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Disclosure Quality and Management Trading Incentives

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ABSTRACT

This study examines whether managers strategically alter disclosure "quality" in response to personal incentives, specifically those derived from trading on their own account. Using changes in market liquidity to proxy for disclosure quality, I find that trading incentives are associated with disclosure quality choices. Tests are performed across three disclosure samples: management forecasts, conference calls, and press releases. Consistent with a desire to reduce the probability of litigation, I find evidence that managers provide *higher quality* disclosures before selling shares than they provide in the absence of trading. Consistent with a desire to maintain their information advantage, I find some, albeit weaker, evidence that managers provide *lower quality* disclosures prior to purchasing shares than they provide in the absence of trading.

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1. Introduction

Well-functioning capital markets rely on high quality disclosure. This study investigates how managerial trading incentives affect disclosure quality choices. I define disclosure quality as the extent to which the management team, prior to trading, reduces its information advantage relative to uniformed traders. I use changes in market liquidity as an empirical proxy for this reduction in information advantage.

Theory suggests that providing public disclosure, which reduces the information advantage of privately informed investors, mitigates adverse selection problems, thereby increasing market liquidity and reducing the cost of capital (e.g., Diamond and Verrecchia [1991], Baiman and Verrecchia [1996]). By assuming truthful disclosure, these models use the statistical precision of the noise in the disclosure to capture disclosure quality. Although measuring the precision of disclosure has proven difficult, empirical studies generally find support for the prediction that increasing the quality of disclosure reduces information asymmetry and increases liquidity (e.g., Welker [1995], Lang and Lundholm [1996], Botosan [1997], Sengupta [1998], Healy, Hutton and Palepu [1999], Leuz and Verrecchia [2000]). In this paper, I invert this relation and use changes in liquidity to infer disclosure quality. An increase in liquidity suggests that management reduces its information advantage by providing higher quality disclosure.

The focus on disclosure quality is especially important in this setting because of the legal restrictions on insider trading and disclosure. The legal environment precludes insiders from trading while in possession of material, nonpublic information but does not provide explicit guidelines for disclosure content. As a result, managers wishing to trade have incentives to disclose *something* but maintain discretion over the quality of their disclosure. Other studies that investigate the relation between disclosure and insider trading typically examine whether managers provide biased disclosures or trade on information prior to release (e.g., Penman [1982], Elliott, Morse, and Richardson [1984], Givoly and Palmon [1985], Noe [1999], Rogers and Stocken [2005], Cheng and Lo [2006]). Because providing false information or trading on material undisclosed news directly violates security laws, the difficulty of detecting these types of behaviors is not surprising. I provide more powerful tests of the effects of insider trading on disclosure choices by examining the decision over which the manager actually has discretion—the quality of the disclosure. Furthermore, my market-based measures of quality enable me to test for disclosure management across various disclosure types (management forecasts, conference calls, and press releases), which would be difficult if one had to rely on self-constructed quality indices (e.g., Botosan [1997]).

This study provides evidence that managers' incentives affect the quality of information they provide to market participants. I find that managers provide *higher quality* disclosures prior to selling shares than they provide in the absence of trading. This result is consistent with managers using high

quality disclosure to reduce the litigation risk associated with management sales. Consistent with a desire to maintain their information advantage, I find some, albeit weaker, evidence that managers provide *lower quality* disclosures prior to purchasing shares than they provide in the absence of trading. This study also makes a methodological contribution to the market microstructure literature by improving the procedure used to match trades to quotes in the Trade and Quote (TAQ) database.

Section 2 develops the hypotheses. Section 3 discusses the relation between market liquidity and disclosure quality from a theoretic perspective. Section 4 describes the sample and provides descriptive statistics. Section 5 explains the calculation of the disclosure quality proxies and tests the relation between these proxies and observable properties of management forecasts. Section 6 provides the hypothesis tests and the results. Section 7 investigates alternative explanations and provides robustness tests. Section 8 contains a brief summary and conclusion.

2. *Hypothesis Development*

2.1 INSIDER TRADING AND DISCLOSURE INCENTIVES

This study examines the relation between disclosure quality and incentives derived from trading by managers. Managers are defined as the team of top executives, which includes CEOs, board chairs, presidents, CFOs, and chief operations officers.[1] These managers likely possess private information about firm value, but their ability to profit from this information is constrained by the legal environment. Specifically, the "disclose or abstain" rule precludes managers from trading on the basis of material nonpublic information.[2] As a result, managers wishing to transact in their firm's shares are likely to provide public disclosure in advance of these transactions to reduce litigation risk. These disclosures provide some protection from allegations of illegal insider trading (Noe [1999]) but likely reduce the returns to trading.

While managers have incentives to provide some type of disclosure prior to trading, they maintain considerable discretion over the specific facts they choose to disclose and their interpretations of these facts. For example, a manager could announce that a new customer has been acquired but exercise discretion over whether to disclose the specific terms of the contract, such as the negotiated price, the minimum contracted volume, and the contract duration. Other examples of discretion over disclosure quality include

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[1] This group is chosen because these executives are capable of affecting disclosure decisions and are most likely to possess private information. Consistent with this assertion, prior research finds that higher-level insider trades are more profitable than trades by lower-level insiders (Baesel and Stein [1979], Nunn, Madden, and Gombola [1983], Seyhun [1986], Lin and Howe [1990], Seyhun[1998]).

[2] "Material" information is generally regarded as information that would affect the trading decision of a reasonable investor, if disclosed.

providing additional "hard" information to increase credibility (Hutton, Miller, and Skinner [2003]) and strategically selecting benchmarks against which to evaluate performance (Schrand and Walther [2000]).

Insider trading regulations focus more on when managers incur the duty to disclose as opposed to specifying the content of disclosure. As a result, managers wishing to trade have incentives to disclose *something* but continue to exercise discretion over disclosure quality.[3] Because high quality disclosure reduces their information advantage and returns to trade (Baiman and Verrecchia [1996]), managers have an incentive to provide low quality information. By providing a disclosure before trading, managers may attempt to convince investors and regulators that they are obeying the insider trading regulations while using their discretion to protect their private information. Thus, the *information advantage hypothesis* predicts that:

H1: Managers provide *lower quality* disclosures prior to trading than they provide in the absence of trading incentives.

However, the amount of discretion that managers choose to exercise is a function of the perceived costs. Managers must trade off the costs of losing their information advantage against potential legal costs. If the litigation costs associated with insider trading are perceived to be severe, then the cost of exercising discretion would dominate the benefits of trading on private information. Thus, the *litigation cost hypothesis* predicts that:

H2: To reduce the threat of legal liability, managers do *not* provide *lower quality* disclosures prior to trading than they provide in the absence of trading.

When managers plan to trade, they face conflicting disclosure incentives. On one hand, they have a desire to provide poor quality disclosure to protect their information advantage (H1). On the other hand, potential legal liability discourages this behavior (H2). These competing hypotheses motivate my empirical tests.

2.2 DIFFERENCES BETWEEN INSIDER PURCHASES AND SALES

While both purchases and sales can be motivated by private information, the extent to which information protection incentives dominate disclosure decisions depends on trade direction.[4] The prevalence of equity compensation suggests that insider sales are more likely to be motivated by personal liquidity or diversification needs than insider purchases. When a substantial portion of executive compensation is derived from stock and option grants, executives must convert equity into cash for consumption purposes or to

[3] Rule 10b-5 makes it unlawful "[t]o make any untrue statement of a material fact or to omit to state a material fact necessary in order to make the statements made, in the light of the circumstances under which they were made, not misleading."

[4] The terms "purchase" and "sale" refer to open-market transactions, thus purchases do not include option exercises.

diversify. While a substantial portion of sales is driven by liquidity needs, liquidity-motivated purchases are unlikely.[5] From a diversification perspective, insiders are overinvested in their firms due to the level of personal wealth and human capital invested. Consistent with these motives, empirical research finds that insider sales are inferior to insider purchases as a predictor of future returns (Jaffe [1974], Finnerty [1976], Seyhun [1986], Rozeff and Zaman [1988], Lin and Howe [1990], Seyhun [1998], Noe [1999]) and recent evidence suggests that insider sales have no predictive ability (Chowdhury, Howe, and Lin [1993], Lakonishok and Lee [2001], Jeng, Metrick, and Zeckhauser [2003]).

Information-based sales are associated with higher expected legal costs than information-based purchases (Cheng and Lo [2006]). On the surface, the insider trading regulations are symmetric, prohibiting trading on the basis of material nonpublic information whether it involves the purchase or sale of securities.[6] Rule 10b-5 and the "disclose or abstain" rule developed under 10b-5 apply equally to insider purchases and sales. In contrast to the Justice Department and the Securities and Exchange Commission (SEC), which pursue cases against illegal sales and purchases, private litigants, who have become the primary enforcers of Rule 10b-5 (Niehaus and Roth [1999]), focus almost exclusively on insider selling cases.

In these lawsuits, plaintiffs claim they suffered losses due to material misstatements or failure to disclose (Skinner [1994, 1997]). To prevail under Rule 10b-5, plaintiffs must not only establish that the defendant provided a material misstatement but must also establish that the person acted with scienter.[7] Because courts recognize insider selling as a mechanism for establishing scienter, many of these lawsuits include insider selling allegations, especially after the enactment of the Private Securities Litigation Reform Act of 1995 (PSLRA).[8] These lawsuits likely cause managers to believe that providing low quality disclosure before selling shares is more costly than providing low quality disclosure before acquiring shares. These asymmetric legal costs, combined with the prevalence of liquidity-driven sales, motivate the hypothesis that:

H3: Managers provide higher quality disclosures prior to selling shares than they provide prior to buying shares.

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[5] In some instances insiders are encouraged to increase their holdings to satisfy incentive contracting requirements (see Core and Larcker [2002]). Even in these circumstances, managers have an incentive to satisfy these requirements when they believe the firm is undervalued.

