Corporate Insider Purchases and the Options Market:

Competition among Informed Investors

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Abstract

Corporate insiders have superior access to information; their trades, particularly purchases, should be informative. However, the extent of their informational advantage may be limited by the presence of other informed market participants. We document less frequent insider purchases in stocks with relatively high options trading activity. These purchases are followed by negligible abnormal returns. In contrast, stocks with less active options trading experience more frequent insider purchases, which yield positive abnormal returns over the subsequent six months. Our novel approach highlights the options market's role in screening uninformed insider trades, which ultimately contributes to more efficient stock market price formation.

JEL Classification: G12, G14

Keywords: insider trading, insider purchases, options trading, information competition, return predictability

1. Introduction

Corporate insiders have superior access to private information regarding the firm, and therefore insider trading activities should contain substantial information value and affect stock prices. The information content of insider trades has long been a focus of both academic research and practitioners' interests. In particular, various studies document that insider purchases precede abnormally positive stock returns (Seyhun, 1986; Lakonishok and Lee, 2001; Jeng, Metrick, and Zeckhauser, 2003) and material news announcements (Ke, Huddart, and Petroni, 2003; Piotroski and Roulstone, 2005; Cziraki, Lyandres, and Michaely, 2021), highlighting the information value of insider purchases.

On the other hand, not all insider purchases are marginally informative. For example, insiders may routinely purchase stocks (Cohen, Malloy, and Pomorski, 2012) or they may engage in strategic (uninformed) purchases to exploit the information power of their trades and manipulate other market participants (Chatterjea, Cherian, and Jarrow, 1993; Cherian and Jarrow, 1995; John and Narayanan, 1997).[1] Moreover, while insiders have access to specific pieces of insider information, they may not know definitively whether each piece of information has been incorporated into stock prices due to the trading activities carried out by other informed investors.

In this paper, we attempt to disentangle the different motives of insider purchases in the stock market by examining the trading activity in the options markets. The rapid development of options markets provides attractive trading venues for informed investors who can magnify their information advantage using the embedded leverage provided by options (Easley, O'Hara,

[1] The information and strategic effects of insider purchases are not likely to extend to insider sales, which seem to be mostly driven by liquidity and portfolio rebalancing motives (Lakonishok and Lee, 2001). Recent studies devise various alternative approaches to identify informed insider trades from uninformed insider trades, relying on time-series pattern of each insider's trading pattern (Cohen et al., 2012; Biggerstaff, Cicero, and Wintoki, 2020).

and Srinivas, 1998). To disentangle the informative and uninformative insider purchases, we examine how trading activity in the options market is related to two facets of insider purchase activity: (1) the frequency of insider stock purchases, and (2) the informativeness of such stock purchases.

A higher level of trading activity in the options market signals more intense competition for information. If the stock options of a particular firm are actively traded, firm insiders may be less likely to purchase the firm's stocks based on their (positive) private information if they think that the prevailing market price already reflects this information. In other words, information competition would reduce the expected profitability from executing insider trades (Holden and Subrahmanyam, 1992; Foster and Viswanathan, 1993; Massa, Qian, Xu, and Zhang, 2015). Therefore, we posit that informed insider purchases would be more frequent and informative in stocks with low options trading activity, as insiders can take better advantage of their informational advantage in those stocks.

Our empirical analyses focus on the options trading intensity measure, *O/S*, which is the ratio between the trading volumes of an underlying stock's various options and the stock itself. Roll, Schwartz, and Subrahmanyam (2010) document empirical evidence that the intensity of informed trading in a multi-market setting can be captured by the ratio of trading volumes in the option and stock markets, i.e., the *O/S* ratio. We measure the options trading volume of a particular underlying stock as the total number of option contracts traded across all listed options on the stock. This aggregated option volume is then scaled by the total number of the underlying stock's shares traded during the same period.

Our main analysis focuses on the frequency of insider purchases. We document that insider purchases are more frequent among stocks with low options trading activity. About 5 percent of stocks in the highest quintile of *O/S* experience net insider purchases in the

subsequent month. The corresponding frequency is 8.78 percent (or 73% higher) for stocks in the lowest quintile of *O/S*. Controlling for various firm characteristics in a logit regression setting results in a marginal odds ratio of 35%, which is economically large and statistically significant.

To explore the channel through which insider purchases are influenced by competition from other informed traders, we exploit two unique events that curtailed private information acquisition by non-insiders: Regulation Fair Disclosure (RegFD) and the arrest of Raj Rajarantnam. A voluminous literature documents the reduction in the acquisition of private information and informed trading in the market following the implementation of Reg FD in October 2000 (Bushee, Matsumoto, and Miller, 2004; Chiyachantana, Jiang, Taechapiroontong, and Wood, 2004; Eleswarapu, Thompson, and Venkataraman, 2004; Ke, Petroni, and Yu, 2008; Bhojraj, Jun Cho, and Yehuda, 2012). We posit that if the relation between insider trading activities and option volume is due to option volume reflecting competition from other (non-insider) informed investors, it should be attenuated with the exogenous reduction in informed trading due to these events.

Consistent with our hypothesis, we document that the relation between *O/S* and subsequent insider purchases attenuates after these events. For example, before RegFD, the odds of experiencing insider purchases are 72% higher for stocks in the bottom *O/S* compared to stocks in the top *O/S* quintile. After RegFD, the corresponding odds diminish to 27%, indicating that insider purchases depend less on option trading activity. This pattern reinforces our main frequency analysis and provides a credible link between insider purchases and the information acquisition and trading activities of other potentially informed traders.

To further investigate whether trading activity in the options market is related to informed insider purchases, we perform two separate analyses. First, prior research documents

that informed insider trades are relatively prevalent immediately after earnings announcements, which form an important set of corporate information events. Motivated by this research, we examine whether the link between insider purchase frequency and options trading activity is more prominent following earnings announcements.[2] Relative to stocks in the highest *O/S* quintile, stocks in the lowest *O/S* quintile have 50% higher odds of experiencing insider purchases in the month immediately following earnings announcements. In comparison, the corresponding increase in odds is only 28% in the other months. Second, we show that the frequency of opportunistic insider purchases over routine insider purchases (Cohen et al., 2012) decreases with *O/S*, indicating that opportunistic insider purchases are more frequent than routine insider purchases among stocks with low option trading activity. In aggregate, the patterns we document from the frequency analyses of insider purchases are consistent with activities in the options market influencing the prevalence of insider purchases.

