

Information asymmetry and cross-sectional variation in insider trading[†]

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We investigate the relationship between insider trading and candidate measures for the degree of information asymmetry between insiders and other market participants. The coefficient estimates on certain of the candidate measures are insignificant or assume a sign that is inconsistent with the predicted relationship between the measure and the degree of information asymmetry. For those measures, either the measures are poor proxies for asymmetry or models of informed trade are not descriptive. In all tests, the median absolute abnormal return over past earnings announcements performs consistent with a price-taking theory of informed trade.

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1. Introduction

This study investigates the relationship between insider trade and a firm's information environment. We address the basic question: Are candidate measures for the degree of information asymmetry between a firm's managers and other market participants associated with insider trading activity in the manner predicted by theories of informed trade? Specifically, we analyze whether and how six candidate measures of information asymmetry explain cross-sectional variation in (i) the abnormal return following a trade, (ii) the value of shares traded, (iii) the profit associated with the trade, (iv) the value of shares traded in a firm-year, and (v) the profit associated with all trades in a firm-year.

While some insider trades are due to insiders' liquidity needs and portfolio rebalancing objectives, a component of insider trades is driven by insiders' informational advantage over other market participants.¹ Since insider trades precede abnormal returns, we take as given that existing financial reporting practices and other information disclosures do not entirely remove insiders' information advantage. Our hypotheses are based on models of informed trade. These models assume that insiders trade to maximize profits and relate trade size and trading profits to information asymmetry. Profits, it is important to note, are the product of three terms: the difference between the price at which shares are traded and their value given the private information that is subsequently revealed, the dollar value of trades made by insiders, and the frequency of trades. Unraveling the relationships among information asymmetry and insider trade requires an understanding of the abnormal return that follows the trade, the value of the trade, the profit on the trade, and the aggregate profits received by a firm's insiders from all trades in a given period. Because information asymmetry cannot be measured directly in archival market data, we test the hypotheses using six proxies from the literature, and report the results of joint tests of the trading models and the validity of the proxies. The proxies we investigate are (1) institutional ownership, (2) analyst following, (3) book-to-market ratio, (4) the frequency with which the firm reports losses, (5) whether the firm reports research and development (R&D) expenditures, and (6) the median absolute abnormal return over past earnings announcements.

Consistent with prior research, we find that the abnormal returns following insider trades are substantial for stocks listed on exchanges regulated by the United States Securities and Exchange Commission (SEC) in the period 1994 to 1997. We further find that the relationship between abnormal returns and the six proxies for information asymmetry we consider are statistically significant in most cases; however, for proxies (1)–(3), the predicted sign of the association for purchases is inconsistent with the predicted association for sales transactions. Moreover, the variation explained by the proxies is small.

Regarding the value of shares traded, different models of informed trade make different predictions about the relationship between information asymmetry and the value of shares traded. The relationships between proxies (1), (2), and (4) and the value of individual trades are inconsistent with both strategic and price-taking models of trade. For proxies (3), (5), and (6) the relationship to trade value is consistent with a price-taking model of trade. Further, we find scant or no evidence that the profitability of insider trading is related to proxies (1)–(5). Overall, the results suggest that either the models of informed trade that we consider are not descriptive, or proxies (1)–(4) do not capture information asymmetry. In contrast, in each of our tests proxies (5) and (6) behave the way a measure of information asymmetry is predicted to behave by a price-taking model of informed trade, although the results for measure (5) are not always significant.

Variables that may proxy for information asymmetry are a component of many empirical studies in accounting. In some studies, the proxy variable serves as a control variable for information asymmetry; in others, it is a test variable of primary interest that is asserted to represent information asymmetry. This study has implications for the other research that interprets these proxies as measures of cross-sectional variation in information asymmetry. If the models of informed trade on which we base our tests are descriptive, our paper casts doubt on measures (1)–(4) as good proxies for information asymmetry. Alternatively, if the measures are good proxies, then our paper casts doubt on the descriptive validity of applying models of informed trade to insider trading.

To our knowledge, the characteristics of firms where informed insider trading is prevalent have not been studied systematically, though various authors present pieces of evidence. Most prior research examines the association between insider purchases and sales and subsequent stock returns. Five studies that attempt to identify characteristics associated with cross-sectional differences in insider trading are summarized here. Seyhun (1986) documents that insiders at small firms, on average, are net purchasers while insiders at large firms are net sellers. He also finds that larger (in absolute value) insider trades are associated with larger (in absolute value) subsequent abnormal returns after controlling for firm size. In concurrent research, Frankel and Li (2004) relate stock returns following insider trade to financial statement information, analyst following, and voluntary disclosure. They find some evidence that increases in financial statement informativeness and analyst following lead to a weaker association between insider trade and subsequent returns. Ofek and Yermack (2000) examine whether stock-based compensation drives insider trading. They find that for executives with large pre-existing positions in firm stock, new grants of equity incentives are associated with stock sales. They argue this behavior is consistent with portfolio rebalancing rather than the exploitation of private information.

Lakonishok and Lee (2001) find that insider trades at small firms predict future returns better than trades at large firms and that insiders are contrarian investors who buy stock with poor past performance. In a paper closely related to our study, Aboody and Lev (2000) hypothesize that research and development (R&D) activities increase the information asymmetry between insiders and investors, thereby allowing insiders at firms with high R&D spending to reap higher profits from their trading than insiders at other firms. Consistent with their hypothesis, they report greater excess stock returns between the transaction date and the reporting date for insider trades at firms with high R&D spending compared with other firms. We note, however, a distinction between excess returns and profits, when profits are defined as the product of excess return and the value of shares traded. Our study differs from these last two in that, besides the

magnitude of excess returns conditional on trade, we examine the value of shares traded and the profitability of trading, both per trade and per firm-year.

The remainder of this paper is organized as follows: section 2 presents the hypotheses that follow from models of informed trade; section 3 describes the data; section 4 analyzes the association between measures of information asymmetry and insider trade; section 5 links the results reported here to some findings from the market microstructure literature and reports the results of some robustness tests; section 6 concludes the paper.

2. Models of informed trade

Insiders' stock trades may be driven by insiders' desire to reap short-term profits from their superior information about firm prospects. Prior research has modeled both these motives within frameworks that capture aspects of the insider trading environment, and we consider the implications of these models in turn. Economic models of informed trade generally assume that the insider is informed in every period and conclude that it is optimal for the insider to trade in every period. In actuality, insider trades are infrequent, which may mean that insiders have an information advantage only some of the time or face important frictions that discourage trade. In particular, regulatory restrictions on insider trading that we describe later complicate insiders' trading behavior in ways that no model fully incorporates. The interaction of these rules with insiders' incentives is a rich and complex phenomenon, while the extant models are sparse in comparison. Consequently, our inquiry is mainly exploratory. Nevertheless, differences in the prior uncertainty about firm value and the precision of the insider's information across firms imply differences in the quantity of insider trades in the cross-section, as we explain next.

In models where the insider's objective is to maximize his welfare by trading to profit from his informational advantage, the quantity traded by the insider depends on the insider's specific private information (formally, the realization of some information variable observed privately by the insider) and aspects of the information environment.

In the a discrete-time Kyle (1985) model, the exogenous variables affecting the insider's trade are the prior variance of stock price (i.e., a measure of the uncertainty surrounding the value of the firm prior to the insider's trade), the precision of the insider's information about fundamental value, the variance of liquidity traders' demands, and the magnitude of the mispricing. The appendix provides a mathematical development supporting the discussion below.

Although an insider's specific private information at a point in time cannot be observed by the researcher, whether trade occurs, the direction of trade, the value of trade, and, hence, trading profits are observable. These aspects of insider trade are a function of the information environment. Informed insider trading is driven by two components of an insider's informational advantage: the prior variance of stock price and the precision of the insider's private information. Higher prior variance of the stock price and higher precision of insider information both increase informational asymmetry, which we also call the insider's information advantage. Given little uncertainty in the marketplace regarding the firm's value, there is little scope for the insider to profit, even if the insider has perfect information about the fundamental value of the firm. Conversely, if there is great uncertainty about the value of the firm, then perfect information held by the insider would be quite profitable. It does not necessarily follow that the insider's informational advantage is large because the market's beliefs about the value of the firm are diffuse; it could be that the insider has no better information about the value of the firm than other market participants. Thus, the second component of an insider's information advantage is the precision of the insider's information. The higher the precision of the insider's information and the lower the precision of outsiders' beliefs about firm value, the more the insider can profit from his trading.²

As an example of these relationships, consider how the intensity of a firm's research and development activities may relate to an insider's information advantage. It may be that the value of an R&D-intensive firm is more uncertain to outsiders, which argues that the information asymmetry is greater for such firms; however, it is also possible

that at such firms, insiders' private information is less precise. If the reduction in precision of the insiders' private information is sufficiently large at R&D intensive firms, then the information asymmetry at such firms could be lower than at a firm with little R&D activity, all else equal.

A basic prediction about information asymmetry and insider trade is that when an insider's information advantage is greater, the abnormal return following a purchase should be greater, and the abnormal return following a sale should be lower, all else equal. Therefore, whether R&D activity (or any other measure) is positively related to information asymmetry can be tested by examining whether abnormal returns following purchases are larger, and abnormal returns following sales are smaller, when R&D activity is greater.

Whether insiders buy (sell) more shares when the firm is undervalued (overvalued) depends on assumptions about the expected price adjustment associated with a trade of a given size. In price-taking models, all traders are price-takers, i.e., individuals believe they can trade any amount without altering the security's price (Grossman and Stiglitz, 1976). In this set-up, the quantity traded does not affect the stock price, but other factors (e.g., risk aversion, wealth constraints, or trading rules) limit the quantity traded by informed insiders. In contrast, in models of imperfect competition, traders believe their transactions influence prices, as illustrated by Kyle (1985), and Spiegel and Subrahmanyam (1992). In these models, price is a function of the quantity traded and the insiders choose the quantities they trade taking account of the anticipated price movements. The price response effectively limits the quantities traded by insiders. In a price-taking model where insiders' sole motive is to profit from their private information, greater prior uncertainty about stock price implies larger average trade size. On the other hand, in models of imperfect competition greater prior uncertainty about stock price can lead to no change in expected trade size (as in Kyle, 1985).