[6] Arshadi [1998] and Bainbridge [2001] provide overviews of insider trading laws and enforcement strategies.

[7] The Supreme Court has defined scienter as "a mental state embracing intent to deceive, manipulate, or defraud." *Ernst & Ernst* v. *Hochfelder*, 425 U.S. 185, 193 n.12 [1976].

[8] Grundfest and Perino [1997] find that 57% of post-PSLRA lawsuits contain insider trading allegations, while only 21% of pre-PSLRA lawsuits contain such allegations. Johnson, Nelson, and Pritchard [2007] and Pritchard and Sale [2003] present similar evidence. Johnson, Nelson, and Pritchard [2007] also find that insider trading allegations are more frequent than accounting-related allegations.

3. *Relation between Market Liquidity and Disclosure Quality*

This paper investigates whether managers protect their private information when making disclosures prior to trading on their own account. The extent to which the management team has reduced its information advantage is termed *disclosure quality*, and I use changes in market liquidity as an empirical proxy for the reduction in information advantage. In the presence of adverse selection, market makers (and other liquidity providers) reduce the firm's liquidity (Bagehot [1971]). Intuitively, uninformed market makers lose to privately informed traders and therefore must recoup these losses from uninformed liquidity traders.

Kyle [1985] demonstrates that an insider's trading profits are proportional to the insider's information advantage, while pretrade price informativeness and market liquidity are inversely related to this information advantage. Holding liquidity traders' demands constant, a greater level of market liquidity implies that the informed trader has a smaller information advantage (earns smaller profits). Diamond and Verrecchia [1991] and Baiman and Verrecchia [1996] extend this research and show that increasing the precision of a firm's disclosure reduces the trading profits of an informed trader and increases market liquidity.

If managers and other informed market participants trade on correlated information, then disclosing private information reduces the information advantage of all informed traders and improves liquidity. Alternatively, managers likely possess some information that is unavailable to any other informed traders. In this case, Diamond and Verrecchia [1991] suggest that liquidity would be unaffected by disclosing the managers' private information. Therefore, the extent to which managers disclose information that hurts their advantage but does not affect the information advantage of other informed traders reduces the power of my tests.

When disclosure truthfully reveals the terminal value of a risky asset plus noise, the precision of this noise term, which investors rationally anticipate, captures the notion of disclosure quality. Therefore, the terms disclosure quality and disclosure precision are used interchangeably. In real-world settings, the assumption of strictly truthful disclosure is unlikely to hold. For example, a manager could selectively omit unfavorable information from a press release or conference call before attempting to sell overvalued shares. Alternatively, a manager could try to convince investors of the firm's excellent growth potential in order to make an earnings disappointment appear less severe. Furthermore, a manager could alter a disclosure's tone in order to sway investors' interpretations. If managers employ any of these strategies, then the truth-telling assumption is violated.

In the absence of truthful-telling constraints, the properties of a signal are insufficient to determine the usefulness of the information to the recipient. Interpreting a signal requires an understanding of the properties of the signaling technology as well as the sender's disclosure strategy. In other words, "the information revealed by a disclosure is not confined

to the information 'contained' in that disclosure. Information is also revealed by the informed party's choice of how, or what, to disclose." (Fishman and Hagerty [1992, p. 429]). In the extreme, the player's payoffs do not depend on the sender's actual message but instead depend on the actions induced by the message (Crawford and Sobel [1982], Farrell [1993], Stocken [2000]). Therefore, when managers are not forced to be entirely truthful, examining the actions induced by a disclosure likely provides a better indication of its value to recipients than examining the properties of the disclosure itself. As a result, changes in liquidity are likely a better proxy for disclosure quality than the directly observable properties of the disclosure.

4. *Sample and Descriptive Statistics*

I use three sets of disclosure events to test my hypotheses: management forecasts, conference calls, and press releases issued by firms who recently completed an initial public offering (IPO). I obtain management forecasts of earnings per share (EPS) from First Call Historical Database. When a firm provides more than one forecast on a given day, I retain the forecast with the longest *Horizon*, where *Horizon* equals the number of calendar days between the forecast release date and the fiscal period-end date for which earnings are being forecast.[9] To focus on earnings forecasts rather than pre-announcements, I eliminate forecasts issued on or after the corresponding fiscal period-end (i.e., $Horizon \leq 0$).

Table 1, panel A, provides distributional information about the sample. Consistent with other studies that use the First Call database (e.g., Anilowski, Feng, and Skinner [2007]), the frequency of management forecasts increases through time with a substantial increase after the enactment of Regulation Fair Disclosure (i.e., after October 23, 2000). To control for variation in forecast quality across time, I include year fixed effects in my hypothesis tests. Also consistent with prior studies, the majority of the sample forecasts are either range estimates (52%) or point estimates (19%).[10] Forecasts of annual EPS are more common than forecasts of quarterly EPS, although this relation reverses if forecasts with the shortest *Horizon* are examined. In approximately 46% of the cases, forecasts are issued within one trading day of an earnings announcement. Therefore, I introduce control variables for whether the firm contemporaneously announced earnings (*Contemp*) and for the earnings surprise (*Esurp*). Approximately 14% (5%) of management

[9] The reported results are unaffected by using the forecast with the shortest *Horizon*.

[10] While First Call maintains an extensive database of earnings forecasts, it contains systematically fewer qualitative forecasts than hand-collected samples (e.g., Hutton, Miller, and Skinner [2003], Miller [2002]). Failure to observe a substantial portion of qualitative forecasts likely adds noise to my analysis and could even introduce bias. Ex ante, it is unclear whether and how First Call's selection procedures bias my hypothesis tests for the management forecast sample.

TABLE 1

Distribution of Samples

Panel A: Management forecasts (2,636 firms)

Year	Frequency
1994	51
1995	186
1996	283
1997	485
1998	1,067
1999	1,273
2000	1,636
2001	3,054
2002	3,986
	12,021

Forecasts Bundled With Earnings	Frequency
No	6,454
Yes	5,567
	12,021

Forecast Type	Frequency
Point	2,275
Range	6,311
Open ended	1,962
Qualitative	1,473
	12,021

Insider Trading	Frequency
Sales	1,717
Purchases	621
Holds (no trading)	9,683
	12,021

Forecast Type	Frequency
Quarterly	5,099
Annual	6,922
	12,021

Panel B: Conference calls (3,017 firms)

Year	Frequency
1995	449
1996	902
1997	1,629
1998	1,973
1999	2,899
2000	4,015
2001	5,677
2002	6,221
	23,765

Calls Bundled With Earnings	Frequency
No	15,401
Yes	8,364
	23,765

Insider Trading	Frequency
Sales	3,711
Purchases	1,409
Holds (no trading)	18,645
	23,765

Panel C: IPO press releases (211 firms)

Year	Frequency
1993	190
1994	240
1995	320
1996	942
1997	431
1998	468
1999	806
2000	1,074
	4,471

Type of Press Release	Frequency
Earnings	724
Operations	2,321
Financing	81
New Financing	142
Personnel	270
Lawsuits	18
Public Relations	328
Forecast	126
Lockup Expiration	28
Investor Relations	48
Acquisitions	334
Divestitures	18
Other	33
	4,471

Insider Trading	Frequency
Sales	630
Purchases	84
Holds (no trading)	3,757
	4,471

All variables are described in appendix A.

forecasts are followed by net insider selling (buying) activity over the next 20 trading days.[11]

Conference call information is also obtained from First Call. Similar to the management forecast sample, the sample of conference calls is concentrated in later years (table 1, panel B). Approximately 16% of conference calls are followed by insider sales while 6% are followed by insider purchases.

The sample of press releases I examine is a subset of that analyzed in Schrand and Verrecchia [2005]. They identified a sample of IPO firms that experienced significant underpricing and collected all press releases from 90 days before to 360 days after the IPO. These press releases then coded into the following 14 categories: (1) earnings announcements, (2) disclosures about the IPO (not used in this study),[12] (3) disclosures related to operating activities, (4) disclosures related to acquisitions of other companies, (5) disclosures related to existing financing activities, (6) announcements of new financing arrangements, (7) disclosures about personnel, (8) disclosures of lawsuits, (9) public relations announcements, (10) earnings guidance, (11) announcements regarding lockup expirations, (12) disclosures about investor relations matters, (13) disclosures related to divestitures, and (14) other disclosures. I only include press releases issued at least 30 trading days after the offering date to eliminate the effect of "quiet period" restrictions.[13] I also exclude press releases issued prior to 1993, because my liquidity proxies are calculated using the TAQ database.[14] The final sample consists of 4,471 press release dates for 211 companies (table 1, panel C). Most of the press release firms are listed on the NASDAQ. The most common types of press releases relate to firm operations (*PR Operations*) and earnings announcements (*PR Earnings*). While approximately 14% of press releases are followed by insider sales, only 2% (84 press releases) are followed by insider purchases.

Table 2 provides descriptive statistics for the three samples, and detailed variable definitions are in appendix A. As expected, market capitalization

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[11] Insider trading data are obtained from the Thompson Financial insider trading database. Insider trading is defined as open-market purchases and sales reported in table 1 of form 4. Purchasers (sellers) are defined as top executives who are net purchasers (sellers), on a dollar basis, in the 20 trading days following the disclosure. To ensure that firms are covered by the Thompson Financial insider trading database, I exclude firms that have no reported insider trading activity in the past 1,000 trading days.

[12] Disclosures about the IPO generally state that an IPO will occur. I restrict my attention to disclosures subsequent to the IPO. Occasionally, firms issue a press release indicating that an IPO has occurred, but this information is unlikely to affect liquidity because it is already public knowledge.

[13] The quiet period runs from the time the firm hires an underwriter to 25 calendar days after the offering. During this time, firms are not allowed to "hype" the stock by making statements that are not contained in the prospectus.

[14] TAQ coverage began in 1993 for all exchanges. Prior to April 6, 1993, the bid and offer sizes (depths) for NASDAQ National Market System (NMS) issues are invalid. Therefore, press releases for NASDAQ firms prior to this date are also excluded.