We next evaluate whether *O/S* can play a role in identifying (more) insider purchases with information on future stock prices. We do this by examining the stock returns after insider purchases, as a function of the activeness of the options market (i.e., *O/S*) before those purchases. To minimize the gap between the day of the insider purchase and the return measurement window, we focus on weekly stock returns immediately following insider purchases. Specifically, stocks with insider purchases are included in a calendar time portfolio for 26 weeks after the purchases. For each calendar week, stocks with insider purchases over the previous six months are divided into quintile portfolios based on their *O/S,* as measured during the four weeks preceding the insider purchase. We then estimate the Fama and French

[2] Many companies prohibit their executives from trading stocks ahead of earnings announcements. Insiders also voluntarily avoids trading before earnings announcement because of potential regulatory and legal actions (Ke et al., 2003). Therefore, insider trading is less frequent when earnings announcement is imminent (Garfinkel, 1997), and their trades carry little information on the subsequent earnings disclosure (Elliott, Morse, and Richardson, 1984; Givoly and Palmon, 1985; Noe, 1999). Therefore, incidence of insider trading increases after earnings disclosure and insiders still make profits from these trades (Sivakumar and Waymire, 1994).

(2015) five-factor alpha of each portfolio to gauge the informativeness of the insider purchases within each quintile portfolio.

We find that insider purchases tend to be followed by positive abnormal returns only when the trading volume in the options market is relatively low prior to the insider purchase. Stocks with insider purchases that reside in the bottom *O/S* quintile earn an average abnormal return of 20 basis points (*t*-stat=3.34) per week, over the subsequent 26 weeks. This indicates that an insider purchase that occurs alongside a relatively less active options market is more likely to have information value. In contrast, for stocks in other, higher *O/S* quintiles, insider purchases are associated with negligible average abnormal returns, ranging from 1 basis point to 8 basis points per week, over the subsequent 26 weeks.

A more detailed analysis indicates that insiders' purchases of stocks in the bottom *O/S* quintile are followed by positive abnormal returns up to at least 6 months after the purchase. On the contrary, insider purchases among stocks in the top *O/S* quintile experience positive abnormal returns for only the first two weeks following the purchases, which revert shortly afterward. Insider purchases in low *O/S* stocks also seem to be more informative regarding positive surprises in the subsequent earnings announcements. This additional evidence supports our assertion that insider purchases alongside sparse option trading activity tend to be informed, unlike insider purchases alongside active options markets.

Furthermore, the return pattern is not explained by the direction of options trades documented in Gilstrap, Petkevich, and Teterin (2020). They document that insider purchases are followed by high abnormal returns when option investors are also optimistic about future stock returns. However, we find that when *O/S* is low, insider purchases are followed by positive abnormal returns regardless of the direction of options trades measured by the difference in call and put implied volatility (*CPSpread*) and options order imbalance (*OOI*).

The patterns we document above remain when we 1) examine recent changes in *O/S* instead of the level of *O/S*, 2) use *O/S* measure constructed monthly instead of weekly, 3) control for various firm characteristics that have been previously documented as being related to the informativeness of insider trades, or 4) focus on stocks with high intensity of insider purchases. In sum, our results are consistent with the information channel: insider purchases have information value, and they are more informative in the absence of other informed investors.

The last set of our analyses further explores the information channel by focusing on the dynamics of the information asymmetry between insiders and other market participants. In particular, we ask whether the *O/S*-insider trade informativeness pattern is more pronounced among firms with higher information asymmetry and during times of high uncertainty. To examine the variation of information asymmetry, we divide stocks based on their option-implied volatility. The relation between options market activeness and the informativeness of insider purchases is the most prevalent among stocks with a high level of option-implied volatility. In the sample of stocks with above-median option-implied volatility, the spread in alphas following insider purchases between low and high *O/S* stocks is 27 bps per week; the corresponding spread is only 8 bps for the sample of stocks with below-median option-implied volatility. We find qualitatively similar results when we use institutional ownership to proxy for information asymmetry.

In the time series, the *O/S*-insider purchase informativeness pattern is more pronounced during periods of high uncertainty, as measured by the aggregate implied volatility, i.e., the VIX measure. During high VIX periods, the average spread in weekly alphas following insider purchases between low and high *O/S* stocks is 25 bps, which is higher than the corresponding average spread of 19 bps during low VIX periods.

Our study contributes to the literature that examines the effect of the information environment on the informativeness of insider trades. Previous literature documents consistent evidence that insider trades are more informative for stocks that are followed by a low number of analysts and those with low financial statement informativeness (Frankel and Li, 2004), for small stocks (Lakonishok and Lee, 2001), and for stock with high R&D expense (Aboody and Lev, 2000). However, Huddart and Ke (2007) find mixed evidence (at best) when they perform a systematic examination of the relation between various information environment proxies and insider trades. The current study provides a new perspective on the informativeness of insider trades by focusing on their competition with other potentially informed investors.

Our study is related to Massa et al. (2015) who show that informed insider sales increase with ex-ante possibility of informed trading "in the future" by short sellers. The main distinction is that we investigate how insider trades *condition on ex-post* informed trading activity. The different timing of the informed trading generates opposite predictions regarding insider trading vis-à-vis the presence of other informed traders: insider trading may increase with a higher ex-ante possibility of future informed trading, but it would decrease with a higher realized activity level of informed trading. Therefore, our paper complement Massa et al. (2015) to give a more complete picture of how insiders consider the possibility and realization of competition from other informed traders.

In the next section, we describe our data and the main variables of interest. In Section 3, we present our main findings on the relation between option volume and the frequency of insider purchases. In Section 4, we investigate the relation between option trading activity and information of insider purchases on future stock returns. Section 5 examines the effect of information asymmetry on our findings. We conclude the paper in Section 6.

2. Data and Variables

Our datasets come from various sources. We obtain stock trading data from CRSP, accounting data from COMPUSTAT, institutional ownership data from Thomson Reuters S34 file, insider trading data from Thomson Reuters, and options market data from OptionMetrics. Risk-free rates (one-month Treasury bill rates) and Fama and French (2015) five factors are sourced from Ken French's website. Data on signed option trades are from ISE open/close trade profile, Nasdaq options market trade outline (NOTO), and Nasdaq PHLX options trade outline (PHOTO).

We consider all common stocks listed in NYSE, NYSE American, and NASDAQ. We only include common stocks with valid prices, trading volume, and the number of shares outstanding. Stocks with a price less than $1 (or "penny" stocks) at the end of the previous month are excluded to minimize the impact of microstructure-related noise. We also require that option volume data is available for each stock. With these data requirements in place, the sample of optionable stocks includes 2,204 stocks per month on average. The sample period covers January 1996 (the beginning of the option data) to December 2016. When we use ISE/NOTO/PHOTO data, our sample periods start from January 2005 due to data availability.

2.1. Insider Trading Activities

The main dataset in this paper is insider trading data provided by Thomson Reuters Insider Filing. The dataset is based on SEC filing by insiders, broadly defined as those with access to non-public, material, and insider information. Insiders typically include officers, directors, and 10% beneficial owners of a company's stock. We only focus on open market purchases and sales recorded in SEC Filing Form 4 and exclude private transactions or option exercises. We also require transaction price, number of traded shares, and eight-digit CUSIP to

be valid.[3]

Since we focus on stock-level analysis, we aggregate insider trading activities at the stock level. For each stock, we aggregate the total number of shares purchased and sold by all insiders within each month. This study focuses on stock-month observations with net insider purchases (the number of shares purchased exceeds the number of shares sold). Previous research provides consistent evidence that while insider purchases are informed, insider sales are not typically predictive of future stock returns. This is consistent with insider sales being mostly driven by diversification, rebalancing, or liquidity needs (Lakonishok and Lee, 2001; Jeng et al., 2003).