Finally, we consider the profitability of insider trade, which we define as the gain following a purchase, or the loss avoided following a sale. The models we consider predict that insider profits increase with increases in the insider's informational advantage.

In summary, both the price-taking model of Grossman and Stiglitz (1976) and the strategic model of Kyle (1985) predict higher information asymmetry leads to (i) greater abnormal returns following purchases, (ii) smaller (i.e., more negative) abnormal returns following sales, and (iii) greater insider profits. While the price-taking model predicts the value of trade increases with information asymmetry, the strategic model predicts no relationship. Whether a perfect or imperfect competition model is more descriptive of insider trading is an empirical question. We consider both possibilities in our tests. For very large trade quantities, it is likely that price moves in response to the trade. However, other factors may constrain insiders to trade sizes small enough to make the price-taking assumption more descriptive. The facts that the volume insiders trade in the United States is quite small—Jeng, Metrick, and Zeckhauser (2003) report that insider purchases and sales represent 0.03% and 0.22% of all purchase and sales, respectively—and the excess return at the time an insider trades is quite small—see, e.g., Lakonishok and Lee (2001)—suggest that the price impact of insider trades is also likely to be small, so that the price-taking model may be most descriptive.

3. Data and descriptive statistics

Section 16 of the Securities and Exchange Act of 1934 defines a class of persons designated as insiders whose trades are subject to specific limitations and reporting requirements. The insider trading data were collected from the Dow Jones News Retrieval Service by downloading the daily newswire covering SEC filings published by Federal Filings, Inc., a wholly-owned subsidiary of Dow Jones & Co., Inc. The insider trading records cover transactions by section 16 insiders during the period from August 1993 to October 1998. Our empirical analyses are limited to trades occurring in fiscal years 1994 to 1997.

We exclude certain types of transactions from the analysis. As the award of stock options is not at the discretion of insiders, we exclude transactions in which insiders are granted stock options in constructing the dependent variables. We also exclude stock option exercises because these transactions are highly correlated with the sale of stock

acquired on exercise of stock options (Ofek and Yermack, 2000). Including stock option exercises would therefore lead to double counting. This treatment of option grants and exercises is consistent with the research on the information content of insider trades, e.g., Seyhun (1992).

Seyhun (1998) summarizes evidence that certain insider trades are less strongly associated with abnormal returns than others. In particular, trades by blockholders are less strongly associated with subsequent abnormal returns. Since our intent is to analyze trades motivated by private information, we exclude trades by entities that statute defines as insiders for the sole reason that the entity owns a block of 10% or more of the corporation's stock, which yields 122,364 unique, non-blockholder insider trading observations. Because our empirical analyses require data from Compustat and CRSP, we further delete 63,512 transactions with missing data, leaving 58,852 records of insider purchases and sales.³

Dependent variables

Because we are interested in explaining the cross-sectional variation in insider trading profits and its components, we construct measures of the abnormal return that follows trade, the value of shares traded, and the profit from insider trading. We report the value of shares traded and the profit from insider trading at both the transaction and firm-year level.

The first dependent variable, AB_RET, is the cumulative abnormal return over the six months after the day on which the insider trades.⁴ Returns are adjusted as in Carhart (1997) for four factors: the market return, the Fama-French book-to-market and size factors, and a momentum factor equal to the stock's return over the prior fiscal year.⁵ We measure returns over a six-month period for three reasons. First, six months is the shortest plausible trading horizon for an insider because Section 16(b) of the Securities and Exchange Act of 1934 provides that insiders must disgorge profits on short-swing transactions. Given this requirement, insiders must not unwind their positions following the purchase or sale of shares in their firm for at least six months in

order to exploit their information advantage.⁶ Second, several studies of U.S. data find that abnormal returns extend for six or more months following insider trades. Thus, a returns horizon of at least 6 months is indicated. Third, while the abnormal returns that follow insider trade can be detected 12 or more months after the trade, the price drift is greatest immediately after the trade and is quite small in months 9 through 12 (Seyhun, 1998 p. 48). This suggests that computing returns over a horizon much longer than six months may introduce noise into the dependent variable. Together, these facts suggest that six months is a reasonable period over which to measure the returns component of insider profit. Results are similar and conclusions are unaffected if returns are computed over 12 months.

The second dependent variable is the value of shares traded by the insider, in millions of dollars, VALUE. Because this variable is highly skewed, we report regression results for LN_VALUE, which is the natural logarithm of VALUE.

The third dependent variable is the profit insiders realize on their trade, PROFIT, which is the abnormal return on the stock over the six months following the trade multiplied by the value of the trade (in millions of dollars). Trade values are signed positive for purchases and negative for sales so that when PROFIT is aggregated over purchase and sales transactions, gains when a stock price rises following a purchase are added to losses avoided when a stock declines subsequent to a sale.

A final component of insider trading profits is related to the frequency of trade. Variation in information asymmetry across firms may lead to variation across firms in the number of trading opportunities (i.e., situations where the insider is informationally advantaged) per unit of time. Variation in information asymmetry may also lead to variation in trade size. Accordingly, we relate the aggregate value and profits of insider trades cumulated over all transactions at a given firm in a given year to the measures of information asymmetry.⁷ Some firms report no insider trades for an entire year. For such firm-years, YR_VALUE and YR_PROFIT are set to zero.

[Table 1]

Panel A of table 1 presents descriptive statistics on these dependent variables. Descriptive statistics on the abnormal returns following purchases and sales are reported separately. There are 20,416 purchase transactions and 38,436 sales transactions in the sample. Thus, insiders engage in about 2 sales transactions for each purchase transaction. The mean (median) abnormal return over the six months following a purchase is 8.584% (5.851%) while the mean (median) abnormal return following a sale is -0.733% (0.069%), indicating that stock prices generally rise after insiders buy, but change little after insiders sell; however, for both purchases and sales, the interquartile variation in each of these variables is more than 25%, which indicates that many insider trades are unprofitable. Indeed, in more than 25% of cases, the abnormal return is negative after an insider buys stock. Likewise, in more than 50% of the cases, the abnormal return is positive after an insider sells stock.

Allowing for differences in sample construction, the mean abnormal returns following purchases and sales are comparable to those reported in prior studies. For instance, the mean abnormal returns following sales is comparable to the -1.7% cumulative daily average prediction error (CAPE) over the 100 days following a sale reported by Seyhun (1986). While the magnitude of the mean abnormal return following purchases is nearly three times the 3.0% CAPE over the 100 days following a sale reported by Seyhun (1986), this discrepancy may be explained by differences in sample period, sample selection criteria, return horizon, and method of computing returns. In particular, refining the selection criteria substantially increases the mean value of the return measure. As an example, Seyhun (1998) reports that the average net-of-market returns over the 12 months following a month when insiders are net purchasers is 4.5%, but this average rises to 12.3% when sample selection criteria are tightened to include only top executives at small firms.

The mean and median values of shares traded (VALUE) are \$556,000 and \$85,000, respectively.⁸ Despite the size of the mean trade and the substantial mean abnormal returns that follow trade, the profits (i.e., PROFIT) insiders realize on their trades are modest. The median gain on a purchase and the loss avoided on a sale are \$1,000

and \$0, respectively. The mean gain on a purchase and the loss avoided on a sale are somewhat larger, \$5,000 and \$10,000, respectively. Since there are about 2 sales for each purchase, these figures suggest that losses avoided on sales and gains on purchases are similar-sized components of total insider profits.

Panel A also reports the value (YR_VALUE) and profitability (YR_PROFIT) of trades cumulated by firm-year. The 58,852 insider trades are spread over 10,571 firm-years, so on average there are 5.567 transactions in a firm-year. There is substantial variation in the value of insider trade over firm-years: in 25% of firm-years, insiders trade more than \$1.566 million of stock; in 25% of firm-years, insiders trade less than \$48,000.⁹ There is also variation in insider profits by firm year: in 25% of firm-years, insider profits are more than \$45,000 million of stock; in 25% of firm-years, insiders trade losses are more than \$15,000. This suggests that measuring insider trade value and profits by firm-year may be important to inferences.

Information environment variables

Prior research suggests many variables that may proxy for aspects of a firm's information environment, but there is limited evidence in support of the notion that these variables proxy for the information asymmetry between insiders and other market participants. We investigate whether aspects of insider trade and six variables used in the literature are associated in a manner consistent with the theories of insider trade we outlined earlier when the variables are interpreted as measures of information asymmetry. We organize the variables under the headings of external information search, nature of the firm's assets and operations, and the price response to earnings announcements, and motivate and describe each variable in turn.

External information search

An important force reducing the information asymmetry between managers and outside investors is the collection of information about the firm by outsiders, including analysts, institutional investors, or stock traders more generally. Alford and Berger

(1999) present some evidence supporting the notion that analysts' information complements other information in reducing uncertainty about fundamental value. As well, Ayers and Freeman (2003) report that prices of firms followed by analysts and largely-owned by institutional investors incorporate futures earnings earlier than prices of other firms, suggesting that value-relevant information is impounded in price sooner for firms with high institutional ownership and large analyst followings. Other studies that assess whether institutional ownership accelerates the incorporation of new information into price include El-Gazzar (1997), Jiambalvo, Rajgopal, and Venkatachalam (2002), Barabanov and McNamara (2002), and O'Neill and Swisher (2003). Studies that link analyst following to bid-ask spreads and liquidity include Brennan and Subrahmanyam (1998); Easley, O'Hara, and Paperman (1998); Roulstone (2003a); and, Kanagaretnam, Lobo, and Whalen (2004). Analyst following is interpreted as a measure of information asymmetry by Ho, Liu, and Ramanan (1997); D'Mello and Ferris (2000); Xue (2003); and, Wu (forthcoming).

Thus, two variables that may be related to outside information search are ANALYSTS, the number of active analysts following a firm, measured in the fiscal year prior to the year in which the trade takes place; and IO, the percentage of common shares held by institutional investors at the beginning of the fiscal year in which the trade takes place.¹⁰ Because ANALYSTS is highly skewed, we report regression results for LN_ANALYSTS, which is the natural logarithm of $1 + \text{ANALYSTS}$. We hypothesize that high values of LN_ANALYSTS and IO imply lower information asymmetry between insiders and outside investors.