TABLE 2
Descriptive Statistics

Panel A: Management forecasts (12,021 disclosures for 2,636 firms)

	Mean	Std. Dev.	25th	Median	75th
Market cap. ($millions)	8,240	22,700	386	1,140	4,580
MtoB	3.71	4.79	1.45	2.40	4.23
$CAR_{0,+1}$	−1.79%	10.26%	−5.79%	−0.48%	3.57%
Sell ($N = 1{,}717$)	$6,522,951	$15,053,000	$447,600	$149,570	$4,797,058
Buy ($N = 621$)	$211,026	$303,901	$23,800	$75,000	$234,900
$Quality_{RESpread}$	2.12	22.55	−11.10	2.00	15.55
$Quality_{\$Depth}$	0.23	31.44	−19.00	−0.01	19.01

Panel B: Conference calls (23,765 disclosures for 3,017 firms)

	Mean	Std. Dev.	25th	Median	75th
Market cap. ($millions)	5,550	15,900	245	798	3,080
MtoB	3.87	5.22	1.40	2.38	4.38
$CAR_{0,+1}$	−0.08%	8.52%	−3.75%	0.02%	3.87%
Sell ($N = 3{,}711$)	$5,058,927	$10,948,390	$351,600	$1,270,170	$4,350,880
Buy ($N = 1{,}409$)	$210,580	$362,435	$17,875	$56,778	$201,060
$Quality_{RESpread}$	3.48	22.82	−9.68	3.21	16.45
$Quality_{\$Depth}$	2.00	32.60	−17.50	1.16	20.77

Panel C: IPO press releases (4,471 disclosures for 211 firms)

	Mean	Std. Dev.	25th	Median	75th
Market cap. ($millions)	2,340	4,300	292	643	2,360
MtoB	−1277.49	11852.94	2.59	9.69	32.68
$CAR_{0,+1}$	0.35%	9.26%	−4.83%	−0.34%	4.86%
Sell ($N = 630$)	$16,015,660	$30,435,890	$832,400	$3,288,406	$11,500,000
Buy ($N = 84$)	$277,497	$360,606	$34,760	$109,400	$357,200
$Quality_{RESpread}$	1.58	23.44	−12.91	1.01	15.33
$Quality_{\$Depth}$	0.10	25.85	−13.85	−0.03	13.99

All variables are described in appendix A.

and market-to-book (*MtoB*) varies considerably across samples. Consistent with prior studies (e.g., Bamber and Cheon [1998]), management forecasts tend to convey bad news as evidenced by the negative average (median) event return of −1.79% (−0.48%). In contrast, event period returns for conference calls and press releases are relatively small in magnitude. Across all samples, the average management sale is considerably larger than the average purchase, and the magnitude of sales for the IPO firms are considerably larger than those for the other samples.

5. *Proxies for Disclosure Quality*

This section describes how I measure disclosure quality from transaction level data. This section also investigates the empirical relation between my measure of disclosure quality and several frequently studied properties of management forecasts.

5.1 MEASURING CHANGES IN MARKET LIQUIDITY

When faced with adverse selection costs caused by information asymmetry, dealers protect themselves by reducing the level of liquidity for firm shares. In security markets, protective measures include increasing quoted spreads (i.e., difference between the ask price and the bid price), decreasing quoted depth, and decreasing the level of price improvement (i.e., when the dealer executes a trade at better than quotes prices). Empirical studies find evidence that high quality disclosure (measured in various ways) improves market liquidity more than low quality disclosure (Greenstein and Sami [1994], Welker [1995], Boone [1998], Coller and Yohn [1997], Leuz and Verrecchia [2000]).

I use changes in market liquidity to proxy for disclosure quality. Specifically, I compare the level of predisclosure liquidity to the level of postdisclosure liquidity, both measured over a nine-trading-day window (-10 to -2 and $+2$ to $+10$, respectively).[15] My first liquidity measure, based on relative effective spreads, is a proxy for the round trip transaction costs (excluding commissions) of trading. Measuring effective spreads requires comparing actual transaction prices to the expected value of the security. Researchers typically assume that dealers center the spread on the security's expected value and use the quote midpoint (i.e., average of the bid and ask) to proxy for this value. Thus, the relative effective spread for each transaction is defined as twice the absolute difference between the transaction price and the quote midpoint, deflated by the quote midpoint.

Unlike the quoted spreads, effective spreads incorporate the effect of price improvement but require the matching of each trade to the dealer quote that is outstanding at the time of the trade. The matching of trades to quotes is complicated by the fact that the time stamp for a trade does not necessarily match the time stamp for the quote that is outstanding at the time of the trade. Recognizing this problem, Lee and Ready [1991] analyze a sample of *isolated* trades for 150 New York Stock Exchange (NYSE) firms during 1988.[16] By examining the relation between the time of the trade and the time of quote revisions, Lee and Ready [1991] determine that the trade time stamp lags the quote time stamp by five seconds on average. The five-second delay recommended by Lee and Ready [1991] has become the standard for microstructure research.

In order to determine whether a five-second lag is still applicable, I devise a test for the appropriate lag to use when matching trades to quotes in the TAQ database (see appendix B). This test indicates that a zero-second lag substantially improves the matching of trades to quotes for both NYSE and

[15] This window is used by Coller and Yohn [1997] to measure the effects of management forecasts on quoted spreads.

[16] Lee and Ready [1991] define an *isolated* trade as the first trade that occurs after 11:00 a.m. but before 2:30 p.m. and has no other trades within one minute on either side.

NASDAQ firms. As a result, I use a zero-second lag when matching quotes and trades.

The process of matching quotes and trades is also computationally intensive. To reduce the computational burden, I calculate a daily average effective spread based on 200 randomly selected trades per day.[17] Thus, *RESpread* is the average of the nine daily averages computed over either the predisclosure or the postdisclosure measurement window.

In addition to adjusting spreads, dealers can also protect themselves from informed traders by adjusting the number of shares (or depth) they are willing to transact at the posted prices.[18] Because these protective measures can be complements or substitutes, unambiguous interpretations of liquidity effects require the examination of both measures (Heflin, Shaw, and Wild [2005]). Therefore, my second proxy for market liquidity is quoted dollar depth ($*Depth*), defined as the average of the number of shares the dealer offers to buy multiplied by the ask price and the number of shares the dealer is willing to sell multiplied by the bid price. Since calculating $*Depth* does not require the matching of quotes and trade, I calculate the daily average of this measure over all available quotes.

To assess disclosure quality (*Quality*), I calculate changes in the liquidity measures around the disclosure event. Specifically, I measure *Quality* as the natural log of postdisclosure liquidity levels less the natural log of predisclosure liquidity levels, both measured over nine trading days.[19] The variables are defined to approximate percentage changes in liquidity, where more positive values indicate higher levels of liquidity. Therefore, log changes in *RESpread* are multiplied by −100 to create $Quality_{RESpread}$, and log changes in $*Depth* are multiplied by 100 to create $Quality_{\$Depth}$. A similar convention is used to define predisclosure liquidity levels.

Table 2 provides descriptive statistics for changes in liquidity. On average, forecasts increase the spread-based measure of market liquidity ($Quality_{RESpread}$) by approximately 2.14% but appear to have little effect on market depth (i.e., mean $Quality_{\$Depth}$ is close to zero). The IPO press release sample demonstrates a similar pattern. In contrast, conference calls appear to affect both measures of liquidity. On average, conference calls increase the spread-based measure of liquidity by approximately 3.48% and the depth-based measure by approximately 2.00%.

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[17] If a security trades less than 200 times in a given day, then all trades are used. To minimize data errors I eliminate quotes: (1) that do not occur on the principal exchange, (2) where the bid price exceeds the ask price, (3) where the quoted relative spread exceeds 0.5, (4) where the quoted spread exceeds the previous and following quoted spread by a factor of 10 or greater, and (5) where the quoted depth is less than or equal to zero. I also exclude quotes and trades outside of regular trading hours.

[18] See Dupont [2000] for an analytical model suggesting that depth is an effective tool to mitigate adverse selection problems.

[19] I use this transformation, as opposed to measuring percentage changes, because the resulting variable is more normally distributed. The paper's conclusions are unaffected by measuring *Quality* as percentage changes in liquidity.

5.2 DISCLOSURE QUALITY AND OTHER DISCLOSURE PROPERTIES

To my knowledge, this is the first paper to use short-term changes in liquidity to proxy for disclosure quality. In this section, I investigate the association between my measure of quality and several frequently used and directly observable properties of management forecasts. Once a manager decides to provide a forecast, he/she faces choices about the properties of the forecast (King, Pownall, and Waymire [1990]). Specifically, managers choose the precision (Baginski, Conrad, and Hassell [1993], Bamber and Cheon [1998], Baginski, Hassell, and Kimbrough [2002]), the specificity (Baginski, Conrad, and Hassell [1993], Baginski and Hassell [1997]), and the horizon (Baginski, Hassell, and Kimbrough [2002]) of their forecasts. If managers use forecast properties to truthfully reveal the quality of their private information these properties should be correlated with my quality measure.

To investigate the relations among disclosure quality, forecast precision, forecast specificity, and forecast horizon, I estimate the following regression (firm and time subscripts have been suppressed):[20]

$$Quality = \beta_0 + \beta_1 Forecast\ Property + Control\ variables + \varepsilon. \quad (1)$$

Quality (defined above) measures liquidity changes, and higher values of *Quality* result from larger increases in liquidity. The three forecast properties are defined as follows. First, forecast *Precision* assumes a value of four for point estimates, three for range estimates (i.e., minimum and maximum estimate provided), two for open-ended estimates (i.e., minimum or maximum, but not both), and one for qualitative estimates (e.g., "about breakeven to slightly positive"). I expect that each type of estimate is progressively less precise and, therefore, less informative to investors.