2.2. Option Trading Activities

The main independent variable of interest in this study is *O/S*, the ratio of option volume to stock volume. Easley et al. (1998) provide a fundamental theoretical model that predicts that informed investors would shift their trading from the stock market to the options market to exploit the latter's embedded leverage. Roll et al. (2010) provide empirical evidence that a spike in option volume represents the high intensity of informed trading on underlying shares. Johnson and So (2012) argue that high *O/S* represents informed trading on negative information since informed investors who face short sale constraints may opt to trade in the options market instead. However, Ge, Lin, and Pearson (2016) argue that *O/S* represents both positive and negative information content.

The *O/S* ratio for a stock is defined as the number of option contracts traded (aggregated across all listed options for the stock) divided by the trading volume of the

[3] We require transaction code to be 'P' or 'S'. We exclude a record if the number of traded shares exceeds daily trading volume, or 20% of number of shares outstanding. We also exclude a record whose transaction price deviates more than 20% from the end of the day price.

underlying stock. We exclude options with days to maturity less than 7 days or more than 91 days following Johnson and So (2012). The number of option contracts is multiplied by 100 as each option contract pertains to 100 shares. Our results are robust to scaling option volume with shares outstanding.

3. Frequency of Insider Purchases and Option Volume

To illustrate our hypothesis regarding insider purchases and option volume, let's consider an informal model in which insiders receive a noisy private signal regarding the true value of the stock, while other informed investors may also receive another noisy private signal. Insiders decide whether to purchase stocks depending on the expected profits and costs of trading (such as litigation risk, liquidity costs, and investment risk). An insider's expected profits depend on how much of the private signal has been incorporated into the stock price (i.e. if other informed investors also possess the private signal and have traded on it). Since insiders cannot directly observe the trades of other informed investors, they can only infer how much of their signal has been incorporated into prices by looking at market outcomes, including prices and trading volumes in both option and stock markets.

Due to the intrinsic leverage offered by options, informed investors would benefit more if they trade on their signal in the options market rather than in the stock market (Black, 1975). As such, the option market trading activity could provide a crucial mechanism through which insiders can evaluate the remaining profitability of their private signal: a high option trading volume would indicate a higher likelihood of (other) informed investors possessing a private signal and trading on it (Roll et al., 2010). In other words, insiders' expected profits would diminish with option volume, which discourages them from trading on their private signal. Furthermore, even if insiders decide to trade, the expected future profits would be lower in

magnitude. On the contrary, low *O/S* indicates a lower chance of other informed investors possessing private signals, motivating insiders to trade more with higher subsequent return.

The informal model above generates a few testable implications:

#1. Higher *O/S* is related to lower insider purchase activities.

#2. Insider purchases in stocks with high *O/S* earn smaller profits.

#3. Implications #1 and #2 are stronger when other informed investors are more likely to receive private signals, e.g. in environments with higher information asymmetry.

In this section, we investigate the first prediction that informed insider purchases correlate with trading activity in the options market.

3.1. Frequency of Insider Purchases and *O/S*

We start with a preliminary analysis on the frequency of insider purchases among stocks within each *O/S* quintile. Stocks are first grouped into quintiles based on *O/S* over the past month. We then calculate the fraction of stocks in each quintile with net insider purchases in the subsequent month and report the time-series average for each quintile in Table 1.

[Table 1]

Table 1 reports that insiders are more likely to purchase a stock when the trading volume on the stock's options is low. Among stocks in the highest *O/S* quintile, only 5.07% of the stocks experience net insider purchases in the subsequent month. For stocks in the lowest *O/S* quintile, the fraction is about 70 percent higher, with 8.78% of those stocks experiencing net insider purchases in the subsequent month. This economically large difference is also highly statistically significant with a *t*-stat of 8.89.

The rest of Table 1 reports the average values of various stock and option characteristics of the constituents of each *O/S* quintile. From analyzing stock characteristics, we observe that high *O/S* stocks are associated with high systematic (market beta) and unsystematic (idiosyncratic volatility) risks.

For option characteristics, Table 1 reports the spread in implied volatility of call and put option volume (*CPSpread*) and options order imbalance (*OOI*). To calculate *Cpspread*, implied volatility is extracted from OptionMetrics volatility surface data with a delta of 0.5 and an expiration of 30 days following An, Ang, Bali, and Cakici (2014). Cremers and Weinbaum (2010) argue that the implied volatility spread positively predicts subsequent future stock returns because it reflects directional informed trading in the options market. The average *CPSpread* decreases from −0.03% in the lowest *O/S* quintile to −1.63% in the highest *O/S* quintile, suggesting that high *O/S* is related to negative directional informed trading.

Option order imbalance (*OOI*) is computed by combining three data sources that start from 2005: ISE, NOTO, and PHOTO. For each option, they report daily volume on synthetic long (long call and short put) and short positions (short call and long put) by non-market makers. Therefore, *OOI* is defined as the difference in synthetic buy volume and synthetic sell volume divided by the sum of the two.[4] Table 1 shows that the option order imbalance is unrelated to option volume. The difference in average *OOI* between the top and the bottom *O/S* quintile is statistically insignificant. It indicates that *O/S* is likely to capture a high intensity of informed trading in *both* positive and negative directions, rather than in only one particular direction. Ge et al. (2016) document that option volume contains information on both negative and positive information as informed traders aim to exploit leverage in the options market. (Roll et al., 2010).

[4] Later in the paper, we compute call (put) option order imbalance which is based soley on signed volume on call (put) options.

Since *O/S* is also correlated with other firm characteristics, including size and past returns as reported in Table 1, we utilize a panel logit regression model to quantify the marginal effect of *O/S* on the likelihood of insider purchases. Table 2 reports the odds ratios from panel logit regressions to predict whether there is a net insider purchase in month t+1. To be specific, we report exp(β) from the following regression:

$$\text{logit}(\textit{Net Purchase}_{i,t+1}) = \beta_0 + \beta_1 \times O/S_{i,t} + \beta \times (\text{Control variables}_t) + \epsilon_{i,t}. \quad (1)$$

Our main independent variable is *O/S* measured in month t. We also include various control variables including the once-lagged value of the dependent variable (lag(Net Purchase)), market beta (*Beta*), idiosyncratic volatility (*Ivol*), log of market equity (ln(*ME*)), lagged one-month stock return (lag(*Ret*)) and its squared term, lagged twelve-month stock return (*Momentum*) and its squared term, and Amihud (2002) illiquidity measure (*Amihud*).