Panel B of table 1 reveals that the median institutional ownership across observations is 44.426%. The amount of institutional ownership ranges from 22.797% at the 25th percentile to 63.171% at the 75th percentile. The median value of ANALYSTS implies that before the typical insider trade, the firm is followed by 6 active analysts. The number of analysts covering the firm ranges from 2 at the 25th percentile to 15 at the 75th percentile.

Nature of the firm's assets and operations

The nature of the firm's activities plausibly affects the firm's information environment either because the activities imply greater uncertainty about the value of the firm or yield to insiders more precise information about this value. Smith and Watts (1992) argue that managers of growth firms have superior knowledge about their firm's investment opportunity set and future cash flows from their firm's existing assets. Other papers that interpret book-to-market as an information proxy are Barclay and Smith (1995), McLaughlin, Safieddine, and Vasudevan (1998), and Barth and Kasznik (1999). We hypothesize that firms with lower book-to-market ratios have greater information asymmetry, and define BM to be the ratio of book value of common equity to the market value of common equity at the beginning of the fiscal year. For the sample, the median value of BM is 0.438.

Hayn (1995) suggests that loss firms may be valued differently from profit firms because the liquidation option is more likely to be exercised. She finds that the association between earnings and returns is weaker for loss firms. Loss firms may exhibit greater information asymmetry because the informativeness of earnings with respect to future cash flows is weaker than for profit firms. Motivated by the possibility that information asymmetry is greater for loss firms, Ertimur (2004) investigates whether a firm's loss status is related to its bid-ask spread and finds that loss status is associated with wider spreads. To capture this aspect of a firm's underlying economic uncertainties, we include the variable LOSS, defined as the ratio of loss quarters to total quarters in the past five fiscal years. For the sample of insider trades, the mean fraction of quarterly losses in the prior five years is 0.166.

A necessary condition for information asymmetry to exist is uncertainty in the minds of outsiders as to the value of the firm. If some businesses are fundamentally riskier than others, then the nature of the firm's assets contributes to this uncertainty, and hence may be related to information asymmetry.

Aboody and Lev (2000) argue that R&D activities are associated with high information asymmetry for two reasons. First, an asset created from R&D expenditures is

likely to be more unique than a tangible asset. Second, while there are markets for trading physical and financial assets, markets for intellectual property that emerges from R&D expenditures are less well-organized and the information necessary to determine the value of these assets may be harder to obtain. RND is an indicator variable that is 1 if the prior year's research and development expense (R&D) is positive, and zero otherwise. When R&D is not reported, RND is set equal to zero. For 47.4% insider trades, R&D expense is positive. We hypothesize that firms with R&D have higher information asymmetry than those without.

R&D activities also may be related to the informativeness of accounting disclosures. Accounting rules that require all R&D to be expensed may contribute to the information asymmetry between insiders and other market participants because such rules prevent the firm from communicating the value of R&D expenditures through selective capitalization. Consistent with the above argument, Kothari, Laguerre, and Leone (1998) and Chan, Lakonishok and Sougiannis (1999) find that R&D spending is positively associated with future earnings variability. Regardless whether RND (or LOSS) capture a firm's information disclosure quality or the magnitude of underlying economic uncertainties, it is not unreasonable to suspect that firms with higher values of these variables imply higher information asymmetry with outside investors, *ceteris paribus*.

Price response to earnings announcements

The information asymmetry between outsiders and a firm's insiders may also be assessed at times when the firm makes financial disclosures. Dierkens (1991) argues that if earnings announcements at a firm typically lead to large abnormal returns, then insiders (who are likely to have advance knowledge of earnings) have a substantial information advantage over other market participants before the earnings announcement. Thus, a direct way to assess the information held by insiders that is not known to other market participants is to measure the magnitude of price reactions when accounting information is released. Accordingly, we define MAG_AR to be the median of the magnitude of the abnormal returns from two days before to the day of the quarterly earnings announcement date for the prior five fiscal years, in percent. Measures similar to MAG_AR also

are used by Thomas (2002) and Lowry (2003). This easy-to-compute variable is a comprehensive measure of one specific and important element of insiders' information advantage at the point in time when disclosure removes the advantage and the value of the information is revealed by the price change.¹¹ We predict that information asymmetry increases in MAG_AR. The mean value of MAG_AR over the sample is 3.485%.

One potential advantage of MAG_AR over the other proxies can be illustrated by contrasting MAG_AR with the loss status of the firm, LOSS. While it is plausible that loss status indicates a special situation where earnings is less informative about future cash flows, to the extent that the managers of loss firms make additional disclosures to compensate for the lack of information in earnings, the information asymmetry is mitigated. Chen, DeFond, and Park (2003), and Lougee and Marquardt (2002) document how the voluntary disclosure choices of loss firms differ from those of profit firms. Because disclosure choice varies with the loss status and may be used to mitigate any additional information asymmetry associated with loss status, losses may be a poor indicator of the information asymmetry between insiders and other market participants. The notion that managers may tune disclosure policy to the firm's situation does not apply solely to loss status as an indicator of information asymmetry. In principle, managers' voluntary disclosure choices may depend on a wide range of firm attributes, including the proxy variables used in this study.

Of the variables we consider, only MAG_AR is a direct measure of the information asymmetry between insiders and other market participants after giving effect to the endogenous, situation-dependent voluntary disclosure choices of the firm. Since information voluntarily disclosed before the earnings announcement ought to be impounded in price before the announcement, the jump at the earnings announcement reflects only the information revealed by the announcement and not disclosed earlier. Because managers know earnings before it is disclosed, whatever price jump occurs at the announcement is due to private information held by managers. Hence, MAG_AR, which is based on the magnitude of price jumps at prior earnings announcements, is increasing in the information asymmetry that remained between insiders and other market participants at

those earnings announcements given the firm’s disclosure policy. Given some stickiness in disclosure policy choices, the magnitude of past surprises can be a good indicator of the magnitude of future surprises, and, hence, of the information asymmetry that exists between insiders and other market participants.

Because `MAG_AR`, like `ANALYSTS`, is right-skewed by construction, in our tests we use the natural logarithm of `MAG_AR`, which we call `LN_MAG_AR`. When `MAG_AR` is used in place of `LN_MAG_AR`, the signs and significance levels of coefficients are similar to those reported.

Correlations among the proxies

[Table 2]

Table 2 presents Spearman rank correlations of the information environment variables. All correlations are significant at the 5% level (two-tailed). The largest correlation, 0.61, is between the external information search variables, `LN_ANALYSTS` and `IO`. The -0.34 correlation between `BM` and `RND` is unsurprising given the fact that R&D-intensive firms are growth firms with many intangible assets. If the six proxy variables have the hypothesized correlations with information asymmetry, then we may expect them to be correlated with each other. Information asymmetry is predicted to be decreasing in `IO`, `LN_ANALYSTS`, and `BM` and increasing with `LOSS`, `RND`, and `LN_MAG_AR`. So, cross-correlations among variables in the group `IO`, `LN_ANALYSTS`, and `BM` might be expected to be positive. Similarly, cross-correlations among variables in the group `LOSS`, `RND`, and `LN_MAG_AR` also might be expected to be positive, while the correlations between variables drawn from different groups might be expected to be negative. Four of the fifteen correlations have signs that are inconsistent with these predictions: `IO` and `BM` (-0.21), `BM` and `LN_ANALYSTS` (-0.24), `RND` and `IO` (0.11), and `RND` and `LN_ANALYSTS` (0.06). One explanation for these correlations is that some of the proxies are not strongly correlated with information asymmetry as hypothesized.

4. Regression analysis

We first examine whether abnormal stock returns following insiders' trades vary with the six measures of information asymmetry. Then we examine how the value and profitability of insider trade is related to the informational environment.

Abnormal returns following insider trade

In the absence of information asymmetry between insiders and other market participants, there is no scope for insider trades to exploit private information and so there can be no abnormal return following insider trades. Recall that a basic prediction about information asymmetry and insider trade is that when an insider's information advantage is greater, the abnormal return following a purchase should be greater, and the abnormal return following a sale should be lower, all else equal. To test this prediction, table 3 presents ordinary least squares regressions of the abnormal stock return AB_RET, over the six months following insider trade t in year y at firm i on the six measures of information asymmetry (IO, LN_ANALYSTS, BM, LOSS, RND, and LN_MAG_AR),

$$\text{AB_RET}_{iyt} = \beta_0 + \beta_1 \text{PROXY}_{iy} + \epsilon_{iyt}$$

where PROXY is one of the information environment variables. Separate regressions are run for purchases (column 'P') and sales (column 'S') transactions. In table 3 and subsequent tables, outliers are deleted using Cook's (1977) distance statistic. Also, since there are multiple observations per firm, for all regressions standard errors and t -statistics are adjusted for correlation among observations from the same firm and for heteroskedasticity using Rogers' (1993) robust standard-error method. This method assumes observations from different firms are independent. All significance levels are based on two-tailed tests.

[Table 3]

Given the hypothesized negative correlation between the insiders' information advantage and the proxies IO, LN_ANALYSTS, and BM, the predicted sign on these proxies in the purchase regression is negative. Given the hypothesized positive correlation

between the insiders' information advantage and the three proxies LOSS, RND, and LN_MAG_AR, the predicted sign on these proxies in the purchase regression is positive. Note that for each proxy, the predicted sign for sales is the opposite of the sign predicted for purchases. So, for example, in specification (5), since R&D-intensive firms are hypothesized to have greater information asymmetry, the predicted sign on RND in table 3 is positive for purchases and negative for sales.

In every specification, the adjusted R^2 is 2.6% or less, which indicates that the proxies capture little of the cross-sectional variation in AB_RET. Of all the proxies, only the coefficient estimates on LOSS, RND, and LN_MAG_AR assume the predicted sign for both purchase and sales, and are significantly different from zero. In the specifications using IO and LN_ANALYSTS, coefficients estimates are significantly negative for both purchases and sales, while for BM, coefficients estimates are significantly positive for both purchases and sales. Thus, the results for variables IO, LN_ANALYSTS, and BM are inconsistent with these variables serving as proxies for information asymmetry between insiders and other market participants. The results are consistent with the interpretation of proxies LN_MAG_AR, LOSS, and RND as measures of information asymmetry.¹²

Control variables

While the predicted relationship between information asymmetry and subsequent returns can be examined in a straightforward univariate regression, additional factors merit consideration in modeling the relationship between the proxies and either trade value or profit. These considerations lead us to add certain control variables to the next regression tests. Table 1 reports descriptive statistics for these variables.