Second, forecast *Specificity* is calculated as the top of the management forecast range less the bottom of the range deflated by prerelease share price for all range estimates; it equals zero for point estimates and is undefined for open-ended and qualitative estimates. This measure is multiplied by −100 for expositional purposes. Ceteris paribus, tighter estimates should provide more information to market participants than wider estimates. Consistent with this notion, Baginski, Conrad, and Hassell [1993] demonstrate that prices react more strongly to tighter estimates.

Third, *Ln_Horizon* is the natural log of the difference between the forecast release date and the last day of the fiscal period being forecasted. Ex ante, the relation between forecast horizon and disclosure quality is unclear. While increasing the horizon of a forecast is consistent with management providing more timely information to the market, shorter horizon forecasts are likely to be more accurate. Therefore, it is an empirical question

[20] I exclude forecasts released prior to trading for this analysis, because the information advantage hypothesis (H1) predicts that trading incentives cause managers to alter these disclosures.

whether shorter or longer horizon forecasts are more effective at reducing information asymmetry. *Control variables* are defined in appendix A and include measures of order flow, the firm's information environment, and announcement returns.

Consistent with expectations, table 3, panel A indicates that more precise and more specific disclosures correspond to higher disclosure quality as measured by $Quality_{RESpread}$. In addition, more timely (i.e., longer horizon) forecasts are associated with larger increases in liquidity. Panel B repeats the analysis, replacing $Quality_{RESpread}$ with $Quality_{\$Depth}$. These results are similar to those reported in panel A with the exception that the coefficient on *Specificity* is not significant in panel B. The controls for order flow indicate liquidity improvements are associated with increases in trading activity ($\Delta Trades$, $\Delta\$Volume$) and decreases in price volatility ($\Delta Std\_midpoint$). The results of these tests support the notion that liquidity improvements are increasing in disclosure quality.

6. *Hypothesis Tests and Results*

I conduct hypothesis tests using the disclosure quality proxies developed in section 5. To determine whether insider trading incentives affect disclosure quality, I estimate the following regression (firm and time subscripts have been suppressed):

$$Quality = \beta_0 + \beta_1 Sell + \beta_2 Buy + Control\ variables + \varepsilon. \tag{2}$$

Where *Quality* (defined above) measures liquidity changes, and higher values of *Quality* result from larger increases in liquidity. *Sell* (*Buy*) is an indicator variable that equals one if the management team is a net seller (purchaser) of equity during the 20 trading days following the disclosure and zero otherwise.[21] *Control variables* are defined in appendix A and include measures of order flow, the firm's information environment, announcement returns, and selected disclosure properties.

Panel A of table 4 provides the results for the management forecast sample. Both of the models are highly significant with R^2 values of 31.90% and 27.17%. As predicted by H3, the relation between disclosure quality and trading depends on whether the manager is purchasing or selling shares. The coefficient on *Sell* is positive and significant for both quality proxies. The magnitude of the coefficient indicates that forecasts before management sales increase $Quality_{RESpread}$ ($Quality_{\$Depth}$) by approximately 3.18% (3.33%) more than forecasts not associated with trading. These effects are relatively large compared to the unconditional sample means, which indicate that the average forecast improves *RESpread* by approximately 2.12% and has little

[21] Sivakumar and Waymire [1994] show that insider trading remains elevated for four weeks after earnings announcements. Noe [1999] also uses a 20-day window to examine insider trading around management forecasts.

TABLE 3

Regression Analysis to Determine the Relation between Management Forecast Properties and Disclosure Quality

Panel A: *Quality*$_{RESpread}$

	Quality$_{RESpread}$ Model 1.1		*Quality*$_{RESpread}$ Model 1.2		*Quality*$_{RESpread}$ Model 1.3	
	Coeff.	*t*-Stat.[a]	Coeff.	*t*-Stat.[a]	Coeff.	*t*-Stat.[a]
Forecast properties						
Precision	0.52	2.22**				
Specificity			2.02	2.43**		
Ln_Horizon					0.54	3.13***
Controls for order flow						
Δ*Std_midpoint*	−25.92	−32.86***	−27.02	−29.41***	−25.88	−32.83***
Δ*Trades*	15.26	11.74***	16.10	10.34***	15.40	11.89***
Δ$*Volume*	1.23	1.71*	1.43	1.64	1.17	1.63
Controls for information environment						
Liquidity$_{Bef}$	−7.92	−13.73***	−8.13	−11.88***	−7.88	−13.67***
Ln_Size	1.51	6.48***	1.55	5.63***	1.45	6.19***
Ln_Analyst	−0.76	−1.70*	−1.06	−1.97**	−0.65	−1.44
Disclosure related controls						
$CAR_{0,+1}$	87.77	36.79***	89.98	31.84***	87.16	36.65***
Contemp	3.41	8.02***	3.15	6.22***	2.96	6.50***
Esurp	−5.45	−0.05	−82.08	−0.70	−1.48	−0.01
Other controls						
MtoB_decile	0.24	2.81***	0.31	2.88***	0.23	2.69***
Nasdaq	−3.03	−5.31***	−2.94	−4.33***	−3.03	−5.30***
Industry fixed effects	Included		Included		Included	
Year fixed effects	Included		Included		Included	
R^2	29.50%***		30.67%***		29.53%***	
N	9,683		6,837		9,683	

Panel B: *Quality*$_{\$Depth}$

	Quality$_{\$Depth}$ Model 2.1		*Quality*$_{\$Depth}$ Model 2.2		*Quality*$_{\$Depth}$ Model 2.3	
	Coeff.	*t*-Stat.[a]	Coeff.	*t*-Stat.[a]	Coeff.	*t*-Stat.[a]
Forecast properties						
Precision	0.92	2.59***				
Specificity			1.49	1.29		
Ln_Horizon					0.78	2.88***
Controls for order flow						
Δ*Std_midpoint*	−11.33	−10.54***	−11.92	−9.61***	−11.26	−10.49***
Δ*Trades*	−16.24	−8.55***	−14.83	−6.54***	−16.02	−8.42***
Δ$*Volume*	26.47	20.94***	25.80	17.35***	26.37	20.82***
Controls for information environment						
Liquidity$_{Bef}$	−21.93	−27.03***	−22.32	−23.55***	−22.01	−26.98***
Ln_Size	8.80	19.04***	8.56	15.48***	8.75	18.85***
Ln_Analyst	1.06	1.58	0.76	0.97	1.23	1.84*
Disclosure-related controls						
$CAR_{0,+1}$	76.71	22.75***	77.18	19.66***	75.83	22.42***
Contemp	0.82	1.27	0.39	0.51	0.20	0.29
Esurp	388.18	2.43**	250.98	1.41	395.52	2.48**
Other controls						
MtoB_decile	0.30	2.36**	0.48	3.06***	0.29	2.26**
Nasdaq	−21.82	−20.61***	−21.30	−17.75***	−21.92	−20.67***
Industry fixed effects	Included		Included		Included	
Year fixed effects	Included		Included		Included	
R^2	25.98%***		26.43%***		25.99%***	
N	9,683		6,837		9,683	

This table provides pooled OLS regressions results for the relation between managerial forecast properties and disclosure quality. More positive values of *Quality* correspond to larger increases in liquidity. *Quality* is measured on a scale that approximates percentage changes in liquidity.

All variables are described in appendix A.

[a]Reported test statistics are based on covariance matrices that are asymptotically robust to heteroskedasticity and standard errors that are clustered by firm.

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, based on two-tailed tests.

TABLE 4

Regression Analysis to Determine the Effect of Managerial Trading Incentives on Disclosure Quality

Management forecast sample ($N = 12{,}021$)	$Quality_{RESpread}$ Model 3.1		$Quality_{\$Depth}$ Model 3.2	
	Coeff.	*t*-Stat.[a]	Coeff.	*t*-Stat.[a]
Hypothesized relations				
Sell	3.18	6.55***	3.33	4.62***
Buy	−2.42	−2.87***	1.54	1.19
Controls for order flow				
Δ*Std_midpoint*	−26.03	−36.67***	−10.60	−10.90***
Δ*Trades*	15.01	13.21***	−16.38	−9.94***
Δ$*Volume*	1.30	2.05**	26.83	23.74***
Controls for information environment				
$Liquidity_{Bef}$	−8.54	−16.30***	−22.01	−29.63***
Ln_Size	1.59	7.75***	8.68	20.40***
Ln_Analyst	−0.43	−1.10	1.25	2.10**
Disclosure-related controls				
$CAR_{0,+1}$	81.62	38.69***	70.04	23.22***
Contemp	3.05	8.08***	0.95	1.63
Esurp	84.94	0.93	423.40	2.97***
Other controls				
$CAR_{+2,+20}$	23.32	15.57***	20.42	10.06***
MtoB_decile	0.21	2.62***	0.40	3.47***
Nasdaq	−2.32	−4.65***	−21.81	−22.67***
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
R^2	31.90%***		27.17%***	

This table provides pooled OLS regressions results for the effect of managerial trading incentives on disclosure quality. More positive values of *Quality* correspond to larger increases in liquidity. *Quality* is measured on a scale that approximates percentage changes in liquidity.

All variables are described in appendix A.

[a]Reported test statistics are based on covariance matrices that are asymptotically robust to heteroskedasticity and standard errors that are clustered by firm.

*, **, and *** denote significance at the 1%, 5%, and 10% levels, respectively, based on two-tailed tests.

effect on $*Depth* (see table 2). These models indicate that managers provide higher quality forecasts prior to selling shares than they provide in the absence of trading.

The results for managerial purchases are weaker than the results for sales. Consistent with managers providing lower quality disclosures prior to buying shares than they provide in the absence of trading, the coefficient on *Buy* is negative and significant in the $Quality_{RESpread}$ model (model 3.1). The coefficient on *Buy* is not significant in the $Quality_{\$Depth}$ model (model 3.2). This analysis provides weak evidence that managers release lower quality forecasts prior to buying shares than they provide in the absence of trading.