[Table 2]

In column (1), the large odds ratio on the dummy variable for the insider purchase in month t (lag(Net Purchase)) suggests that insider purchases tend to be persistent over time. An odds ratio less than one on size (ln(*ME*)) is consistent with previous findings from the literature that insider purchases are more prevalent in small firms. Low odds ratios on lagged one-month return (lag(*Ret*)) and lagged twelve-month return (*Momentum*) confirm that insiders are contrarian traders.

For the main variable of interest, the odds ratio on *O/S* is 0.944 and is significantly different from 1 at the 1% level. This indicates that a one-standard-deviation reduction in options trading activity in a particular month t increases the odds of net insider purchases in the subsequent month t+1 by 5.6% (=1−0.944), after controlling for various stock characteristics.

In column (2), we replace the continuous *O/S* variable with *O/S* quintile dummies to

facilitate the interpretation of the odds ratios. We use dummy variables, one for each of the *O/S* quintiles uniquely denoting membership to that *O/S* quintile. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. In column (2), the odds ratio on *O/S:Q1* is 1.35, indicating that the odds of insider purchases increase by 35% for stocks in the lowest *O/S* quintile relative to those in the highest *O/S* quintile. The higher probability of insider trades is also experienced by stocks in the second and third lowest *O/S* quintile, with odds ratios of 1.16 and 1.09, respectively.

Since insider purchase activities are quite persistent, we perform a robustness check by dropping stocks with insider purchases in the previous month (reported in column (3)) and focusing on how *O/S* predicts "fresh" insider purchase activities. The odds ratio on *O/S:Q1* is 1.417, which is slightly stronger than the corresponding estimate in column (2), consistent with *O/S* driving the initiation of insider purchase activities.

We next control for option-based variables that reflect the trading direction of option investors. Johnson and So (2012) document that high *O/S* signals negative information in the options market, and Gilstrap et al. (2020) argue that insider purchases are less prevalent when options trading direction is negative. To control for the predictability of options trading direction, we use four different proxies of option trading directions: call-put implied volatility spread (*CPSpread*), option order imbalance (*OOI*), call option order imbalance (*OOI_C*), and put option order imbalance (*OOI_P*). In the logit regressions, we include dummy variables that signal positive signs of option trading direction proxies. For example, *OOI* takes a positive sign when volume on long call and short put option positions exceeds that on short call and long put option positions. *OOI_P* takes a positive sign when the volume on short put options exceeds the volume on long put options.

Column (4) shows that controlling for variables that reflect options trading direction does not impact our main result. The odds ratio on *O/S:Q1* remains statistically significant and high at 1.27.[5] Therefore, the drop in insider purchase activities following high *O/S* cannot be fully explained by negative directional informed trading in the options markets.

We also explore the temporal dimension of the effect of *O/S* on future insider purchases. In Figure 1, we report the parameter estimates from logit regressions to predict net insider purchase in month $t+i$ (i=1⋯12, respectively) using *O/S* in month *t*. The figure illustrates that the odds ratios are significantly lower than 1 for the first 5 months after the measurement period of *O/S*, but gradually increase over time, becoming statistically indistinguishable from 1 (i.e., no negative effect) by month 6. In sum, we observe that the negative effect of *O/S* on future insider purchases remains significant for at least five months.

[Figure 1]

In sum, stocks whose options experience relatively higher levels of activity (i.e., high *O/S*) tend to have fewer insider purchases in the subsequent period. This pattern is robust to different specifications with various sets of control variables. This suggests that the decision of insiders whether to participate in the stock market is shaped by the information environment as reflected by the activities in the options market. A less active options market is associated with scarce competition for private information, increasing the expected profitability and consequently the frequency of insider purchases.

3.2. Exogenous Reduction of Informed Trading in Options Markets and Insider

[5] Because of ISE/NOTO/PHOTO data availability, option order imbalance variables are missing before 2005 in column (4). In order to maintain a fair comparison between columns, we replace missing values of option order imbalance with zeros. If we omit observations with missing option order imbalance data, the results are stronger.

Purchases

To provide additional empirical evidence on our hypothesis linking option trading and insider purchase activities, we exploit two unique events to explore potential causal links. We employ Regulation Fair Disclosure (RegFD) and the arrest of Raj Rajaratnam as exogenous shocks to the information environment and examine how the link between *O/S* and insider purchases evolves around these shocks. With these events curtailing access to private information for non-insiders, the difficulty of acquiring private information for potential informed traders increases considerably. As a result, we posit that the option market would become less informed after these shocks and the insider purchase would have a weaker link with *O/S* measure.

RegFD was implemented in October 2000 by the SEC to deter selective disclosures of material information to certain individuals without contemporaneous public disclosures. A voluminous literature documents the deleterious effect of RegFD on the acquisition of private information and informed trading in the market (Bushee et al., 2004; Chiyachantana et al., 2004; Eleswarapu et al., 2004; Ke et al., 2008; Bhojraj et al., 2012).

The second shock that we employ is based on the arrest of Raj Rajaratnam, a billionaire hedge fund superstar, with insider trading charges in October 2009. He was later sentenced to 11 years in prison, the longest-ever sentence for insider trading. His arrest was followed by the largest increase in insider trading enforcement in the next few years. Bondarenko and Muravyev (2022) show that his arrest had a large impact on informed trading particularly in the options market, with the put-to-call option ratio no longer reliable in predicting future stock returns after the event. Therefore, we posit that the option market would be less informed after these plausibly exogenous events, and that the *O/S* measure would have a weaker link with insider purchase activities.

We first test the impact of RegFD on the relation between option volume and insider purchases, by restricting our sample period from October 1999 to October 2001, one year before and after the implementation of RegFD. We run a panel logit regression that predicts insider purchases in month *t*+1 with *O/S* in month *t*. To be specific, we estimate the following logit model.

$$logit(Net\ Insider\ Purchase_{t+1}) = \beta_0 + \beta_1 O/S_t \times Post_t + \beta_2 O/S_t + \beta_3 Post_t + \beta \times (Controls_t) + \epsilon, \quad (1)$$

where *Post* takes the value of 1 after RegFD's implementation in October 2000. For easier interpretation, we report analyses using *O/S* quintile dummy variables instead of the continuous *O/S* variable.

[Table 3]

Column 1 of Table 3 replicates the baseline regression model in Column 2 of Table 2 for the subsample, whereas Column 2 of Table 3 reports the odds ratio from the panel regression following the equation (1) above. The odds ratios in Column 2 indicate that the relation between *O/S* and insider purchases attenuates substantially after Reg FD implementation. The odds ratio on *O/S:Q1* is 1.723, indicating that before RegFD, stocks in the bottom quintile had 72.3% higher odds of having insider purchases. However, the odds ratio of *O/S:Q1* × *Post* is 0.737, indicating that after RegFD, low *O/S* stocks have only 27% (=1.723 × 0.737 − 1) higher odds of experiencing insider purchases, or less than half of the corresponding difference before RegFD.