In some models of imperfect competition, notably Kyle (1985), the insider's trading strategy is affected by the variance of the net amount of stock demanded by liquidity traders in a given period, i.e., a measure of the variability of uninformed trading volume. Intuitively, when this quantity is small, the market maker infers that a given order imbalance is likely due to the actions of the informed trader. Accordingly, the change in

price occasioned by a given total order imbalance is large. As the variability of uninformed order imbalance increases, the market maker infers that the imbalance is more likely due to random variation in uninformed demand than to informed trading. So, for a given order imbalance, the price adjustment is smaller. Thus, the volatility of volume can be a determinant of insider trade value and profit although it is not necessarily an indicator of information asymmetry.¹³ Therefore, we include SD_VOL, defined as the standard deviation of monthly trading volume over total shares outstanding estimated over the previous three years in our trade value and profit regressions.¹⁴ SD_VOL has a mean and median of 0.040 and 0.028, respectively.

Portfolio rebalancing for reasons unrelated to private information is often cited by executives as a reason for trading stock. For this reason, larger stock trades, both purchases and sales, are likely to be associated with larger insider stock and stock option positions. Hence, a positive relation between holdings and trade size would be expected. Insider stock and option holdings can be gleaned from Execucomp data for only 39% of the firms in our sample. Since executive compensation and the value of executive stock and option holdings are strongly positively correlated with firm size, firm size could be used in place of insider stockholdings as a measure of non-information based motives for trade. To preserve sample size, we adopt this approach. As well, Seyhun (1986) documents that insider trade value (scaled by the value of equity) is negatively related to firm size, indicating that firm size is important to insider trade.¹⁵ The median observation has a market value of common equity at the beginning of the fiscal year of \$361 million and the mean MV is nearly seven times greater. Because MV is highly skewed, we report regression results for LN_MV, which is the natural logarithm of MV. Given Seyhun's earlier findings, we expect that LN_MV is positively related to LN_VALUE, the logarithm of the value of shares traded.

Finally, Rozeff and Zaman (1998) and Lakonishok and Lee (2001) document that insider trade is related to past stock returns, though the reason for this relationship is unclear. We include MOMENTUM, the six-month compounded buy-and-hold raw return ending on the day before the insider trading date, as a control variable in regressions where the dependent variable is the value of trade. Panel C shows that the mean values of MOMENTUM is 18.132%, reflecting the strong stock returns in the sample period.

Value of trades

Table 4 reports the results of six regressions of the value of insider trades on the information environment variables and the control variables (SD_VOL, LN_MV, and MOMENTUM, discussed above) for the corresponding firm-year:

$$\begin{aligned} \text{LN_VALUE}_{iyt} = & \beta_0 + \beta_1 \text{PROXY}_{iy} + \beta_2 \text{SD_VOL}_{iy} + \beta_3 \text{LN_MV}_{iy} \\ & + \beta_4 \text{MOMENTUM}_{iy} + \beta_5 \text{SALE}_{iyt} + \epsilon_{iyt} \end{aligned}$$

The observations are individual insider trades. Since the value of insider trades that are sales is much larger than the value of trades that are purchases, we allow sales and purchases to have different intercepts by including the indicator variable SALE in the regression. SALE takes the value 1 for sales transactions, and is 0 otherwise.

[Table 4]

Turning first to the control variables, note that the positive coefficient estimate for the SALE variable reflects the fact that the value of insider sales is greater than the value of insider purchases. This is because compensation contracts generally grant stock and other equity incentives to executives that executives then seek to sell over time. As a result, SALE is strongly positive. Consistent with the evidence in Lakonishok and Lee (2001) that insiders are contrarian, the association between LN_VALUE and MOMENTUM, which is dominated by insider selling, is positive in each specification. Consistent with Seyhun (1986), the value traded increases in the size of the firm, LN_MV. In each specification, the coefficient estimate on SD_VOL is significantly positive. The Grossman and Stiglitz (1976) model does not relate the variability of uninformed order flow to informed trade, but the Kyle (1985) model predicts a positive relation between the variability of the uninformed order imbalance, for which SD_VOL may be a proxy.

As explained earlier, the predicted relationship between increases in information asymmetry and the size of insider trade can be positive (in, e.g., the case of the price-taking) or none (in, e.g., the case of the Kyle, 1985, model). The evidence in favor of the hypothesized role of the measures is mixed. While the coefficient estimates on each

of the proxies are significantly different from zero, the coefficient signs for some of the proxies are inconsistent with the predictions of either model. Thus, either the models are not descriptive or some of the proxies do not measure the information asymmetry concept as hypothesized.

If lower values of IO and LN_ANALYSTS and higher values LOSS indicate higher information asymmetry, then the coefficient estimates on these variables are inconsistent with both the Kyle (1985) strategic and the Grossman and Stiglitz (1976) price-taking models. If larger values of RND and LN_MAG_AR, and lower values of BM indicate higher information asymmetry, then the coefficient estimates on these variables are consistent with the Grossman and Stiglitz (1976) price-taking model of informed trade.

Profitability of trades

Table 5 reports the results of six regressions of the profits derived from insider trades on the information asymmetry proxies, SD_VOL and SALE:

$$\text{PROFIT}_{iyt} = \beta_0 + \beta_1 \text{PROXY}_{iy} + \beta_2 \text{SD_VOL}_{iy} + \beta_3 \text{LN_MV}_{iy} + \beta_3 \text{SALE}_{iy} + \epsilon_{iyt}$$

The control variables are described above. MOMENTUM is not included as a control variable because the abnormal return component of PROFIT is net of a momentum factor adjustment.¹⁶ The Kyle (1985) strategic model predicts that profits are greater when uninformed order flow is more variable, which is consistent with the significant positive coefficient on SD_VOL in all specifications. Insider profits generally are not significantly related to firm size, LN_MV. The SALE variable is insignificant. This may be explained as follows. While insiders typically sell more stock than they buy, the (typically negative) abnormal returns that follow a sale are smaller in magnitude than the (typically positive) abnormal returns that follow purchases. The combination smaller trade quantities and larger (in magnitude) subsequent returns for purchases means that losses avoided on sales are not significantly different from the gains on purchases, controlling for firm size and the variability of trading volume.

[Table 5]

Both price-taking and strategic models predict a positive relationship between profits and information asymmetry. There is evidence of the predicted association between trading profits and both LOSS and LN_MAG_AR, but the coefficient estimates on the four other proxies are insignificant or have the opposite sign to the one predicted. For IO, LN_ANALYSTS, and BM, the results in this regression may be attributed to the finding from table 3 that lower levels of these variables do not imply both (i) more positive abnormal returns following sales and (ii) more negative abnormal returns following purchases. In the case of IO, for instance, table 3 indicates that lower IO implies higher abnormal returns following both purchases and sales. Thus, lower IO has offsetting effects on the purchases and sales that are summed to form profits.

Analysis of value traded and profitability by firm-year

A complete assessment of the relationship between insider trading profits and information asymmetry requires that the frequency of trade, as well as the value of trade and the abnormal returns subsequent to trade, be assessed. An analysis that considers only profits conditional on trade may overstate profits because, e.g., trades when they occur are highly profitable, but trades themselves are rare. Importantly for our tests of the proxies, high (low) information asymmetry may express itself as frequent (infrequent) trades by insiders. In this case, the tests reported in tables 4 and 5 may not capture the association of the proxies with information asymmetry, since those tests are conditioned on the occurrence of trade.

To address these issues, the regressions reported in tables 6 and 7 are analogous to the regressions in tables 4 and 5, respectively, except that trade value and trade profits are aggregated by firm-year before they are regressed on the proxies and control variables. Thus, the unit of observation is a firm-year rather than a trade. The 692 firm-years in which no insider trades occur are included in this definition of an observation. For such observations, YR_VALUE and YR_PROFIT are set to 0. These observations may represent instances where information asymmetry is low; implicitly, they are omitted from earlier analyses. Because purchases and sales within a firm year are aggregated, we drop the SALE indicator variable from the regression specifications.

[Table 6]

[Table 7]

Qualitatively, the results reported in tables 6 and 7 are very similar to the results reported in tables 4 and 5, respectively, with one exception: The significant positive relationship between LOSS and insider profit at the trade level is insignificant at the firm-year level.

The lack of a significant relationship between RND and either PROFIT or YR_PROFIT deserves comment. Aboody and Lev (2000) report that at R&D firms, insider purchases precede more positive abnormal returns and insider sales precede more negative abnormal returns than at other firms, which is consistent with table 3. Aboody and Lev further report that insiders at R&D firms trade more shares and trade more frequently than insiders at other firms, which is consistent with tables 4 and 6. Since insider profits are the product of trade value and the abnormal return following the trade, the lack of a significant association in table 5 between profit and RND suggests that the observations driving the result that insider trades at R&D firms are associated with large abnormal returns are not the same observations driving the result that insiders trade more shares and more frequently at R&D firms. That is, the largest insider trades at R&D firms may not be associated with largest abnormal returns, a possibility that Aboody and Lev do not examine. The general result in table 5 with respect to RND is not altered by computing total insider profit by firm-year (and including firm-year observations omitted where no insiders trade) does not alter this impression.

Overall, the results in tables 6 and 7 contribute the impression that, among the measures we consider, the one which behaves most consistently with predictions is LN_MAG_AR. While RND does not behave inconsistently with predictions, coefficient estimates for this measure are sometimes insignificant. The other four measures behave, in one or more ways, inconsistently with predictions from models of informed trade.

5. Connections to other measures of information asymmetry

Our study is one of a class of studies that seeks to identify variables that proxy for information asymmetry. Besides the proxies we consider, measures derived from intra-day trade and quote data may also proxy for information asymmetry. Easley, Hvidkjaer, and O'Hara (2002) argue that stocks that have a higher probability of information-based trading provide a higher equilibrium return to compensate for the added risk associated with adverse selection. From intra-day trade data for a portion of NYSE firm-years that overlap with our sample, they compute a probability of information-based trading (PIN) and present evidence that PIN is a source of risk that is priced in by market.

Clarke and Shastri (2000) examine the correlations among PIN and other information asymmetry measures computed from trade and quote data. They also correlate these measures with the aggregate volume of insider trade. They find no relation between PIN and insider trading, and conclude that this casts doubt on the validity of PIN as a measure of information asymmetry. Our interpretation of the lack of correlation between PIN and insider trade is somewhat different, as we explain next.