The conference call sample (table 5) provides similar results. I continue to find an asymmetry between disclosure quality preceding sales versus disclosure quality preceding purchases. In each model, the coefficient on *Sell* is significant and represents an approximately 2.4% increase in liquidity. In model 4.1 the significantly negative coefficient on *Buy* suggests a reduction

TABLE 5

Regression Analysis to Determine the Effect of Managerial Trading Incentives on Disclosure Quality

Conference call sample ($N = 23{,}765$)	$Quality_{RESpread}$ Model 4.1		$Quality_{\$Depth}$ Model 4.2	
	Coeff.	*t*-Stat.[a]	Coeff.	*t*-Stat.[a]
Hypothesized relations				
Sell	2.40	6.61***	2.41	4.78***
Buy	−4.18	−6.68***	−1.68	−1.86*
Controls for order flow				
Δ*Std_midpoint*	−27.61	−51.68***	−12.11	−16.98***
Δ*Trades*	16.15	20.18***	−10.55	−8.97***
Δ$*Volume*	1.80	3.80***	23.39	28.26***
Controls for information environment				
$Liquidity_{Bef}$	−5.71	−20.92***	−23.72	−38.97***
Ln_Size	1.77	12.26***	9.99	28.12***
Ln_Analyst	−0.62	−2.57**	0.22	0.54
Disclosure-related controls				
$CAR_{0,+1}$	70.26	39.38***	68.68	28.38***
Contemp	2.07	7.52***	−0.91	−2.08**
Esurp	165.73	5.92***	102.50	2.45**
Other controls				
$CAR_{+2,+20}$	24.33	25.87***	20.43	16.69***
MtoB_decile	0.14	2.58**	0.18	1.92*
Nasdaq	−1.04	−2.88***	−22.58	−28.25***
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
R^2	29.27%***		26.98%***	

This table provides pooled OLS regressions results for the effect of managerial trading incentives on disclosure quality. More positive values of *Quality* correspond to larger increases in liquidity. *Quality* is measured on a scale that approximates percentage changes in liquidity.

All variables are described in appendix A.

[a]Reported test statistics are based on covariance matrices that are asymptotically robust to heteroskedasticity and standard errors that are clustered by firm.

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, based on two-tailed tests.

in the spread-based liquidity measure of approximately 4.18% while the reduction in the depth-based measure is a more modest and less significant 1.68% (model 4.2).

Evidence for the press release sample is consistent with the previous results and is reported in table 6. The coefficients on *Sell* are somewhat larger than in the other two samples and are both significant. As previously noted, purchases tend to be relatively uncommon in the sample of recent IPO firms, but the coefficient on *Buy* is relatively large and negative in both models but is only significant in model 5.2.

In summary, these three samples provide relatively consistent evidence regarding H1 through H3. First, when managers provide disclosure prior to purchasing shares on their own account, the evidence suggests that the information advantage motive dominates potential legal costs, resulting in *lower* quality disclosure. Therefore, for disclosures that precede purchases, I reject the litigation cost hypothesis, H2, in favor of the information advantage

TABLE 6

Regression Analysis to Determine the Effect of Managerial Trading Incentives on Disclosure Quality

Press releases for post-IPO sample ($N = 4{,}471$)

	$Quality_{RESpread}$ Model 5.1		$Quality_{\$Depth}$ Model 5.2	
	Coeff.	*t*-Stat.[a]	Coeff.	*t*-Stat.[a]
Hypothesized relations				
Sell	6.17	4.59***	4.00	2.14**
Buy	−4.42	−1.02	−8.82	−2.58**
Controls for order flow				
Δ*Std_midpoint*	−15.21	−9.05***	4.37	2.37**
Δ*Trades*	6.53	3.69***	−0.32	−0.16
Δ$*Volume*	4.50	3.93***	4.06	3.01***
Controls for information environment				
$Liquidity_{Bef}$	−11.00	−10.14***	−17.10	−10.64***
Ln_Size	3.99	7.26***	7.57	8.87***
Ln_Analyst	1.04	1.23	0.41	0.37
Disclosure-related controls				
$CAR_{0,+1}$	47.76	11.62***	63.77	16.18***
PR_Earnings	0.72	0.17	−3.35	−0.79
PR_Operations	0.51	0.13	−4.22	−1.01
PR_Finance	0.31	0.07	0.38	0.07
PR_Newfin	1.02	0.22	−0.55	−0.11
PR_Personnel	1.64	0.41	−5.61	−1.25
PR_Lawsuit	0.91	0.12	−3.21	−0.50
PR_PubRel	1.12	0.26	−5.12	−1.18
PR_Forecast	−4.88	−1.08	−5.62	−1.27
PR_Lockup	0.15	0.03	−1.15	−0.23
PR_IRelations	2.16	0.47	−3.17	−0.71
PR_Acquire	2.73	0.66	−1.83	−0.42
PR_Divest	11.09	2.02**	9.47	1.27
Other controls				
$CAR_{+2,+20}$	16.59	10.21***	17.06	9.58***
MtoB_decile	0.27	1.79*	0.33	1.89*
Nasdaq	−7.18	−3.71***	−21.62	−4.62***
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
R^2	23.64%***		24.28%***	

This table provides pooled OLS regressions results for the effect of managerial trading incentives on disclosure quality. More positive values of *Quality* correspond to larger increases in liquidity. *Quality* is measured on a scale that approximates percentage changes in liquidity.

All variables are described in appendix A.

[a]Reported test statistics are based on covariance matrices that are asymptotically robust to heteroskedasticity and standard errors that are clustered by firm.

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, based on two-tailed tests.

hypothesis, H1. Second, when managers provide disclosures prior to selling shares, the evidence suggests that the fear of legal liability dominates their profit-seeking motives, resulting in *higher* quality disclosure. Therefore, for disclosures that precede sales, I reject the information advantage hypothesis, H1, in favor of the litigation costs hypothesis, H2. Third, these results provide evidence of a strong asymmetry between the disclosure incentives associated with purchases versus sales, allowing me to reject the null for H3.

Although I predict that managers provide higher quality disclosure before sales than they provide before purchases, the finding that they provide higher quality disclosure before selling than they provide in the absence of trading is unexpected. One interpretation of this result is that managers have become fearful of plaintiffs' attorneys using managerial selling as a basis for accusing managers of withholding relevant information. As a result, managers use higher quality disclosures to protect against these allegations.

7. *Alternative Explanations and Robustness Tests*

7.1 ENDOGENEITY

My analysis is based on the assumption that managerial trading drives disclosure quality. The fact that managers choose whether to disclose, whether to trade, and the quality of their disclosure raises concerns about self-selection and endogeneity. Specifically, managers could choose to sell shares when disclosures result in low information asymmetry and choose to buy shares when the market has difficulty interpreting their disclosure (i.e., relatively higher information asymmetry). Under this scenario, managers could be conveying their private information to the best of their abilities but choose whether to trade based on the market reaction.

I use a treatment effect model to investigate whether the reported results are driven by self-selection.[22] While managers can choose to buy, sell, or hold shares at almost any point in time, I simplify the testing by assuming managers are not simultaneously considering purchasing and selling shares. Therefore, I model the decision to buy versus hold and separately model the decision to sell versus hold. Based on this simplification, I address endogeneity concerns by fitting two treatment effect models for each sample (and each quality proxy) using the two-step estimator from Maddala [1983].

In the first stage, I model the decision to trade. For the management forecast and conference call samples, I predict trading behavior using the following variables: (1) lagged stock return volatility ($STD_{-120,-1}$), (2) lagged stock returns ($CAR_{-120,-1}$), (3) natural log of the dollar value of stock holdings calculated from the insider trading database (*Ln_$Stock*), (4) whether the management team received a stock or option grant in the 10 days prior to the disclosure (*Grant*), (5) a proxy for whether the firm has insider trading window restrictions (*Restrict*) interacted with whether the disclosure is bundled with an earnings announcement (*Contemp*), (6) lagged trading behavior (*Prior Sell/Buy*), (7) predisclosure liquidity ($Liquidity_{Bef}$), (8) firm size (*Ln_Size*), and (9) firm market-to-book ratio (*MtoB_decile*). Precise variable definitions are included in appendix A. Since reliable data for prior trading

[22] Leuz and Verrecchia [2000] provide a detailed description of the treatment effect model. They use this model to study how proxies for the information asymmetry component of the cost of capital are affected by German firms that choose to switch to an international reporting regime (international accounting standards or U.S. generally accepted accounting principles).

behavior, trading window restrictions, and stock holdings are not readily available for the IPO firms, I replace these instruments with an indicator variable for whether the lockup provision has expired (*Post_Lockup*). I also calculate lagged returns and lagged volatility over a 30-day window instead of a 120-day window.

Table 7 through table 9 present the treatment effect models for the three samples. In the first stage, most of the variables used to predict "sell versus hold" are highly significant in the expected direction. Fewer of the coefficients in the first stage of the "buy versus hold" models are significant, indicating it is more difficult to predict insider purchases. In the second stage models, the coefficients on the control variables are not reported for parsimony but are similar to those reported in table 4 through table 6.

Overall, the results do not indicate that my results are driven by self-selection. In table 7, panel A, the inverse-Mills Ratio is not significant in either specification, providing no evidence of a selection bias. While the coefficients on *Sell* are slightly larger than those reported in table 4, their significance is reduced to the 10% level. In panel B, the significant inverse-Mills ratio in model 6.3 suggests the presence of selection bias. Controlling for this bias, however, increases both the magnitude and significance of the coefficient on *Buy* (compared to table 4). I find no evidence of selection bias in model 6.4.

These tests are repeated for the conference call and press release samples in table 8 and table 9, respectively. The overall conclusions for these tables are similar to the forecasting sample. In the conference call sample, the inverse-Mills ratio is only significant (at the 10% level) in one (model 7.2) of the four specifications. Controlling for the selection bias in model 7.2 increases the magnitude and significance of the coefficient on *Sell*. For the press release sample, three of the four models suggest the presence of self-selection bias. In two of these models (model 8.2 and model 8.3) the hypothesized relations increase in magnitude and significance, while the coefficient on *Sell* is not significant and has flipped signs in one of these models (model 8.1). While attempts to correct for endogeneity are subject to several well-known caveats (see Larcker and Rusticus [2007]), these tests do not suggest that my results are driven by endogeneity.