In Panel B, we investigate the arrest of Raj Rajaratnam and find similar evidence. In the year before the arrest of Raj Rajaratnam, stocks in the bottom *O/S* quintile had 64% higher odds of insider purchases in the next month than stocks in the top *O/S* quintile. After the arrest,

the difference in odds drops to 31.5% (=1.640 × 0.802 – 1), which is slightly less than half of the corresponding difference before the arrest.

There is plausible concern that our event-based results above may be explained by a time-trend pattern that the relation between insider purchases and *O/S* is declining over time. To investigate this possibility, we repeat the analyses above for pseudo-event dates, i.e., October of each year from 1997 to 2015. Inconsistent with the time-trend driving our results, none of the odds ratios on the interaction term between *O/S:Q1* and *Post* are less than 1 for these pseudo-events, unlike the two events reported in Table 3.

In sum, we provide additional empirical evidence consistent with the relation between insider purchases and option volume being driven by competition among information-driven trades. When *O/S* no longer represents competition, insider purchases are less affected by *O/S*. When *O/S* is more likely to reflect potentially intense competition to exploit private information, it strongly predicts insider purchases.

3.3. Insider Purchases Around Earnings Announcements

Since insiders have access to more private information than other shareholders and potential investors, many regulations are put in place to prevent insiders from making profits from their inside information. Most notably, many companies prohibit their executives from trading stocks ahead of earnings announcements. Many insiders also voluntarily avoid trading before earnings announcements because of potential regulatory and legal actions (Ke et al., 2003). Therefore, insider trading is less frequent when an earnings announcement is imminent (Garfinkel, 1997). Reflecting the concern regarding regulatory scrutiny, insider trades that do occur seem to carry little information on the subsequent earnings disclosure (Elliott et al., 1984; Givoly and Palmon, 1985; Noe, 1999). As a result of these regulatory- and self-imposed

restrictions on insider trading before earnings announcements, the incidence of insider trading tends to increase after earnings disclosures, with insiders still profiting from such trades (Sivakumar and Waymire, 1994). It suggests that even if insiders cannot trade on foreknowledge of earnings, they continue to have an informational advantage over outside investors, as they could possess other forms of private information and/or interpret earnings information better following the disclosure.

The different dynamics of insider trading activities before vs. after earnings announcements provide us with a useful setting to investigate how option volume relates to informed insider purchases. For insider purchases executed before the earnings announcement, which are presumably driven by motives other than private information, we expect the effect of *O/S* on these purchases to be weaker. The information channel also predicts that the effect of *O/S* to be stronger for insider purchases executed shortly after earnings announcements. This setting is useful as it allows us to falsify the effect of *O/S* on insider purchases: if the correlation between *O/S* and insider purchases merely reflects other (unobserved) characteristics, we should observe the correlation to be independent of the timing of insider purchases.

We perform panel logit regressions predicting insider purchases in the subsequent period with *O/S* as the main variable of interest. More importantly, we investigate the interaction between dummy variables for *O/S* quintile membership and an indicator variable representing the month immediately following the firm's earnings announcement. To be specific, the dummy variable, *PostEA*, takes a value of 1 in the month immediately following the earnings announcement, and 0 otherwise.

Table 4 reports the results from these regression models. We observe that *O/S* is strongly related to insider purchases in the month immediately after the earnings announcement. In other months (i.e. *PostEA*=0), stocks in the bottom *O/S* quintile (*O/S:Q1*) have 28% higher

odds of having insider purchases compared to the stocks in the top *O/S* quintile. In the months immediately following the earnings announcement (i.e. *Post*=1), this difference in odds is amplified by 17%, i.e., the odds ratio of 1.17 for *O/S:Q1×PostEA*. Therefore, low *O/S* stocks have 50% (=1.28 × 1.172 – 1) higher odds of insider purchases, relative to high *O/S* stocks, during these post-announcement months. This pattern indicates that while options trading activities affect insider purchases prior to earnings announcements, the effect is stronger in the post-announcement period, consistent with the information channel that we posit.

[Table 4]

In Column (2) of Table 4, we control the effect of options trading direction by including dummy variables for positive values of options trading direction proxies following Column (4) in Table 2. The estimates are largely unaffected, with the odds ratio on *O/S:Q1×PostEA* of 1.166, indicating that low *O/S* stocks have 16% higher odds of insider purchases in the month after earnings announcement vs. in other months. It confirms that insider purchases are closely related to the intensity of informed trading in the options market having the direction of trading in the options market controlled for.

3.4. Opportunistic Insider Purchases and Option Volume

To further bolster our claim that an active option market is related to the frequency of informed buys by insiders, we distinguish routine insider purchases from opportunistic insider purchases. Cohen et al. (2012) find that some insider purchases are routine, and they do not carry information on future returns. On the other hand, opportunistic buys have robust information content on the future price of the stock. Therefore, we examine if the occurrence of opportunistic buys correlates with *O/S*.

[Table 5]

In Table 5, for stocks with insider purchases, we run panel logit regressions predicting whether there are any opportunistic insider purchases in month t+1 in relation to *O/S* measured during month t. Across four different specifications, we find robust evidence that scant option trading volume leads to a higher occurrence of opportunistic buys. For example, in column (3), stocks in the bottom *O/S* quintile have 25.7% higher odds that there will be at least one opportunistic purchase in the next month, relative to stocks in the highest *O/S* quintile. Furthermore, including various proxies for options trading direction as control variables has little effect on the relation between *O/S* and the frequency of opportunistic purchases, as reported in columns (2) and (4).

4. Returns after Insider Purchases and Options Trading Activity

In this section, we extend our analysis to the information content of insider purchases on future returns. The main interest of this section is to examine the stock's performance after insider purchases, conditional on options market activity (*O/S*) measured before the insider trades. Empirical analysis in this section aims to test hypothesis #2 stipulated at the beginning of the previous section. In this section, we focus on weekly returns instead of monthly returns. It is to minimize the gap between the day of the insider purchase and the return measurement window. However, investigating monthly returns does not affect our results.

4.1. Methodology: Calendar Time Portfolio

To investigate how the return predictability of insider purchases varies with *O/S*, we examine the abnormal returns of calendar time portfolios constructed based on insider purchases and the corresponding *O/S*. Since insider trading could have a long and persistent impact on market prices (Seyhun, 1986), investigating calendar time portfolio alpha alleviates

the bias from cross-correlation of long-run return (Fama and French, 2008) and offers straightforward statistical tests that accommodate heteroscedasticity and autocorrelation.

In constructing a calendar time portfolio, stocks with net insider purchases in week t are included in a portfolio from week t+1 to t+26. The 26-week (i.e. 6 months) holding period, though arbitrary, corresponds to the minimum time in the short-swing rule. SEC rule states that "profits made by insiders from transactions involving equity securities of publicly held companies, when a purchase and a sale are made less than 6 months apart, must be disgorged and paid over to the issuer." Thus, investigating long-run returns allows us to fully capture the information content and market impact of insider trades that tend to reveal in the long run.