In interpreting Clarke and Shastri's (2000) results, it is important to recognize that information asymmetries may exist between any pair of economic agents. Beside information asymmetry between insiders and other investors, there may exist information asymmetries among non-insider market participants. We focus on the former, but do not discount the latter. Also, some non-insiders may have some information that insiders do not have (e.g., information about the firm's competitors or customers).

In our data there are, on average, fewer than 6 trades per firm-year. Thus, the adverse selection faced by uninformed investors that is due to trade against insiders is small, a point also made by Jeng, Metrick, and Zeckhauser (2003). Since PIN is computed from all trades, and most trades are between two parties who are not insiders, PIN is likely to be most highly correlated with information asymmetries that exist between non-insider investors rather than asymmetries that exist between insiders and other investors. As a result, it is possible that PIN is computed mainly from observations of one component of information asymmetry while insider trading is purely due to a second component.¹⁷

Recognizing that information asymmetry may have two components has an important implication for our empirical tests: Since information asymmetries between non-insiders may be due to information not known to insiders, they represent an element of risk to the insider. As a result, our computations of the abnormal returns and profits received by insiders may be overstated if we do not control for this source of risk. For this reason, we reperform the analyses of abnormal returns and abnormal profits in tables (3), (5), and (7) including PIN as control variable. PIN is available to us only for a subset of NYSE-listed stocks representing about half of our transactions data and firm-years. In table 3, including PIN does not alter the sign of the coefficient estimate on any of the measures, but the coefficients estimates on BM in both the purchase and sale regressions are insignificant, and the coefficient on RND in the sale regression is insignificant.¹⁸ When PIN is included as a control variable, the coefficient estimates on LN_MAG_AR and LOSS become insignificant in Table 5. In table 7, only the coefficient on LN_MAG_AR is significant; if PIN is included, LN_MAG_AR remains the only significant measure. Overall, we conclude that inclusion of PIN in the regressions has little effect inference.

6. Summary and interpretations

Insider trading is a rich and complicated phenomenon of crucial interest to disclosure standard setters and market regulators, who seek to promote efficient price formation, preserve market integrity, and curb unfair enrichment by those with access to private information. The abnormal profits insiders earn from their trades depend on three factors: the frequency with which they trade, the quantity traded, and the difference between the fundamental value of the firm and the price at which insiders are able to trade. While prior research has focused on the returns to trading strategies derived from the record of insider trades, we consider determinants of the variation in the profitability of insider trade across firms and in the components of profitability: trade value and subsequent abnormal return.

Study of insider trades permits joint tests of (i) theories of informed trade and (ii) the adequacy of specific empirical proxies for the theoretical constructs they represent. Our empirical investigations are motivated by private information trading models of short-term profit-seeking. These models differ in their implications for how the volume and direction of insider trade changes with changes in the information asymmetry between insiders and other market participants. Many studies document positive returns, on average, following insider purchases and negative returns, on average, following insider sales. This suggests trading profits are of first-order importance to insider trading decisions.

While the models that motivate our tests are parsimonious and make clear testable predictions, it is important to recognize that restrictions on insider trading complicate insiders' trading behavior in ways that no model fully incorporates: (i) some firms limit when insiders can trade to short trading windows following earnings announcements (Bettis, Coles, and Lemmon, 2000); (ii) SEC rules broadly prohibit insiders from trading on material non-public information; (iii) SEC rules specifically prohibit insiders from short-selling, and require them to disgorge any profits from any purchase and sale, or any sale and purchase, within any period of less than six months; and, (iv) insiders must disclose their trades after the fact.

The recent Sarbanes-Oxley Act mandates a tightening of these rules.¹⁹ Such rule changes may reduce, but are unlikely to eliminate, the profits insiders derive from superior information. This follows because past rule changes that either tighten reporting requirements (e.g., the adoption in 1991 of Rule 16a-4 which requires that insider trades in derivative securities be reported on Form 4) or increase penalties for improper insider trade (e.g., the Insider Trading Sanctions Act of 1984 and the Insider Trading and Securities Fraud Enforcement Act of 1988) did not eliminate abnormal returns to insiders following trade. More timely disclosure of insider trade may shorten the time period over which abnormal returns to insider trade occur because insider trades are disclosed more promptly to market participants. Thus, while the scope for insiders to profit from their superior information may be diminished by recent regulatory changes, it is unlikely to

be eliminated. Although the period over which an abnormal returns accumulate may be accelerated by more timely reporting of insider trades, this is unlikely to advantage insiders since the short-swing rule effectively obliges insiders to hold positions for at least six months.

The information asymmetry in the models that motivate our study is exogenously-specified. In a more complete theory, information asymmetry would be determined endogenously: It is reasonable to believe, for example, that whether an analyst chooses to follow a particular stock depends on the number of analysts who are already following the stock; as a consequence the measures are endogenous, though we treat them as exogenous. Nevertheless, treating the variables in this way is a first step towards a more comprehensive understanding of the role of the proxies and information asymmetry more generally in explaining insider trade.

It also may be that the trading profits insiders earn on their trades are only one factor affecting their trading decisions. Though it might seem intuitive at the outset that informed insider trade is motivated primarily by the opportunity to earn near-term profits from buying stock when it is undervalued and selling stock when it is overvalued, insider trade also may have subtle but potentially large consequences on insider wealth and human capital (including current and future compensation), given that insider trades must be publicly disclosed after the fact. While insider-managers may profit from trade on private information and optimal contracts may, in fact, take account of this opportunity (as argued by Manne, 1966; Dye, 1984; and Roulstone, 2003b), it is not obvious that these trading profits are the dominant motive for insider trades. In particular, insider-managers also receive other compensation (e.g., in the form of salary, bonus, or additional awards of stock-based compensation) that are increasing in the firm's stock price. To the extent that insider trades signal firm value to other market participants, they affect the stock price and hence the manager's compensation.

For instance, a stock sale by an insider might be interpreted by other market participants as an indication that the stock is overvalued, prompting a subsequent reduction in

stock price. In turn, the stock price drop may reduce the value of non-transferable stock-based compensation held by the insider in the form of stock options or restricted stock. In addition, it may lead to reductions in the insider's future compensation and increase the likelihood that the insider's employment is terminated. Potentially, these indirect effects of insider trade on the value of insiders' wealth and human capital may be larger than the profits that could be derived from exploiting informational advantages.

While there is evidence that abnormal returns subsequent to trade and the value of shares traded are related to our measures of the firm's information environment, the significant relationships for some of the measures are difficult to reconcile with each other in the context of a single coherent model of informed trade. Further, there is little evidence that insider profit is related to four of the information variables. One caution our study raises is that finding larger abnormal returns following trades at R&D-intensive firms does necessarily imply that insiders at those firms receive greater profits than insiders at other firms. Of the variables we consider, only coefficient estimates on LN_MAG_AR (i.e., the median abnormal return over past earnings announcements) are significant and consistent with predictions from a single model across all the tests we conduct.

Future research could follow several avenues: First, one could examine subsets of the data, such as small and large firms to see whether the explanatory power of the measures is more pronounced for some types of firms. Second, one could construct an *ex post* measure of information asymmetry by dividing observations according to subsequent stock returns. When returns are large in absolute value and positive (negative) following an insider purchase (sale), there is evidence that the insider had a significant advantage. Conversely, when subsequent returns are small, the pre-existing asymmetry was likely small. Third, it may be that there is too little variation in information asymmetry across the publicly-listed U.S. companies in our sample for some of our tests to have adequate power. In this case, a study of cross-jurisdictional data would be warranted.

Appendix. Models of informed trade

To build some intuition for our empirical inquiry, we extend slightly the one-shot trading model presented in Kyle's (1985) seminal paper on informed trade. We interpret the consequences of varying aspects of the information environment in this strategic trading model where the insider receives noisy private information prior to placing market orders and the market maker anticipates the possibility that information drives trading and sets price so as to break even in expectation.

A.1 Structure and notation

The *ex post* liquidation value of the risky asset, denoted \tilde{v} , is normally distributed with mean p_0 and variance \sum_0 . The quantity traded by noise (or uninformed) traders, denoted \tilde{u} is normally distributed with mean zero and variance σ_u^2 . Before trading, the insider learns the realization of an imperfect private signal $\tilde{\eta} = \tilde{v} + \tilde{\epsilon}$, where ϵ is normally distributed with mean 0 and variance σ_ϵ^2 . The random variables $\tilde{\epsilon}$, \tilde{u} and \tilde{v} are independently distributed.

The insider places an order for x shares conditioned on the realization of η . The market maker chooses a price, p_1 , based on the total order flow, $\tilde{x} + \tilde{u}$. Trading is structured in two steps as follows: In step one, the exogenous values of \tilde{v} , $\tilde{\epsilon}$ and \tilde{u} are realized. The insider chooses the quantity he trades \tilde{x} , knowing $\tilde{\eta} = \tilde{v} + \tilde{\epsilon}$ but not \tilde{u} or \tilde{v} . The insider's trading strategy, X , is as a function $\tilde{x} = X(\tilde{\eta})$. In step two, the market maker determines the price \tilde{p}_1 at which he trades the quantity necessary to clear the market. When doing so, he observes $\tilde{x} + \tilde{u}$ but not \tilde{x} or \tilde{u} (or \tilde{v}) separately. The market maker's pricing rule, P , is the function $\tilde{p}_1 = P(\tilde{x} + \tilde{u})$. The profits of the insider are given by $\tilde{\Pi} = (\tilde{v} - \tilde{p}_1)\tilde{x}$.

The insider takes into account the effect the quantity he chooses to trade in step one is expected to have on the price established in step two. In doing so, he takes the rule market makers use to set prices in step two as given. The quantity he trades is required to be optimal, given his information set at the time it is chosen. The insider is not allowed to condition the quantity he trades on price.

The equilibrium X and P are determined by the exogenous parameters Σ_0 , σ_ϵ^2 , and σ_u^2 . It is helpful to define each of these market factors at the outset. The variance of the net amount of stock demanded by liquidity traders in a given period is σ_u^2 . That is, it is a measure of the variability of the order imbalance between uninformed buyers and sellers.