7.2 MANAGEMENT TRADING DIRECTLY AFFECTING LIQUIDITY

The thesis of this paper is that managers adjust the quality of disclosure in anticipation of insider trading. I use changes in liquidity to proxy for disclosure quality, but, theoretically speaking, changes in liquidity could be driven by the mere presence of managerial trading. If insiders are informed investors and execute trades of sufficient volume, one might expect liquidity to decrease as a result of their trades. Chung and Charoenwong [1998] provide evidence that firms with more insider trading have higher spreads, on average, but do not find that spreads are higher on the days that insiders actually trade. Cao, Field, and Hanka [2004] examine a sample of recent IPO firms and find that liquidity increases following lockup expirations,

TABLE 7

Treatment Effects Models for the Management Forecast Sample

Panel A: Sell versus hold ($N = 8{,}593$)

	$Quality_{RESpread}$ Model 6.1		$Quality_{\$Depth}$ Model 6.2	
	Coeff.	*z*-Stat.	Coeff.	*z*-Stat.
First stage: equation to model sell versus hold				
Variables to predict trading				
$Std\_Ret_{-120,-1}$	4.82	3.26***	4.19	2.83***
$CAR_{-120,-1}$	0.58	10.73***	0.58	10.86***
Ln_$Stock	0.07	6.72***	0.07	6.71***
Grant	0.15	2.32**	0.15	2.32**
Contemp	0.49	11.57***	0.49	11.60***
Restrict	−0.23	−3.02***	−0.24	−3.09***
Contemp × *Restrict*	0.27	2.89***	0.27	2.92***
Prior Sale	0.50	11.44***	0.51	11.62***
$Liquidity_{Bef}$	0.21	3.74***	0.06	1.73*
Ln_Size	−0.01	−0.59	−0.01	−0.33
MtoB_decile	0.05	6.91***	0.06	7.28***
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
Second stage: disclosure quality equation				
Hypothesized relation				
Sell	4.02	1.86*	5.30	1.71*
Inverse-Mills ratio	−0.64	−0.52	−0.89	−0.50
Control variables	Included		Included	
Wald χ^2	7,331.45***		7,532.68***	
p-Value	<0.01		<0.01	

Panel B: Buy versus hold ($N = 7{,}695$)

	$Quality_{RESpread}$ Model 6.3		$Quality_{\$Depth}$ Model 6.4	
	Coeff.	*z*-Stat.	Coeff.	*z*-Stat.
First stage: equation to model buy versus hold				
Variables to predict trading				
$Std\_Ret_{-120,-1}$	−0.38	−0.20	0.77	0.39
$CAR_{-120,-1}$	−0.41	−4.87***	−0.41	−4.84***
Ln_$Stock	−0.02	−1.71*	−0.02	−1.66*
Grant	0.08	0.90	0.08	0.83
Contemp	0.09	1.49	0.09	1.53
Restrict	−0.09	−1.06	−0.10	−1.14
Contemp × *Restrict*	0.17	1.38	0.17	1.42
Prior Buy	0.65	8.71***	0.65	8.61***
$Liquidity_{Bef}$	−0.05	−0.94	0.08	1.62
Ln_Size	−0.05	−1.95*	−0.10	−3.09***
MtoB_decile	−0.01	−1.02	−0.01	−1.01
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
Second stage: disclosure quality equation				
Hypothesized relation				
Buy	−21.02	−4.42***	−4.20	−0.61
Inverse-Mills ratio	9.10	3.88***	3.02	0.88
Control variables	Included		Included	
Wald χ^2	3,956.38***		3,166.87***	
p-Value	<0.01		<0.01	

This table provides pooled treatment effects models to examine whether self-selection and endogeneity affect the relation between management trading incentives and disclosure quality. In these models, I simplify that analysis by assuming that managers are not simultaneously considering both buying and selling shares. Therefore the decision to sell versus hold is modeled separately from the decision to buy versus hold. More positive values of *Quality* correspond to larger increases in liquidity. *Quality* is measured on a scale that approximates percentage changes in liquidity.

All variables are described in appendix A.

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, based on two-tailed tests.

TABLE 8

Treatment Effects Models for the Conference Call Sample

Panel A: Sell versus hold ($N = 18{,}348$)

	$Quality_{RESpread}$ Model 7.1		$Quality_{\$Depth}$ Model 7.2	
	Coeff.	*z*-Stat.	Coeff.	*z*-Stat.
First stage: equation to model sell versus hold				
Variables to predict trading				
Std_Ret$_{-120,-1}$	1.72	1.96*	0.77	0.88
CAR$_{-120,1}$	0.41	13.30***	0.41	13.60***
Ln_$Stock	0.06	8.96***	0.06	9.09***
Grant	0.10	2.30**	0.10	2.28**
Contemp	0.33	10.43***	0.34	10.72***
Restrict	0.02	0.37	0.02	0.38
Contemp × *Restrict*	0.08	1.15	0.08	1.16
Prior Sale	0.62	21.83***	0.62	22.05***
$Liquidity_{Bef}$	0.10	3.78***	−0.01	−0.32
Ln_Size	0.02	1.98**	0.05	3.21***
MtoB_decile	0.06	11.81***	0.06	12.03***
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
Second stage: disclosure quality equation				
Hypothesized relation				
Sell	1.37	0.93	6.20	2.93***
Inverse-Mills ratio	0.79	0.93	−2.16	−1.78*
Control variables	Included		Included	
Wald χ^2	7,204.76***		7,130.89***	
p-Value	<0.01		<0.01	

Panel B: Buy versus hold ($N = 16{,}464$)

	$Quality_{RESpread}$ Model 7.3		$Quality_{\$Depth}$ Model 7.4	
	Coeff.	*z*-Stat.	Coeff	*z*-Stat.
First stage: equation to model buy versus hold				
Variables to predict trading				
Std_Ret$_{-120,-1}$	−0.46	−0.42	−0.11	−0.10
CAR$_{-120,-1}$	−0.34	−7.22***	−0.34	−7.28***
Ln_$Stock	0.01	0.86	0.01	0.77
Grant	0.05	0.84	0.05	0.85
Contemp	0.02	0.53	0.02	0.40
Restrict	−0.10	−1.24	−0.09	−1.21
Contemp × *Restrict*	0.21	2.34**	0.21	2.33**
Prior Buy	0.66	14.42***	0.66	14.45***
$Liquidity_{Bef}$	−0.03	−1.19	0.00	−0.08
Ln_Size	−0.07	−4.87***	−0.08	−4.05***
MtoB_decile	−0.02	−3.69***	−0.02	−3.74***
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
Second stage: disclosure quality equation				
Hypothesized relation				
Buy	−7.69	−2.44**	−2.93	−0.65
Inverse-Mills ratio	1.56	0.98	−0.07	−0.03
Control variables	Included		Included	
Wald χ^2	6,255.17***		6,005.96***	
p-Value	<0.01		<0.01	

This table provides pooled treatment effects models to examine whether self-selection and endogeneity affect the relation between management trading incentives and disclosure quality. In these models, I simplify that analysis by assuming that managers are not simultaneously considering both buying and selling shares. Therefore the decision to sell versus hold is modeled separately from the decision to buy versus hold. More positive values of *Quality* correspond to larger increases in liquidity. *Quality* is measured on a scale that approximates percentage changes in liquidity.

All variables are described in appendix A.

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, based on two-tailed tests.

TABLE 9

Treatment Effects Models for the Post-IPO Sample

Panel A: Sell versus hold ($N = 4{,}387$)

	$Quality_{RESpread}$ Model 8.1		$Quality_{\$Depth}$ Model 8.2	
	Coeff.	*z*-Stat.	Coeff.	*z*-Stat.
First stage: equation to model sell versus hold				
Variables to predict trading				
Std_Ret$_{-30,-1}$	−2.18	−1.16	−2.24	−1.19
CAR$_{-30,-1}$	0.25	6.47***	0.23	5.91***
PR_Earnings	0.43	5.90***	0.41	5.59***
Grant	−0.18	−1.00	−0.20	−1.13
Post_Lockup	0.53	8.52***	0.53	8.42***
Liquidity$_{Bef}$	0.26	4.36***	0.02	0.31
Ln_Size	−0.07	−1.86*	0.02	0.51
MtoB_decile	−0.03	−3.03***	−0.03	−2.64***
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
Second stage: disclosure quality equation				
Hypothesized relation				
Sell	−6.38	−1.53	27.84	5.60***
Inverse-Mills ratio	7.59	3.15***	−13.88	−4.88***
Control variables	Included		Included	
Wald χ^2	4,094.18***		6,886.45***	
p-Value	<0.01		<0.01	

Panel B: Buy versus hold ($N = 3{,}841$)

	$Quality_{RESpread}$ Model 8.3		$Quality_{\$Depth}$ Model 8.4	
	Coeff.	*z*-Stat.	Coeff.	*z*-Stat.
First stage: equation to model buy versus hold				
Variables to predict trading				
Std_Ret$_{-30,-1}$	−8.24	−2.06**	−8.30	−2.10**
CAR$_{-30,-1}$	−0.46	−3.07***	−0.47	−3.14***
PR_Earnings	−0.10	−0.33	−0.10	−0.35
Grant	0.46	3.34***	0.45	3.28***
Post_Lockup	−0.04	−0.30	−0.06	−0.45
Liquidity$_{Bef}$	0.15	1.50	0.20	1.49
Ln_Size	−0.34	−4.11***	−0.36	−3.96***
MtoB_decile	0.03	1.11	0.03	1.12
Industry fixed effects	Included		Included	
Year fixed effects	Included		Included	
Second stage: disclosure quality equation				
Hypothesized relation				
Buy	−45.70	−4.46***	−24.21	−2.05**
Inverse-Mills ratio	18.97	4.00***	6.63	1.20
Control variables	Included		Included	
Wald χ^2	1,608.99***		2,476.86***	
p-Value	<0.01		<0.01	

This table provides pooled treatment effects models to examine whether self-selection and endogeneity affect the relation between management trading incentives and disclosure quality. In these models, I simplify that analysis by assuming that managers are not simultaneously considering both buying and selling shares. Therefore the decision to sell versus hold is modeled separately from the decision to buy versus hold. More positive values of *Quality* correspond to larger increases in liquidity. *Quality* is measured on a scale that approximates percentage changes in liquidity.