To account for the exposure of portfolio returns to common factors, we compute alphas by running the following time-series regression:

$$r_{p,w}-r_{f,w}=\alpha_p+\beta_{\mathrm{MKT},p}MKT_w+\beta_{\mathrm{SMB},p}SMB_w+\beta_{\mathrm{HML},p}HML_w+\beta_{\mathrm{RMW},p}RMW_w+\beta_{\mathrm{CMA},p}CMA_w \quad (2)$$

where $r_{p,w}$ is the raw return of portfolio p in the week w, $r_{f,w}$ is the one-month T-bill rate. The regression intercept α and the coefficients β correspond to the alpha and the factor loadings, respectively. Our main factor model is the Fama and French (2015) five-factor model that incorporates the following factors: the market factor (excess return on the value-weighted CRSP market index over the one-month *T*-bill rate, MKT), the size factor (small minus big return premium, SMB), the book-to-market factor (high book-to-market minus low book-to-market return premium, HML), the profitability factor (robust profitability minus weak profitability return premium, RMW), and the investment factor (conservative investment minus aggressive investment return premium, CMA).

4.2. Returns after Insider Purchases and *O/S*

Panel A of Table 6 reports the Fama-French five-factor alphas of calendar time portfolios constructed based on insider purchases and *O/S*. The column labeled 'All' reports the average alphas of all stocks with insider purchases. Within the sample of optionable stocks, insider purchases are followed by abnormal stock returns of +0.09% per week in the subsequent 26 weeks. The economic magnitude and statistical significance are lower than what has been reported in previous studies because our sample focuses on optionable stocks, which tend to be large-cap stocks. Our focus on optionable stocks also limits the sample period to start from 1996. Furthermore, we control for the Fama-French 5-factor model that explains a wide range of return anomalies in the stock market, reducing the potential alpha of any trading strategy that is correlated with other anomalies.[6]

[Table 6]

More to the point, we investigate the role of *O/S* in distinguishing informed and uninformed insider purchases. In each calendar week, we divide stocks into quintiles based on *O/S* measured during the four weeks preceding the week of insider purchases. Stocks in each quintile are equally weighted and held until the next calendar week. Panel A reports that quintile portfolio alphas monotonically decrease from 0.20% (*t*-stat=3.34) in the lowest *O/S* quintile to 0.01% (*t*-stat=0.16) in the highest *O/S* quintile. The latter illuminates a stark pattern that insider purchases do not contain directional information on future stock prices when those purchases coincide with high options trading volume. In other words, insider purchases that are made amid high options trading activity are not informed.

As reported in the column labeled "L−H" in Panel A, the difference in alpha of 0.19% (*t*-stat=3.5) within the sample of stocks experiencing insider purchases is economically large.

[6] In Appendix Table A1, we find that stocks with net insider sales earns alphas that are indistinguishable from zero. It confirms that insider sales are mostly driven by diversification, rebalancing or liquidity needs (Lakonishok and Lee, 2001; Jeng et al., 2003).

This stands in stark contrast to the absence of a relation between *O/S* and future returns among stocks with net insider sales, which is reported in Table A1. The alphas of calendar-time portfolios of insider sales fall within a narrow range from −0.02% (lowest *O/S*) to 0.08% (highest *O/S*) across five *O/S* quintiles. This suggests that the negative relation between *O/S* and the informativeness of insider trades is unique to purchases, and does not merely reflect the unconditional negative return predictability of *O/S* documented in the previous literature (Johnson and So, 2012).[7]

To mitigate potential concerns that our results are driven by some stock characteristics that are correlated with *O/S*, we investigate the temporal change in *O/S* (*ΔO/S*) instead of the level of *O/S*. The variable *ΔO/S* is defined as the percentage change of *O/S* from its past 12-month average. As shown in the bottom of Panel A, the alpha reaches up to 0.21% (*t*-stat=2.89) per week for the lowest *ΔO/S* quintile while it is insignificant at 0.02% per week for the highest *ΔO/S* quintile. The difference in alpha between the top and bottom quintile reported in the "L−H" row is 0.19% (*t*-stat=3.57), which is practically identical to the main result that we obtained using the level of *O/S*. This indicates that our main inference is not driven by unobserved static firm characteristics and is robust to alternative definitions of option trading activities.

We also examine whether the return pattern documented in Panel A is sensitive to the choice of return measurement methodology. In Appendix Table A2, we report excess returns (excess of risk-free rate), market-adjusted returns (raw returns minus CRSP VW market returns), and Fama-French six factor alphas (FF6, i.e., FF5 plus momentum factor) of the quintile portfolios. We find that returns after insider purchases monotonically decrease with *O/S* using all return measurement methodologies.

In Panel B, we attempt to distinguish the respective identification roles of the levels

[7] We will further discuss insider sales in Section 6.2.

and changes in *O/S*. Stocks with insider trades in week *t* are included in the portfolio for the next 26 weeks (*t*+1 to *t*+26). In each calendar week, stocks are sequentially double sorted into quintiles, firstly on past levels of *O/S* (*pO/S*) and then on changes in *O/S* (*ΔO/S*). The past level of *O/S* is defined as the average *O/S* from week *t*−52 to *t*−5 to capture the permanent and persistent level of *O/S* before the insider trades. The change in *O/S* is defined as a percentage difference between *O/S* averaged from week *t*−4 to *t*−1 and *O/S* averaged from week *t*−52 to *t*−5, capturing the temporal variation in options trading volume in the period immediately before insider trades.

For stocks that had experienced negative shocks in option volume (stocks in the low *ΔO/S* quintile), insider purchases tend to be followed by positive alphas regardless of the past level of *O/S*. For the five *pO/S* quintiles in the lowest *ΔO/S* quintile, alphas range from 0.09% to 0.25%. In contrast, for stocks in the highest *ΔO/S* quintile – which experience positive shocks in option volume, alphas after insider purchase are always lower than 0.03%. This pattern indicates that temporal shocks to *O/S* around insider purchases drive our main inference and that these shocks to *O/S* form a useful signal of the informativeness of insider purchases.

4.3. Direction of Options Trades and Returns after Insider Purchases

Johnson and So (2012) document that high *O/S* is followed by negative subsequent return, which reflects options investors' negative private information. Also, Gilstrap et al. (2020) argue that insider purchases are informative when the trading direction of options traders agrees with insider purchases. Therefore, in this section, we investigate how the direction of option trading directions proxied by *CPSpread* and *OOI* explain our main finding that insider purchases are followed by positive returns exclusively among stocks with low *O/S*. In Panel A of Table 7, we report the alphas of *O/S* quintile portfolios among stocks with the positive and

negative signs of *CPSpread*. Stocks with insider purchases are divided into two groups based on the sign of their *CPspread*. Within each group, stocks are further divided into quintiles based on *O/S*. In the lowest quintile of *O/S*, stocks are followed by a significantly positive abnormal return for both positive and negative *CPSpread* groups. The weekly alphas following insider purchases are high at 0.13% and 0.23% for negative and positive *CPspread* group, respectively. On the other hand, when *O/S* is high, insider purchases are not followed by positive returns even when *CPSpread* is positive. When *CPSpread* is negative (positive), the alpha is −0.04% (0.09%) per week, confirming that high option trading activity detects uninformed insider purchases regardless of its direction. Furthermore column "L−H" confirms that returns following insider purchases decrease with *O/S* in both negative and positive *CPspread* groups.