We interpret Σ_0 as a measure of the uncertainty about the fundamental value of the firm. The variable σ_ϵ^2 measures the error variance of the insider's private information. Thus, the inverse of this quantity, $1/\sigma_\epsilon^2$, measures the precision of the insider's information. The information asymmetry between the insider and other market participants is greatest when σ_ϵ^2 is small and disappears as σ_ϵ^2 becomes large. A challenge in our empirical work is finding proxies for the formal constructs σ_u^2 , σ_ϵ^2 and Σ_0 .

A.2 Equilibrium

An equilibrium is defined as a pair X, P such that the following two conditions hold:

(1) *Profit Maximization*: For any alternate trading strategy X' and for any v and η ,

$$E\left(\tilde{\Pi}(X, P) \mid \tilde{\eta} = \eta\right) \geq E\left(\tilde{\Pi}(X', P) \mid \tilde{\eta} = \eta\right).$$

(2) *Market Efficiency*: The random variable \tilde{p}_1 satisfies

$$P(\tilde{x}, \tilde{u}) = E(\tilde{v} \mid \tilde{x} + \tilde{u}).$$

This model has an elegant equilibrium in which the rules X and P are simple linear functions.

Theorem: *There exists a unique equilibrium in which X and P are linear functions.*

Define constants β and λ by

$$\beta = \sqrt{\frac{\sigma_u^2}{\Sigma_0 + \sigma_\epsilon^2}} \tag{A.1}$$

and

$$\lambda = \frac{\Sigma_0}{2\sigma_u \sqrt{\Sigma_0 + \sigma_\epsilon^2}}. \tag{A.2}$$

The equilibrium P and X are given by

$$X(\tilde{\eta}) = \beta(\tilde{\eta} - p_0), \quad \text{and} \quad P(\tilde{x} + \tilde{u}) = p_0 + \lambda(\tilde{x} + \tilde{u}).$$

Proof: The proof parallels Kyle's (1985) one-period analysis, in the slightly more general case where the insider's information about firm value may be noisy. Suppose that for constants μ , λ , α , and β , linear functions P and X are given by

$$P(y) = \mu + \lambda y, \quad \text{and} \quad X(\eta) = \alpha + \beta \eta.$$

Given the linear rule P , insider profits can be written

$$E[(\tilde{v} - P(X(\eta) + \tilde{u}))X(\eta) \mid \tilde{\eta} = \eta] = (M\eta - \mu - \lambda X(\eta))X(\eta), \quad (\text{A.3})$$

where $M = \Sigma_0/(\Sigma_0 + \sigma_\epsilon^2)$. Profit maximization of this quadratic objective requires that X solve $M\eta - \mu - 2\lambda X = 0$. Since we conjecture $X(\eta) = \alpha + \beta\eta$, we thus have

$$\beta = \frac{M}{2\lambda} \quad (\text{A.4})$$

and $\alpha = -\beta\mu/M$. Note that the quadratic objective (implied by the linear pricing rule P) rules out mixed strategies and also makes linear strategies optimal even when nonlinear strategies are allowed.

Given linear X and P , the market efficiency condition is equivalent to

$$\mu + \lambda y = E[\tilde{v} \mid y],$$

where $y \equiv \alpha + \beta\tilde{\eta} + \tilde{u}$. Normality makes the regression linear and application of the projection theorem yields

$$\begin{aligned} \lambda &= \frac{\text{Cov}(v, y)}{\text{Var}(y)} \\ &= \frac{\beta \Sigma_0}{\beta^2 (\Sigma_0 + \sigma_\epsilon^2) + \sigma_u^2}. \end{aligned} \quad (\text{A.5})$$

Solving (A.4) and (A.5) subject to the second order condition $\lambda > 0$ yields (A.1) and (A.2). Note that we have $\mu = p_0$, $\alpha = -\beta p_0/M$, and the second order condition rules out a solution with β and λ both negative. ■

A.3 Properties of the equilibrium

According to the model, differences in the variability of the uninformed order imbalance, σ_u^2 , and differences in the informational advantage of insiders over other market participants drive cross-sectional differences in the amount of insider trading.

Intuitively, when σ_u^2 is small, the market maker infers that a given order imbalance is likely due to the actions of the informed trader. Accordingly, the change in price occasioned by a given total order imbalance is large. As the variability of uninformed order imbalance increases, the market maker infers that the imbalance is more likely due to random variations in uninformed demand than to informed trading. So, for a given order imbalance, the price adjustment is smaller. The insider's profits are a function of the quantity he trades and the price at which he trades. Since the insider rationally anticipates the market maker's expected price adjustment, he maximizes his information rent by trading more when the variability of the order imbalance is larger.

The precision of the insider's signal about the fundamental value of the firm is $1/\sigma_\epsilon^2$. Conditional on knowing η , the insider's posterior beliefs about the value of the firm have mean

$$\frac{\eta \Sigma_0 + p_0 \sigma_\epsilon^2}{\Sigma_0 + \sigma_\epsilon^2} = M\eta + (1 - M)p_0$$

and variance

$$\Sigma_0 \left(1 - \frac{\Sigma_0}{\Sigma_0 + \sigma_\epsilon^2} \right).$$

Thus, the insider profits from buying when η is positive and selling when η is negative. Formally, the information advantage of the insider, measured as the difference between the unconditional variance of the value of the firm, Σ_0 , and the variance conditional on knowing η , is

$$\frac{\Sigma_0^2}{\Sigma_0 + \sigma_\epsilon^2},$$

which increases in the prior uncertainty about the value of the firm, Σ_0 , and the precision of the insider's private information, $1/\sigma_\epsilon^2$.

When the information asymmetry is larger, the expected mispricing of the asset is greater. Since the insider buys when $\eta > 0$, the expected price adjustment given a purchase is

$$\begin{aligned}
& E(v - p_0 \mid \tilde{\eta} = \tilde{v} + \tilde{\epsilon} > 0) \\
&= \int_{-\infty}^{\infty} \int_{-v}^{\infty} (v - p_0) g(\epsilon) f(v) d\epsilon dv \\
&= \int_{-\infty}^{\infty} (v - p_0) (G(\infty) - G(-v)) f(v) dv \\
&= \int_{-\infty}^{\infty} (v - p_0) f(v) G(v) dv \\
&= \sqrt{\frac{\Sigma_0^2}{2\pi(\Sigma_0 + \sigma_\epsilon^2)}},
\end{aligned}$$

where $f(v)$ is the PDF of \tilde{v} , and $g(\epsilon)$ and $G(\epsilon)$ are the PDF and CDF of $\tilde{\epsilon}$, respectively. The case when the insider sells is symmetric. Thus, the model predicts a greater upward (downward) price movement conditional on a purchase (sale) when the insider's information advantage is greater (i.e., either Σ_0 is greater or σ_ϵ^2 is smaller).²⁰

The quantity traded by the insider depends on whether his private information indicates the current stock price is above or below the fundamental value, v . While the insider's private information cannot be observed by the researcher, the intensity with which an insider trades on his private information, β , is a function of the information environment.

The theorem implies that the insider's trading intensity, β , increases in the precision of his private information, but decreases in the prior uncertainty about firm value.²¹

The conclusion that the intensity with which the insider trades on his private information falls with Σ_0 is driven by the fact that the quantity $1/\lambda$, which measures the "depth" of the market (i.e. the order flow necessary to induce prices to rise or fall by one dollar), is also chosen strategically. Market depth is proportional to a ratio of the amount of noise trading to the amount of private information the informed trader is expected to have.

Thus, differences in the Σ_0 and σ_ϵ across firms imply differences in the quantity of insider trades in the cross-section. From an empirical standpoint, the important question is how the quantity traded changes as the information environment changes.

In the model, the expected trade is equally likely to be a buy or a sell, so the expected trade is zero. The expected number of shares traded is given by:²²

$$\begin{aligned} E|X(\tilde{\eta})| &= \beta E|\tilde{\eta} - p_0| \\ &= \sqrt{\frac{\sigma_u^2}{\Sigma_0 + \sigma_\epsilon^2}} \sqrt{\frac{2(\Sigma_0 + \sigma_\epsilon^2)}{\pi}} \\ &= \sigma_u \sqrt{\frac{2}{\pi}}. \end{aligned}$$

Hence, the Kyle (1985) model predicts the number of shares traded by an informed insider does not change as the information environment changes, though it does increase in the variability of the uninformed order imbalance. There may also be variation in the observed quantity of trades by insiders if more information asymmetry creates more situations when the insider is informed: the frequency of trade, and therefore the total shares traded over some period, may increase though the mean value of each trade is unchanged.

From (A.3), insider *ex ante* expected profits can be calculated as

$$\begin{aligned} &E[(M\tilde{\eta} - \lambda X(\tilde{\eta})) X(\tilde{\eta})] \\ &= \frac{1}{2} M \beta E[\tilde{\eta}^2] \\ &= \frac{\sigma_u \Sigma_0}{2\sqrt{\Sigma_0 + \sigma_\epsilon^2}}. \end{aligned}$$

This implies that *ex ante* insider profits increase in the prior uncertainty of firm value, the precision of the insider's information, and the variability of the uninformed order imbalance in the firm's stock.

A.4 Sensitivity of predictions to model specification.

In a simpler model where λ is an exogenous positive constant, our conclusion with respect to the effect of a change in Σ_0 or $1/\sigma_\epsilon^2$ on β is reversed. This follows from

assuming λ fixed in (A.3). Thus, when the market maker's price adjustment does not depend on the information environment or the insider's strategy, but where the insider is strategic, β is proportional to M and so

$$\begin{aligned} & E|X(\tilde{\eta})| \\ &= \beta E|\tilde{\eta} - p_0| \\ &\propto M \sqrt{\Sigma_0 + \sigma_\epsilon^2}, \\ &= \frac{\Sigma_0}{\sqrt{\Sigma_0 + \sigma_\epsilon^2}} \end{aligned}$$

which implies x is increasing in Σ_0 and $1/\sigma_\epsilon^2$, all else equal. That is, the quantity traded by the insider increases in information asymmetry.

This analysis, while parsimonious, ignores potentially important institutional features, such as the prohibition of short selling by insiders. This restriction may bind on insiders with low or zero stockholdings and who have information that the firm is overvalued. The restriction may be less important for insiders who receive new grants of stock or options at regular intervals. For a model of insider trade where insiders hold large stock positions, see Huddart, Hughes, and Williams (2004).