All variables are described in appendix A.

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively, based on two-tailed tests.

as opposed to the decrease expected if lockup expirations allow greater informed trading. Since the prior evidence does not fully support, nor dismiss, a direct relation between managerial trading and changes in market liquidity, the possibility that the presence of insider trading affects liquidity seems compelling enough to warrant further investigation.

To investigate this concern, I estimate the following pooled regression (results not tabulated):

$$Liquidity = \beta_0 + \beta_1 Trade\ Date\ Sell + \beta_2 Trade\ Date\ Buy + \beta_3 Report\ Date\ Sell + \beta_4 Report\ Date\ Buy + Control\ variables + \varepsilon. \quad (3)$$

Liquidity is measured for each trading day from −10 to +10. *Trade Date Sell* (*Trade Date Buy*) is an indicator variable that equals one if an executive sells (purchases) shares on that day. *Report Date Sell* (*Report Date Buy*) is an indicator variable that equals one if an executive reports a sale (purchase) to the SEC on that day. Control variables are similar to those used in equation (1) but are measured for each trading day.

For the management forecast sample, the only significant coefficient is on *Trade Date Buy* in the model that uses \$*Depth* to measure liquidity. This coefficient indicates that the market has greater depth on days when managers purchase shares and would work against the previously reported results. None of the regression coefficients are significant for the conference call sample. For the press release sample, the coefficient on *Trade Date Sell* is positive and significant in the model that uses *RESpread* to measure liquidity while the coefficient on *Trade Date Buy* is negative and significant for the model that uses \$*Depth*. These coefficients suggest that my findings for the press release sample could, at least partially, be driven by a direct effect of insider trading.

For two of the three samples, these tests provide no evidence that my findings are due to the presence of managerial trades. Since I find relatively consistent results for the hypothesized relations across the three disclosure samples, it appears unlikely that my results are driven by managerial trading directly affecting market liquidity.

8. *Summary and Conclusions*

This study investigates whether managers' personal incentives affect the information they disclose to the market. Using changes in market liquidity to proxy for disclosure quality, I compare the quality of disclosures in the absence of trading to the quality of disclosures that precede managerial trades. From the shareholder perspective, if managers provide optimal quality disclosures when not trading, then deviations from this benchmark suggest suboptimal disclosure choices.

I find some evidence that managers react to their personal incentives by providing *lower quality* disclosures prior to purchasing shares than they provide in the absence of trading. This result helps explain the documented

profitability of insider purchases and is consistent with managers using disclosure prior to share purchases to protect or even create profitable trading situations. In other words, the current regulations and enforcement strategies appear to be insufficient to deter opportunistic insider purchases.

I also find that managers provide *higher quality* disclosures prior to selling shares than they provide prior to purchasing shares. These contrasting results suggest that the higher scrutiny associated with managerial selling encourages higher disclosure quality. Furthermore, the asymmetric enforcement results in *higher quality* disclosure before selling than in the absence of trading, raising questions about whether the intense scrutiny of insider sales encourages the disclosure of proprietary information against the best interest of shareholders.

APPENDIX A

Market Liquidity–Based Variables	
$\$Depth$	$\$Depth$ is the average of the number of shares the dealer offers to buy multiplied by the ask price and the number of shares the dealer is willing to sell multiplied by the bid price.
$Liquidity_{Bef}$	$Liquidity_{Bef}$ is the predisclosure level of liquidity calculated over the nine trading days leading up to the disclosure date. Specifically, it is the average of the daily averages from $t = -10$ to $t = -1$. The variable is based on one of the two liquidity measures, thereby taking on one of two values: $\$Depth$ or *RESpread* multiplied by -1.
$Quality_{\$Depth}$	$Quality_{\$Depth}$ is the natural log of postdisclosure $\$Depth$ (calculated over $t = +1$ to $t = +10$) less the natural log of predisclosure $\$Depth$ (calculated over $t = -1$ to $t = -10$), multiplied by 100.
$Quality_{RESpread}$	$Quality_{RESpread}$ is the natural log of postdisclosure *RESpread* (calculated over $t = +1$ to $t = +10$) less the natural log of predisclosure *RESpread* (calculated over $t = -1$ to $t = -10$), multiplied by -100.
RESpread	*RESpread* is twice the absolute difference between the transaction price and the quote midpoint deflated by the quote midpoint. Quote midpoint equals the average of the bid price and the ask price.
Managerial Trading Variables	
Buy (*Sell*)	*Buy* (*Sell*) is a dummy variable that equals 1 if the management team (CEOs, board chairs, presidents, CFOs, and chief operations officers) is a net purchaser (seller) of shares (based on dollar value) in the 20 trading days following the disclosure and 0 otherwise. Purchases (sales) are defined as open-market purchases (sales) listed on form 4 and therefore do not include option exercises.
Report Date Buy (*Report Date Sell*)	*Report Date Buy* (*Report Date Sell*) is a dummy variable that equals 1 on the date that a purchase (sale) is reported to the SEC and 0 otherwise.
Trade Date Buy (*Trade Date Sell*)	*Trade Date Buy* (*Trade Date Sell*) is a dummy variable that equals 1 on the date that a member of the management team executes a purchase (sale).
Controls for Order Flow	
$\Delta Std\_midpoint$	$\Delta Std\_midpoint = \text{Ln}(Std\_midpoint_{aft}) - \text{Ln}(Std\_midpoint_{bef})$. Where $Std\_midpoint_{bef}$ ($Std\_midpoint_{aft}$) is the standard deviation of the quote midpoint, calculated over all quotes during the nine-trading-day window before (after) the disclosure date.

(*Continued*)

APPENDIX A—*Continued*

$\Delta Trades$	$\Delta Trades = \text{Ln}(Trades_{aft}) - \text{Ln}(Trades_{bef})$. Where $Trades_{bef}$ ($Trades_{aft}$) equals the average number of trades executed on the primary exchange, where the average is taken over the nine-trading-day window before (after) the disclosure date.
$\Delta\$Volume$	$\Delta\$Volume = \text{Ln}(\$Volume_{aft}) - \text{Ln}(\$Volume_{bef})$. Where $\$Volume_{bef}$ ($\$Volume_{aft}$) equals the average dollar volume of trades executed on the primary exchange, where the average is taken over the nine-trading-day window before (after) the disclosure date.
Controls for Information Environment	
Ln_Size	*Ln_Size* is the natural log of the firm's market capitalization one day prior to the disclosure.
Ln_Analyst	*Ln_Analyst* is the log of 1 plus the number of analysts forecasting earnings.
Other Controls	
$CAR_{0,+1}$	
$CAR_{+2,+20}$	$CAR_{0,+1}$ is the cumulative daily return less the size decile–matched Center for Research in Security Prices (CRSP) value-weighted index return calculated over the window from the disclosure release date ($t = 0$) to the day after the disclosure release date ($t = +1$). $CAR_{+2,+20}$ is similarly defined, but over the window from disclosure release date +2 to disclosure release date +20.
Contemp	*Contemp* is a dummy variable that equals 1 if the firm announces earnings on the same day as the disclosure is released and 0 otherwise.
Esurp	When *Contemp* equals 1, *Esurp* equals the value of actual EPS less the analyst consensus deflated by the preannouncement share price ($t = -1$). When *Contemp* equals 0, *Esurp* equals 0.
Industry Fixed Effects	*Industry Fixed Effects* are dummy variables for industry membership based on two-digit Standard Industrial Classification codes.
MtoB	*MtoB* is defined as the firm's market capitalization (measured one day
MtoB_decile	prior to disclosure) divided by the book value of equity. For the management forecast and conference call samples, book value of equity is the Compustat value at the end of the previous quarter. For the press release sample, book value of equity is measured at the end of the current quarter to ensure the IPO proceeds are included in the measure. *MtoB_decile* is the decile ranked version of *MtoB*.
Nasdaq	*Nasdaq* is a dummy variable that equals 1 if the firm's primary exchange is the NASDAQ and 0 if the firm's primary exchange is the NYSE.
Post Disclosure	*Post Disclosure* is a dummy variable that equals 1 on all dates after the disclosure is released and 0 otherwise.
Post_FD	*Post_FD* is a dummy variable that equals 1 if the disclosure is issued after the passage of Regulation Fair Disclosure (effective October 23, 2000).
$Std\_Ret_{-120,-1}$	$Std\_Ret_{-120,-1}$ is the standard deviation of daily stock returns measured over 120 trading days prior to disclosure.
Year Fixed Effects	*Year Fixed Effects* are dummy variables for the year in which the disclosure is released.
Management Forecast Variables	
Precision	*Precision* assumes a value of 4 for point estimates, 3 for range estimates (i.e., minimum and maximum estimate provided), 2 for open-ended estimates (i.e., minimum or maximum, but not both), and 1 for qualitative estimates (e.g., "about breakeven to slightly positive").
Specificity	*Specificity* is calculated as the top of the management forecast range less the bottom of the range deflated by the prerelease share price for all range estimates; it equals 0 for point estimates. This measure is multiplied by −100 for expositional purposes.

