Management and Research (AIMR). *FD e-Survey Summary*. 2001. Web site, http://www.aimr.com/pressroom/01releases/regfd˙surveysum.htm.

BAGEHOT, W. "The Only Game in Town." *Financial Analysts Journal* 27 (1971): 12–22.

BAILEY, W.; H. LI; C. MAO; AND R. ZHONG. "Regulation Fair Disclosure and Earnings Information: Market, Analyst, and Corporate Responses." *The Journal of Finance* 58 (2003): 2487–514.

BLACK, F., AND M. SCHOLES. "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy* 81 (1973): 637–59.

BOLLEN, N.; T. SMITH; AND R. WHALEY. "Modeling the Bid/Ask Spread: Measuring the Inventory-Holding Premium." *Journal of Financial Economics* 72 (2004): 97–141.

BUSHEE, B.; D. MATSUMOTO; AND G. MILLER. "Managerial and Investor Responses to Disclosure Regulation: The Case of Reg FD and Conference Calls." *The Accounting Review* 79 (2004): 617–43.

EASLEY, D.; N. KIEFER; M. O'HARA; AND J. PAPERMAN. "Liquidity, Information, and Infrequently Traded Stocks." *The Journal of Finance* 51 (1996): 1405–36.

ELESWARAPU, V.; R. THOMPSON; AND K. VENKATARAMAN. "The Impact of Regulation Fair Disclosure: Trading Costs and Information Asymmetry." *Journal of Financial and Quantitative Analysis* 39 (2004): 209–25.

FOSTER, F., AND S. VISWANATHAN. "Strategic Trading When Agents Forecast the Forecasts of Others." *The Journal of Finance* 51 (1996): 1437–78.

FRANCIS, J.; D. NANDA; AND X. WANG. "Re-Examining the Effects of Regulation Fair Disclosure Using Foreign Listed Firms to Control for Concurrent Shocks." *Journal of Accounting & Economics* 41 (2006): 271–92.

FRANKEL, R., AND LI. "Characteristics of a Firm's Information Environment and the Information Asymmetry between Insiders and Outsiders." *Journal of Accounting and Economics* 37 (2004): 229–59.

GADAROWSKI, C., AND P. SINHA. "On the Efficacy of Regulation Fair Disclosure: Theory and Evidence." Working paper, Rowan University, 2005.

GINTSCHEL, A., AND S. MARKOV. "The Effectiveness of Regulation FD." *Journal of Accounting & Economics* 37 (2004): 293–314.

GOMES, A.; G. GORTON; AND L. MADUREIRA. "SEC Regulation Fair Disclosure, Information, and the Cost of Capital." Working paper, Washington University, 2006.

HEFLIN, F.; K. SUBRAMANYAM; AND Y. ZHANG. "Regulation FD and the Financial Information Environment: Early Evidence." *The Accounting Review* 78 (2003a): 1–37.

HEFLIN, F.; K. SUBRAMANYAM; AND Y. ZHANG. "Stock Return volatility before and after Regulation FD." Working paper, University of Southern California, 2003b.

HOLDEN, C., AND A. SUBRAHMANYAM. "Long-Lived Private Information and Imperfect Competition." *The Journal of Finance* 47 (1992): 247–70.

HUANG, R., AND H. STOLL. "Dealer versus Auction Markets: A Paired Comparison of Execution Costs on NASDAQ and NYSE." *Journal of Financial Economics* 41 (1996): 313–57.

HUANG, R., AND H. STOLL. "The Components of the Bid-Ask Spread: A General Approach." *The Review of Financial Studies* 10 (1997): 995–1034.

HUDDART, S.; B. KE; AND C. SHI. "Jeopardy, Non-Public Information, and Insider Trading Around SEC 10-K and 10-Q Filings." *Journal of Accounting & Economics* 43 (2007): 3–36.

HUTTON, A. "Determinants of Managerial Earnings Guidance Prior to Regulation Fair Disclosure and Bias in Analysts' Forecast Errors." Working Paper, Boston College, 2004.

IRANI, A., AND I. KARAMANOU. "Regulation Fair Disclosure, Analyst Following, and Analyst Forecast Dispersion." *Accounting Horizons* 17 (2003): 15–29.

JAGOLINZER, A., AND D. ROULSTONE. "Litigation Risk and the Timing of Insiders' Trades Around Earnings Announcements." Working paper, Stanford University, 2007.

JORION, P.; Z. LIU; AND C. SHI. "Informational Effects of Regulation FD: Evidence from Rating Agencies." *Journal of Financial Economics* 76 (2005): 309–30.

KIM, O., AND R. VERRECCHIA. "Market Liquidity and Volume Around Earnings Announcements." *Journal of Accounting & Economics* 17 (1994): 41–67.

MERTON, R. "Theory of Rational Option Pricing." *Bell Journal of Economics* 4 (1973): 141–83.

MOHANRAM, P., AND S. SUNDER. "How Has Regulation FD Affected the Operations of Financial Analysts?" *Contemporary Accounting Research* 23 (2006): 491–525.

NG, J. "Earnings Surprises and Changes in Liquidity." Working paper, University of Pennsylvania, 2007.

PAGE, A., AND K. YANG. "Controlling Corporate Speech: Is Regulation Fair Disclosure Unconstitutional?" *U.C. Davis Law Review* 39 (2005): 1–84.

PricewaterhouseCoopers. "Top Executives Say 'Best' Analysts Focus More on Fundamentals Than Forecasts." *Management Barometer* (August 14, 2001): 1–5.

Securities and Exchange Commission (SEC). *Selective Disclosure and Insider Trading*. Release Nos. 33–7881, 34–43154. Washington, DC: SEC, 2000a.

Securities and Exchange Commission (SEC). *Opening Statement of Chairman Arthur Levitt: Open Meeting on Regulation Fair Disclosure, August 10, 2000*. Washington, DC: SEC, 2000b.

SHANE, P.; N. SODERSTROM; AND S. YOON. "Earnings and Price Discovery in the Post-Reg. FD Information Environment: A Preliminary Analysis." Working paper, University of Colorado at Boulder, 2001.

STRASER, V. "Regulation Fair Disclosure and Information Asymmetry." Working paper, University of Notre Dame, 2002.

SUNDER, S. "Investor Access to Conference Call Disclosures: Impact of Regulation Fair Disclosure on Information Asymmetry." Working paper, Northwestern University, 2002.

URLOCKER, M. "How to Fix the Flaws in Equity Research; There Are Signs the Business Model for Research Is Fraying." *National Post* (May 4, 2007): 3.

VENKATESH, P., AND R. CHIANG. "Information Asymmetry and the Dealer's Bid-Ask Spread: A Case Study of Earnings and Dividend Announcements." *The Journal of Finance* 41 (1986): 1089–102.

WEBER, J. "Full Disclosure for All Web Allows Corporations to Share Information Quickly and Cheaply." *Business Week* (September 18, 2000): 106.