Optimal insider behavior hinges critically on assumptions about insider risk aversion and the number of insiders with information (see, e.g., Admati and Pfleiderer, 1988), sanctions or other regulatory attention that attend large insider trades or trades in proximity to certain information releases (e.g., Bainbridge 1999), as well as the opportunity of an insider to trade multiple times on the same information (Kyle, 1985), and whether insider trades themselves are disclosed (e.g., Huddart, Hughes, and Levine, 2001).

Notes

1. This advantage has been demonstrated in several studies that find significant abnormal stock returns following insider trades. For instance, Seyhun (1992) presents compelling evidence that such trades are legal, widespread, increasing in volume, and yield abnormal returns.
2. Lang and Lundholm (1993, 251) make a similar point. The volatility of past returns measures the unpredictability of firm value. Unpredictability (to outsiders) of firm value is necessary, but not not sufficient, for information asymmetry to exist. In addition, managers must know something about firm value that outsiders do not for information asymmetry to exist. Lang and Lundholm further point out that voluntary disclosure by managers can alter information asymmetry and may be related to the variability of firm performance. After introducing six candidate measures of information asymmetry, we consider how endogenous voluntary disclosure choices affect the predicted association between each measure and information asymmetry.
3. Research summarized in Seyhun (1998) further shows that medium-sized trades predict future returns better than smaller or larger trades, and that trades by executives (i.e., the CEO, CFO, Chairman, President, or COO) predict returns better than trades by non-executives. Although applying filters to remove large trades, small trades, and trades by non-executives sharply reduces the sample size, inferences and conclusions are essentially unchanged when the analysis is

- reperformed on this subset of the data, although the significance of coefficient estimates for LOSS and RND are weaker than those reported in table 3 below.
4. To be consistent with the literature, we report results for returns computed over a window that begins the day after the insider trades. Strategic trading models predict that some price adjustment takes place when the insider trades, because order flow, which includes the trades submitted by insiders, reveals some of the insider's information. For this reason, it might be appropriate to compute abnormal returns over a window that begins before the insider trades. As a practical matter, there is little price adjustment at the time of insider trades so regression results are nearly identical when abnormal returns are computed so as to include the day on which the insider trades.
 5. Parameter estimates for the four factors are obtained from a first-stage regression of daily returns on the factors over a two-year period ending on the last day of the month before the first insider trade in our sample. Next, daily abnormal returns for each firm are obtained by subtracting the predicted return (based on the factors and parameters estimated in the first stage) from the raw return. Finally, daily abnormal returns are cumulated over the six months after the trade date.
 6. As well, the provision generally reduces insiders' incentives to trade on short-term private inside information by forcing them to wait six months before they can rebalance their portfolios. Givoly and Palmon (1985), Sivakumar and Waymire (1994), and Noe (1999) suggest that insider transactions are not prompted by a

single forthcoming disclosure, but instead by insider's knowledge of longer-term developments.

7. Abnormal returns are specific to the transaction and so cannot be cumulated by firm year.
8. When insiders sell stock, they typically trade an amount that is nearly ten times greater than the amount they trade when they buy stock.
9. In 6.5% of firm-years, insiders do not trade any stock.
10. An active analyst is defined as one who updates a firm's forecast at least twice a year.
11. Firm policy and case law discourage insiders from trading immediately prior to the release of earnings. As a result, one might expect foreknowledge of earnings disclosures to be an element of insider's information advantage that the insiders cannot exploit. However, Ke, Huddart, and Petroni (2003) present evidence that insiders know earnings long before it is announced and trade to profit from this information.
12. Notice that the associations between the proxies and the returns are effectively adjusted for market-wide price movements, firm size, and momentum, because the dependent variable, abnormal returns, is the residual return after adjusting for factors that include the market return, the Fama-French size factor, and the stock's return over the prior fiscal year (i.e., momentum). It is possible that market liquidity, measured by the standard deviation of trading volume (SD_VOL) affects momentum. Including SD_VOL as an explanatory variable in the regression does

not alter the sign of the coefficient estimates on the proxy variables. The significance of the coefficient estimates is similar, except that the coefficient on RND in the sales transactions regression becomes insignificant.

13. Alternatively, volume may be endogenously determined by information asymmetry. Huddart, Hughes, and Brunnermeier (1999) develop a model in which uninformed traders concentrate their trading in stocks where the informational advantage of insiders is the least.
14. To preserve the sample size, as few as 18 months of data are used to compute SD_VOL in some cases.
15. One might also argue that market value is a proxy for information asymmetry, but any such interpretation would be problematic because market value is plausibly correlated with so many aspects of the firm. We prefer to side-step this issue by including LN_MV as a control variable in the trade value and profit regressions.
16. Results are qualitatively similar if MOMENTUM is included as a control variable.
17. Arguably, mediating the information asymmetry between insiders and other investors is more relevant to the valuation role of accounting than is mediating information asymmetries among investors. After all, managers cannot be held responsible for disclosing information they do not know.
18. Using the restricted sample for which PIN is available, but omitting PIN as control variable yields coefficient estimates on the measures that are very similar in sign and significance to those when PIN is included. This suggests the loss of significance is due to the smaller number of observations rather than the inclusion of PIN as a control variable.

19. While the Sarbanes-Oxley Act does not change the definition of an insider or the types of transactions which must be reported, the Act shortens the filing deadline for Forms 4 from the tenth of the month following the trade to the second business day after a reportable transaction occurs. Also, the types of transactions for which delayed reporting on Form 5 is allowed is narrowed. Finally, most executive option grants are to be reported on Form 4 within two business days of the date of grant even though these transactions may be exempt from Section 16(b) liability. Sarbanes-Oxley also gives the SEC new powers to seek “any equitable relief that may be appropriate or necessary for the benefit of investors” for violations of securities laws. This is an interesting topic for future research. The period covered by our study also precedes the introduction of pre-planned trading programs under Rule 10b5-1. The effects of this rule on the abnormal returns and profitability of insider trade are analyzed by Jagolinzer (2004).
20. Analysis of $E(v - p_1 \mid \tilde{\eta} = \tilde{v} + \tilde{\epsilon} > 0)$ is more complicated because the total mispricing is corrected, in part, by market maker’s price adjustment in response to the order flow.
21. Equation (A.1) shows that the insider makes no trade in the limit $\sigma_\epsilon^2 \rightarrow \infty$.
22. The expected value of the absolute value of a normal random variable with zero mean and variance σ^2 is $\sigma\sqrt{2/\pi}$.

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Table 1
Descriptive statistics

	<i>N</i>	Mean	Standard Deviation	25 th Percentile	Median	75 th Percentile
<i>Panel A. Aspects of insider trade</i>						
<i>Purchase transactions</i>						
AB_RET	20,416	8.584	34.030	-6.722	5.851	21.700
PROFIT	20,416	0.005	0.229	-0.001	0.001	0.004
<i>Sale transactions</i>						
AB_RET	38,436	-0.733	40.267	-15.465	0.069	15.295
PROFIT	38,436	0.010	1.307	-0.023	0.000	0.027
<i>All transactions</i>						
VALUE	58,852	0.556	3.814	0.021	0.085	0.344
<i>All transactions, aggregated by firm-year</i>						
YR_VALUE	10,571	3.094	13.771	0.048	0.283	1.566
YR_PROFIT	10,571	0.048	3.892	-0.015	0.001	0.045
<i>Panel B. Information environment variables</i>						
IO	58,852	43.500	24.380	22.797	44.426	63.171
ANALYSTS	58,852	9.975	10.704	2.000	6.000	15.000
BM	58,852	0.493	0.346	0.256	0.438	0.659
LOSS	58,852	0.166	0.249	0.000	0.050	0.222
RND	58,852	0.474	0.499	0.000	0.000	1.000
MAG_AR	58,852	3.485	2.162	1.975	3.022	4.489
<i>Panel C. Control variables</i>						
SD_VOL	58,852	0.040	0.050	0.014	0.028	0.051
MV	58,852	2,521.340	7,591.022	100.132	361.626	1,532.827
MOMENTUM	58,852	18.132	41.130	-2.710	13.067	31.496

Notes: There are 20,416 purchases and 38,436 sales for a total of 58,852 transactions in the sample. These transactions come from 9,879 firm-years. Descriptive statistics for the firm-year level variables, YR_VALUE and YR_PROFIT, are based on these years and an additional 692 firm-years in which no insider trades; for a total of 10,571 firm-years.

Table 1 (continued)

- AB_RET** is the cumulative abnormal return over the six months after the day on which the insider trades. As described in the text, returns are adjusted as in Carhart (1997) for four factors: the market return, the Fama-French book-to-market and size factors, and a momentum factor equal to the stock's return over the prior fiscal year.
- PROFIT** is the abnormal return on the stock over the six months following the trade (i.e., **AB_RET**) multiplied by the value of the trade (in millions of dollars). For sales transactions, this value is multiplied by -1 so that losses avoided on sales have the same sign as gains on purchases.
- VALUE** is the value (in millions of dollars) of shares traded, by trade (either purchase or sale).
- YR_VALUE** is the value (in millions of dollars) of shares traded by insiders within a firm-year. Shares are valued at the trade-date closing price. For years without trades, **YR_VALUE**= 0.
- YR_PROFIT** is the profit (in millions of dollars) to insiders in a firm-year, computed as the sum over all trades in the firm-year of the abnormal return following the trade multiplied by the value of the trade. In the sum, abnormal returns following sales are multiplied by -1 so that losses avoided on sales are added to gains on purchases. For years without trades, **YR_PROFIT**= 0.
- IO** is the percentage of common shares held by institutional investors at the beginning of the fiscal year in which the trade takes place.
- ANALYSTS** is the number of active analysts following a firm, measured in the fiscal year prior to the year in which the trade takes place. An active analyst is defined as one who updates a firm's forecast at least twice a year.
- BM** is the ratio of book value of common equity to the market value of common equity at the beginning of the fiscal year.
- LOSS** is the ratio of loss quarters to total quarters in the past five fiscal years.
- RND** is an indicator variable that is 1 if the prior year's research and development expense (R&D) is positive, and zero otherwise. When R&D is not reported, **RND**= 0.
- MAG_AR** is the median magnitude of the cumulative abnormal returns from two days before to the day of the quarterly earnings announcement date for the prior five fiscal years, in percent.
- SD_VOL** is the standard deviation of the ratio of monthly trading volume to total shares outstanding over the prior three fiscal years. To preserve the sample size, as few as 18 months of data are used to compute **SD_VOL** in some cases.
- MV** is the market value of common equity at the beginning of the fiscal year, in millions of dollars.
- MOMENTUM** is the six-month compounded buy-and-hold raw return ending on the day before the insider trading date.