(*Continued*)

APPENDIX A—*Continued*

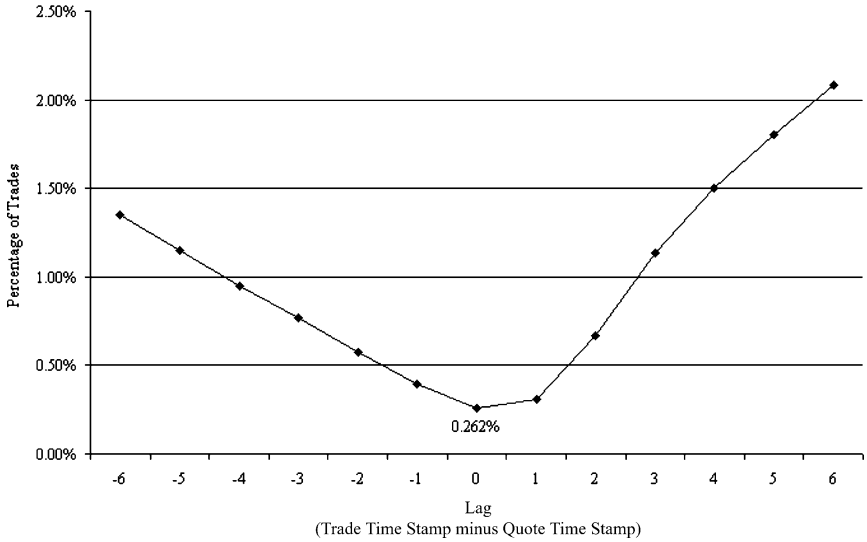
Horizon *Ln_Horizon*	*Horizon* (*Ln_Horizon*) is defined as (the natural log of) the number of days between the forecast release date and the end of the fiscal period (associated with the forecast).
IPO Variables (see Schrand and Verrecchia [2005] for detailed descriptions)	
PR_Earnings	*PR_Earnings* is a dummy variable that equals 1 if the press release contains an earning announcement and 0 otherwise.
PR_IPO	*PR_IPO* is a dummy variable that equals 1 if the press release contains information related to the IPO itself and 0 otherwise (not used in this study).
PR_Operations	*PR_Operations* is a dummy variable that equals 1 if the press release contains information about operating activities and 0 otherwise.
PR_Finance	*PR_Finance* is a dummy variable that equals 1 if the press release contains information about financing activities (excluding new debt or equity offerings) and 0 otherwise.
PR_Newfin	*PR_Newfin* is a dummy variable that equals 1 if the press release contains information about new debt or equity offerings and 0 otherwise.
PR_Personnel	*PR_Personnel* is a dummy variable that equals 1 if the press release contains personnel-related information and 0 otherwise.
PR_Lawsuit	*PR_Lawsuit* is a dummy variable that equals 1 if the press release contains information about a lawsuit against the firm and 0 otherwise.
PR_PubRel	*PR_PubRel* is a dummy variable that equals 1 if the press release contains event- or product-related information and 0 otherwise.
PR_Forecast	*PR_Forecast* is a dummy variable that equals 1 if the press release contains earnings guidance and 0 otherwise.
PR_Lockup	*PR_Lockup* is a dummy variable that equals 1 if the press release announces the end of the lockup period and 0 otherwise.
PR_IRelations	*PR_IRelations* is a dummy variable that equals 1 if the press release contains investor relation information (e.g., about shareholder meetings, conference calls) and 0 otherwise.
PR_Acquire	*PR_Acquire* is a dummy variable that equals 1 if the press release contains information about the acquisition of another company and 0 otherwise.
PR_Divest	*PR_Divest* is a dummy variable that equals 1 if the press release contains information about restructurings, acquisitions of the firm, or spinoffs and 0 otherwise.
PR_Other	*PR_Other* is a dummy variable that equals 1 if the press release contains information of a nature not associated with the previously described categories, including names changes, changes in accounting procedures, and being added to an index, and 0 otherwise.
Additional Variables Used to Predict Managerial Trading	
$CAR_{-120,-1}$ $CAR_{-30,-1}$	$CAR_{-120,-1}$ (and $CAR_{-30,-1}$) is the cumulative daily return less the size decile–matched CRSP value-weighted index return over the window. The measurement windows are relative to the disclosure release date.
Grant	*Grant* is a dummy variable that equals 1 if the management team receives an option grant in the 10 days prior to the disclosure.
Post_Lockup	*Post_Lockup* is a dummy variable that equals 1 if the firm releases its disclosure after the lockup provision expires and 0 otherwise.
Ln_$Stock	*Ln_$Stock* is the natural log of the dollar value of the management team's stock holdings. Shares are valued using the preannouncement share price ($t-1$).

(*Continued*)

APPENDIX A—*Continued*

Prior Sale (Prior Purchase)	*Prior Sale* (*Prior Purchase*) is a dummy variable that equals 1 if the management team is a net seller (net purchaser) of shares after the prior disclosure.
Restrict	*Restrict* is a dummy variable that equals 1 if it the firm restricts managerial selling to predefined windows and 0 otherwise (see Roulstone [2003] for calculation details).
$STD_{-120,-1}$ $STD_{-30,-1}$	$CAR_{-120,-1}$ (and $CAR_{-30,-1}$) is the standard deviation of raw daily returns over the window. The measurement windows are relative to the disclosure release date.

Panel A: Sample of NYSE trades (based on approximately 1.77 million trades)



Panel B: Sample of NASDAQ trades (based on approximately 3.38 million trades)

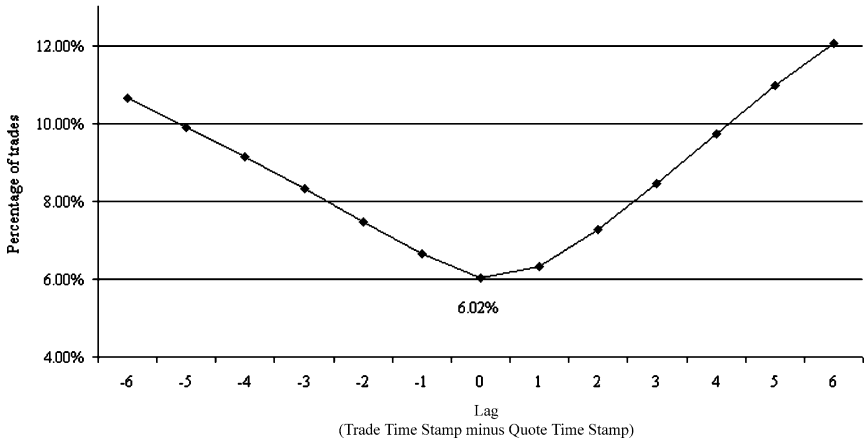


FIG. A1.—Determining the optimal lag between the trade time stamp and the quote time stamp: based on percentage of trades executed inside the quoted depth but outside the quote spread.

APPENDIX B

Researchers frequently use the NYSE TAQ database to calculate liquidity measures. The TAQ database consists of a consolidated quote (CQ) and consolidated trade (CT) file. The quote file contains the bid price and ask price as well as the corresponding depth for each and the time of the quote. The trade file contains the number of shares, transaction price, and time of transaction, but does not indicate whether the trade is buyer or seller initiated.

For basic microstructure measures (e.g., quoted spreads, quoted depth, and volume), the quote and trade files can be used independently. For more sophisticated measures (e.g., effective spreads and spread decompositions), it becomes necessary to match trades to the quote that is outstanding at the time of the trade. The matching of trades to quotes is complicated by the fact that the time stamp for a trade does not necessarily match the time stamp for the quote that is outstanding at the time of the trade. Recognizing this problem, Lee and Ready [1991] analyze a sample of isolated trades for 150 NYSE firms during 1988.[23] By examining the relation between the time of the trade and the time of the quote revisions, Lee and Ready [1991] determine that trades lag quotes by five seconds on average. The five-second delay recommended by Lee and Ready [1991] has become the standard for microstructure research.

In order to determine whether a five-second lag is still applicable, I devise a test for the appropriate lag to use when matching trades to quotes. Due to significant advances in processing speeds and automation since 1988, it seems likely that the lag between trade and quote reporting has diminished. The quotes entered into the CQ database are supposed to represent the best bid and best ask available for that exchange. These quotes represent firm obligations to trade at the stated price (or better) and the stated depth (or larger). As a result, trades that are executed within the quoted depth, but outside the quoted spread, which I term outside trades, should be somewhat infrequent. In order to determine the optimal lag between quotes and trades, I minimize the percentage of outside trades.

To test for the optimal lag between quotes and trades, I select samples of firms listed on NYSE and NASDAQ. For NYSE-listed firms, I randomly select 100 firms per month from January 1993 to December 2002. Prior to April 6, 1993, the bid and offer sizes (depths) for NASDAQ NMS issues are invalid. Therefore, I randomly select 100 firms per month from April 1993 to December 2002 for NASDAQ firms. For each observation, I then randomly assign one trading date from the month and test for the optimal lag using every trade on that date. If a firm has fewer than 10 trades on this date, then I replace the firm.

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[23] An isolated trade is defined as the first trade that occurs after 11:00 a.m. but before 2:30 p.m. with no other trades within one minute on either side.

For each trade, I match quotes to trades using lags from −6 seconds to +6 seconds. Figure A1 provides graphs of the percentage of outside trades (i.e., number of outside trades divided by total number of trades) for the various lags. For both NYSE- and NASDAQ-listed firms, the percentage of outside trades is minimized at a zero-second lag. These optimal lags are substantially shorter than the standard adjustments used in most microstructure studies. Using the Lee and Ready [1991] adjustment (lag = 5 seconds) increases the percentage of outside trade from 0.26% (6.01%) to 1.80% (10.96%) for NYSE (NASDAQ) firms. In addition, the Lee and Ready [1991] adjustment results in higher effective spread calculations. When moving from a zero-second lag to a five-second lag, the average effective spreads increase by 7.11% for NYSE firms and 11.62% for NASDAQ firms. Based on the results of these tests, I use a zero-second lag when matching quotes and trades.

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