[Table 7]

In Panels B, C, and D, we use option order imbalance as a proxy of option trading direction. In Panel B, for example, stocks are divided into two groups based on the sign of option order imbalance (*OOI*). Positive *OOI* indicates that trading volume on long call and short put option position exceeds that on short call and long put option position. Then, stocks are further divided into quintiles based on *O/S*. In Panels C and D, we use call option order imbalance (*OOI_C*) and put option order imbalance (*OOI_P*). *OOI_C* (*OOI_P*) is positive when trading volume on the long call (short put) option position exceeds the short call (long put) option position. Note that the analyses in these panels start from 2005 when the data on the signed option trades becomes available.

Despite the difference in the sample, all three Panels report similar results to Panel A: 1) insider purchases are informed when *O/S* is low irrespective of the option order imbalance and 2) insider purchases are uninformed when *O/S* is high regardless of the option order imbalance. Across three panels, weekly alpha after insider purchases ranges from 0.13% to

0.18% when *O/S* is low, and it ranges from −0.24% to −0.05% when *O/S* is high. Lastly, high alphas of over 0.2% per week reported in column "L−H" suggest that *O/S* plays an important role in distinguishing informed insider purchases in all states of order imbalance. In sum, the options trading direction does not fully explain our result.

Combined with our empirical findings in the previous section, the results suggest that reduced trading activity in the options market is closely related to a higher prevalence of informed insider purchases that are followed by positive abnormal returns in the next 6 months. In contrast, insider purchases among stocks with high option trading volumes are relatively rare, and they do not predict subsequent returns.

4.4. Returns after Insider Purchases and *O/S*: BHAR

In this subsection, we provide a more detailed pattern of how stock prices evolve each week after insider purchases.

[Figure 2]

Figure 2 reports buy-and-hold abnormal return (BHAR) calculated using weekly returns over 26 weeks following insider purchases. A stock's BHAR is defined as its cumulative raw return minus its corresponding benchmark portfolio's cumulative raw return. To construct a benchmark portfolio, we sequentially group stocks into quintiles based on size, book-to-market ratio, and the past 12-month return, which results in 5×5×5 = 125 equal-weighted portfolios. A particular stock's benchmark portfolio is one of the 125 portfolios to which the stock belongs.

BHAR of insider purchases in stocks with low *O/S* is followed by continuously high returns for up to 26 weeks after insider purchases. BHAR in week 26 is 3.9% and the economic

magnitude is comparable to our main result in Table 6 which documents a Fama-French five-factor alpha of 0.2% per week. For stocks in the high *O/S* quintile, the BHAR initially increases in the first two weeks after the insider purchase, resulting in a 2-week cumulative return of 0.9%. Then, it subsequently decreases and reaches −0.8%. in week 26. Therefore, the insider purchases and their announcement temporarily push up the price, but it eventually reverses in the long run.

4.5. Abnormal Return around Earnings Announcement

As another way to validate the relation between options trading activity and information content of insider purchases, we investigate the magnitude of earnings shock following insider purchases. If insider purchases in stocks with less frequent option trading are more informative, we expect them to be followed by more positive news in the subsequent earnings announcements.

[Figure 3]

Figure 3 reports cumulative abnormal return (CAR) around the first earnings announcement after insider purchases. For each stock with net insider purchases, we assign it to the top or the bottom *O/S* quintile based on the *O/S* measured four weeks prior to the insider purchase. We then calculate its CAR during the following earnings announcement period. Figure 3 reports the average CAR for stocks in the bottom (solid line) and top (dashed line) *O/S* quintiles from 5 days before to 5 days after earnings announcements. CAR is defined as the cumulative sum of market-adjusted return (raw stock return minus CRSP value-weighted index return).

Figure 3 depicts a clear pattern that the insiders' purchases of stocks with low *O/S* are followed by positive earnings surprise while purchases of stocks with high *O/S* are not.

Cumulative abnormal return in the two weeks surrounding the announcement is over 1.2% for stocks in the bottom quintile of *O/S*. On the contrary, the cumulative abnormal return of stocks in the top quintile of *O/S* never exceeds 0.3%. Furthermore, the magnitude of CAR of low *O/S* stocks is much larger than the unconditional alpha of 0.2% per week reported in Table 6. It suggests that a large part of return predictability concentrates around the earnings announcement. Therefore, it is consistent with our claim that 1) insider purchases alongside active options trading have little information content, and 2) insider purchases among stocks with low option volume contain positive information on the stock.

4.6. Returns after Insider Purchases and *O/S*: Panel Regression

In this subsection, we control for other firm characteristics that can potentially confound our inference on the relationship between the return predictability of insider purchases and options trading volume. We do so by regressing 26-week buy-and-hold abnormal return (BHAR) after insider purchases on various firm characteristics. A stock's BHAR is defined as its 26-week cumulative raw return minus its corresponding benchmark portfolio's 26-week raw return. To construct a benchmark portfolio, each week, we sequentially group stocks into quintiles based on size, book-to-market ratio, and the past 12-month return, which results in 5×5×5 = 125 equal-weighted portfolios. A particular stock's benchmark portfolio is one of the 125 portfolios to which the stock belongs.

We perform a panel regression of this BHAR variable to control for market beta (*Beta*), idiosyncratic volatility (*Ivol*), log of market equity (ln(*ME*)), lagged one-month stock return (lag(*Ret*)) and its square, lagged twelve-month stock return (*Momentum*) and its square, and Amihud (2002) illiquidity measure (*Amihud*). We also include variables that proxy for directional informed trading in the options market. Specifically, we include four dummy

variables that indicate positive sign of options trading direction proxies: *CPSpread*, *OOI*, *OOI_C*, and *OOI_P*. Including these variables allows us to test whether option volume has unique information on insider purchases that is distinct from the information conveyed via option prices (Gilstrap et al., 2020) [8]

[Table 8]

Column (1) of Table 8 presents the parameter estimates from the panel regression. For ease of interpretation, our main independent variables are dummy variables for the stock's *O/S* quintile membership. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. The statistically significant coefficient on *O/S:Q1* in column (1) of Table 8 indicates that the 26-week BHAR of stocks in the lowest *O/S* quintile is 3.401% higher than that of stocks in the highest *O/S* quintile.

This economic magnitude is similar to the corresponding 26-week BHAR reported in Figure 2. As the panel regression includes variables that proxy for directional informed trading in the options market, the robustness of our results to the inclusion of these variables indicates that option volume has unique information on insider purchases that is distinct from the directional information that can be gleaned from the options market.