Table 2
Spearman rank correlations among information environment variables

	IO	LN_ANALYSTS	BM	LOSS	RND
LN_ANALYSTS	0.61				
BM	-0.21	-0.24			
LOSS	-0.13	-0.23	-0.04		
RND	0.11	0.06	-0.34	0.18	
LN_MAG_AR	-0.11	-0.19	-0.15	0.32	0.26

Notes: Variables are defined in table 1, except that LN_ANALYSTS is $\ln(1 + \text{ANALYSTS})$ and LN_MAG_AR is $\ln(\text{MAG_AR})$. Correlations are based on 58,852 observations. All correlations are significant at the 5% level (two-tailed).

Table 3 Regression of abnormal returns subsequent to insider trade on measures of information asymmetry

$$AB_RET_{iyt} = \beta_0 + \beta_1 PROXY_{iy} + \epsilon_{iyt}$$

	(1) IO		(2) LN_ANALYSTS		(3) BM		(4) LOSS		(5) RND		(6) LN_MAG_AR	
	P	S	P	S	P	S	P	S	P	S	P	S
Predicted sign on proxy	-	+	-	+	-	+	+	-	+	-	+	-
PROXY	-0.167 ***	-0.084 ***	-3.997 ***	-1.607 ***	5.801 ***	7.521 ***	8.243 ***	-5.660 ***	1.366 *	-1.755 **	3.659 ***	-3.676 ***
Constant	13.278 ***	3.683 ***	13.652 ***	2.584 ***	3.661 ***	-3.861 ***	6.244 ***	0.154	6.753 ***	0.454	3.647 ***	3.187 ***
Adjusted R^2	0.026	0.005	0.034	0.004	0.008	0.006	0.006	0.002	0.001	0.001	0.009	0.006
N	19,451	37,250	19,552	37,419	19,378	37,371	19,293	37,033	19,352	37,478	19,383	37,241

Notes: The table presents the results of ordinary least squares regressions of the abnormal stock return AB_RET, over the six months following insider trade on six measures of information asymmetry (IO, LN_ANALYSTS, BM, LOSS, RND, and LN_MAG_AR). Separate regressions are run for purchases (column ‘P’) and sales (column ‘S’) transactions. Variables are defined in table 1, except that LN_ANALYSTS is $\ln(1 + ANALYSTS)$ and LN_MAG_AR is $\ln(MAG_AR)$. Significance at the 10%, 5%, and 1% levels (two-tailed) is denoted by *, **, and ***, respectively.

Table 4 Regression of the logarithm of the value of insider trade on measures of information asymmetry and control variables

$$\text{LN_VALUE}_{iyt} = \beta_0 + \beta_1 \text{PROXY}_{iy} + \beta_2 \text{SD_VOL}_{iy} + \beta_3 \text{LN_MV}_{iy} \\ + \beta_4 \text{MOMENTUM}_{iy} + \beta_5 \text{SALE}_{iyt} + \epsilon_{iyt}$$

	(1)		(2)		(3)		(4)		(5)		(6)	
	IO		LN_ANALYSTS		BM		LOSS		RND		LN_MAG_AR	
Predicted sign on proxy:												
Strategic model	0		0		0		0		0		0	
Price-taking model	-		-		-		+		+		+	
PROXY	0.008	***	0.040	**	-0.522	***	-0.522	***	0.069	**	0.342	***
SD_VOL	6.380	***	7.263	***	6.708	***	7.734	***	7.251	***	5.544	***
LN_MV	0.250	***	0.298	***	0.284	***	0.312	***	0.315	***	0.348	***
MOMENTUM	0.007	***	0.007	***	0.007	***	0.007	***	0.007	***	0.007	***
SALE	1.724	***	1.760	***	1.720	***	1.760	***	1.745	***	1.717	***
Constant	-5.827	***	-5.883	***	-5.417	***	-5.891	***	-5.939	***	-6.382	***
Adjusted R^2	0.470		0.466		0.467		0.462		0.464		0.472	
N	56,478		56,334		56,427		56,413		56,525		56,374	

Notes: The table presents the results of ordinary least squares regressions of the logarithm of the value of insider trades on six measures of information asymmetry (IO, LN_ANALYSTS, BM, LOSS, RND, and LN_MAG_AR) and control variables (SD_VOL, LN_MV, MOMENTUM, and SALE). Variables are defined in table 1, except that LN_VALUE is $\ln(\text{VALUE})$, LN_MAG_AR is $\ln(\text{MAR_AR})$, LN_ANALYSTS is $\ln(1 + \text{ANALYSTS})$, LN_MV is $\ln(\text{MV})$, and SALE is an indicator variable that is 1 for sales transactions and 0 otherwise. Significance at the 10%, 5%, and 1% levels (two-tailed) is denoted by *, **, and ***, respectively.

Table 5 Regression of insider trading profits on measures of information asymmetry and control variables

$$\text{PROFIT}_{iyt} = \beta_0 + \beta_1 \text{PROXY}_{iy} + \beta_2 \text{SD_VOL}_{iy} + \beta_3 \text{LN_MV}_{iy} + \beta_3 \text{SALE}_{iy} + \epsilon_{iyt}$$

	(1)	(2)	(3)	(4)	(5)	(6)
	IO	LN_ANALYSTS	BM	LOSS	RND	LN_MAG_AR
Predicted sign on proxy	–	–	–	+	+	+
PROXY	0.0002 *	0.000	–0.005	0.015 **	0.002	0.012 ***
SD_VOL	0.146 **	0.219 ***	0.182 ***	0.147 **	0.215 ***	0.125 **
LN_MV	0.000	0.002	0.001	0.002	0.002	0.003 **
SALE	0.003	0.003	0.003	0.003	0.002	0.001
Constant	–0.010	–0.014	–0.008	–0.016 *	–0.016 *	–0.029 ***
Adjusted R^2	0.002	0.002	0.001	0.001	0.002	0.002
N	58,424	58,443	58,451	58,447	58,420	58,431

Notes: The table presents the results of ordinary least squares regressions of the insider trading profits (i.e., gains on purchases or losses avoided on sales) over the six months following the trade date on six measures of information asymmetry (IO, LN_ANALYSTS, BM, LOSS, RND, and LN_MAG_AR) and control variables (SD_VOL, LN_MV, and SALE). Variables are defined in tables 1 and 4. Significance at the 10%, 5%, and 1% levels (two-tailed) is denoted by *, **, and ***, respectively.

Table 6 Regression of the logarithm of the value of firm-year insider trade on measures of information asymmetry and control variables

$$\text{LN_YR_VALUE}_{iy} = \beta_0 + \beta_1 \text{PROXY}_{iy} + \beta_2 \text{SD_VOL}_{iy} + \beta_3 \text{LN_MV}_{iy} + \beta_4 \text{MOMENTUM}_{iy} + \epsilon_{iy}$$

	(1)		(2)		(3)		(4)		(5)		(6)	
	IO		LN_ANALYSTS		BM		LOSS		RND		LN_MAG_AR	
Predicted sign on proxy:												
Strategic model	0		0		0		0		0		0	
Price-taking model	-		-		-		+		+		+	
PROXY	0.003	***	0.073	***	-0.169	***	-0.125	***	0.074	***	0.169	***
SD_VOL	1.802	***	1.955	***	1.843	***	2.372	***	1.904	***	1.494	***
LN_MV	0.164	***	0.164	***	0.187	***	0.195	***	0.197	***	0.221	***
MOMENTUM	0.006	***	0.006	***	0.006	***	0.006	***	0.006	***	0.006	***
Constant	-0.561	***	-0.546	***	-0.453	***	-0.589	***	-0.640	***	-0.898	***
Adjusted R^2	0.310		0.310		0.311		0.310		0.312		0.326	
N	9,961		10,024		10,044		10,034		9,990		10,000	

Notes: The table presents the results of ordinary least squares regressions of $\text{LN_YR_VALUE} = \ln(1 + \text{YR_VALUE})$ (i.e., the logarithm of one plus the annual dollar value, in millions, of insider trades) on six measures of information asymmetry (IO, LN_ANALYSTS, BM, LOSS, RND, and LN_MAG_AR) and control variables (SD_VOL, LN_MV, and MOMENTUM). Variables are defined in tables 1 and 4. Significance at the 10%, 5%, and 1% levels (two-tailed) is denoted by *, **, and ***, respectively.

Table 7 Regression of firm-year insider trading profits on measures of information asymmetry and control variables

$$\text{YR_PROFIT}_{iy} = \beta_0 + \beta_1 \text{PROXY}_{iy} + \beta_2 \text{SD_VOL}_{iy} + \beta_3 \text{LN_MV}_{iy} + \epsilon_{iy}$$

	(1)		(2)		(3)		(4)		(5)		(6)	
	IO		LN_ANALYSTS		BM		LOSS		RND		LN_MAG_AR	
Predicted sign on proxy	-		-		-		+		+		+	
PROXY	0.002		0.015		-0.020		0.021		0.032		0.068	***
SD_VOL	0.926	***	1.109	***	1.163	***	1.095	***	1.084	***	0.631	***
LN_MV	0.007		0.016	**	0.022	***	0.022	***	0.024	***	0.029	***
Constant	-0.090	***	-0.101	***	-0.098	***	-0.115	***	-0.127	***	-0.200	***
Adjusted R^2	0.005		0.004		0.004		0.003		0.004		0.004	
N	10,434		10,451		10,453		10,445		10,433		10,439	

Notes: The table presents the results of ordinary least squares regressions of the firm-year profits to insiders (i.e., the sum of gains on purchases and losses avoided on sales) on six measures of information asymmetry (IO, LN_ANALYSTS, BM, LOSS, RND, and LN_MAG_AR) and control variables (SD_VOL and LN_MV). Variables are defined in tables 1 and 4. Significance at the 10%, 5%, and 1% levels (two-tailed) is denoted by *, **, and ***, respectively.