4.7. Returns after Insider Purchases and *O/S*: Earnings Announcement

As highlighted in Section 3.3, insider trading patterns and motives are different before and after the earnings announcement. The relation between *O/S* and insider trading frequency

[8] Because of ISE/NOTO/PHOTO data availability, option order imbalance variables are missing before. In order to maintain a fair comparison with previous tables, we replace missing values of option order imbalance with zeros. If we omit observations with missing option order imbalance data, the results are stronger.

also differs before and after the earnings announcement. Therefore, in this subsection, we investigate if the relation between *O/S* and the informativeness of insider purchases is more pronounced for purchases made shortly after earnings announcements. We do so by investigating the 26-week buy-and-hold abnormal return of insider purchases that occur in the month immediately after earnings announcements vs. other insider purchases that occur more than a month after the preceding earnings announcement (but before the next one). Then, for each subsample, we estimate a panel regression that predicts buy and hold abnormal return (BHAR) with *O/S*.

In column (2) of Table 8, we restrict our sample to insider purchases made during the month immediately after the firm's most recent earnings announcement. The coefficient on *O/S:Q1* indicates that insider purchases in stocks in the lowest *O/S* quintile earn 3.609% higher abnormal return over the subsequent six months, relative to insider purchases in the highest *O/S* quintile stocks (which is the omitted group in the regression). This estimate is economically large and statistically significant. Other quintiles of *O/S* also show a statistically significant drop in BHAR relative to the top *O/S* quintile.

For comparison, we investigate the remaining sample of purchases that occur more than one month after the earnings announcement in column (3). The coefficient on *O/S:Q1* indicates that insider purchases in the lowest *O/S* quintile stocks earn a higher abnormal return of 2.646% than corresponding purchases in the highest *O/S* quintile. However, the number is not significant. None of the coefficients are significant, which suggests that BHAR after insider purchases made more than a month after earnings announcement cannot be distinguished with *O/S*.

5. The Effect of Uncertainty on Informed Trading in the Options Market

Our empirical findings link information competition for a stock with insiders' decisions to make informed or uninformed insider purchases. Models of informed trading in the options market (Easley et al., 1998) imply that information asymmetry leads some informed investors to choose the options market over the stock market. Therefore, the informativeness of *O/S* would be higher among stocks with high information asymmetry, consistent with hypothesis #3 outlined at the beginning of Section 3.

Previous literature also documents some empirical evidence that the informativeness of insider trading activities varies with the information environment. Frankel and Li (2004) document that insider trades are less informative with more extensive analyst following and more informative financial statements. Lakonishok and Lee (2001) document higher abnormal returns following insider purchases among small stocks. However, Heath, Huddart, and Lang (1999) systematically examine the relation between various information environment proxies and the informativeness of insider trades, and find that the empirical evidence is mixed at best.

With this backdrop, we investigate whether the role of option volume in signaling the informativeness of insider purchases will be more prevalent for stocks with more uncertainty or during periods of high uncertainty. We first start with cross-sectional analyses – examining another set of potentially informed investors and a stock-level volatility measure – and continue with a time-series analysis examining the time variation of market-level volatility measure.

5.1. Cross-sectional Analysis: Institutional Ownership

We first posit that options traders are likely to face a lower level of competition for information in stocks with lower fractions of institutional ownership. We also expect that these stocks have more pronounced information asymmetry in general. Therefore, we expect the role of *O/S* in marking the informativeness of insider purchases to be more pronounced among these

stocks. In particular, we hypothesize that the negative relation between *O/S* and the informativeness of insider purchases will be more pronounced among stocks with a lower level of institutional ownership. Institutional ownership (*IO*) is measured as the total number of shares held by 13F-filing institutions in the most recent quarter divided by the total number of shares outstanding. A low value of *IO* represents higher information asymmetry and lower competition for informed trading.

Panel A in Table 9 reports the alphas for calendar time portfolios constructed based on insider purchases and *O/S*, conditional on institutional ownership (*IO*). Stocks with net insider purchases in week *t* are included in a portfolio for the next 26 weeks (*t*+1 to *t*+26). In each calendar week, these stocks are first divided into two groups based on median *IO* in week *t,* i.e., the insider purchase week. Within each *IO* group, stocks are further divided into quintiles based on *O/S*, and equal-weighted portfolios are constructed.

[Table 9]

In the column "Low *IO*" of Table 9, we restrict our sample to stocks whose *IO* is below the cross-sectional median. In this subsample, we find a stronger effect of *O/S* in identifying informed insider purchases: stocks earn weekly alpha of 0.25% (*t*-stat=3.21) when there were insider purchases accompanied by low *O/S*. Following insider purchases with high *O/S* in this subsample, the average weekly alpha is 0.04%. The difference in weekly alphas of 0.21% is economically large and statistically significant (*t*-stat=3.45). For a sample of stocks with above-median *IO* (column "High *IO*"), on the other hand, the spread in alphas between the low and high *O/S* is relatively small at 0.10% and is not statistically significant (*t*-stat=1.43). This pattern highlights the importance of *O/S* in distinguishing informed and uninformed insider purchases when there is less active competition for informed trading.

5.2. Cross-sectional Analysis: Option-implied Volatility

We also expect that options trading is more beneficial in marking informed insider purchases for the stock with high uncertainty. To capture (future) uncertainty, we use a measure also derived from the options market, i.e., the implied volatility of option prices. The option-implied volatility is extracted from OptionMetrics Volatility Surface, which provides the interpolated value of implied volatility with specified maturity and delta. Specifically, we choose ATM (delta=0.5) call and put options with 30 days to maturity and take the average of the two. Examining the option-implied volatility measure offers a distinct advantage over our previous analysis of institutional ownership: the former is likely to capture future uncertainty in a forward-looking manner.

Stocks with insider purchases during week t are included in a calendar time portfolio from week t+1 to t+26. For each calendar week, these stocks are first divided into a high and low group based on the cross-sectional median of option-implied volatility measured on the last day in week t, i.e., the insider purchase week. Within each group, they are further divided into quintiles based on *O/S* measured from t−4 to t−1. We investigate the Fama-French five-factor alphas of each equal-weighted calendar time portfolio.

Panel B in Table 9 reports the alphas of these portfolios in the high (low) option-implied volatility group. The results in column "High Vol Stocks" indicate that *O/S* provides a strong complementary signal on insider purchases when uncertainty is high. Insider purchases accompanied by low option volume generate a large abnormal return of 0.25% per week (t-stat=3.06). When option volume is high around the insider purchases, the abnormal return diminishes to practically zero (−0.02%; t-stat=−0.27), resulting in a difference in weekly alphas of 0.27% (t-stat=3.38). In the low volatility group (column "Low Vol Stocks"), insider purchases accompanied by low option volume generate an abnormal return of 0.07% per week,

which is considerably smaller in magnitude relative to the corresponding abnormal return in the high volatility group (0.25%). This result indicates that options trading volume is particularly meaningful in identifying informative insider purchases when the stock experiences more uncertainty.

5.3. Time-series Analysis: VIX

In addition to cross-sectional variation in uncertainty, we also expect that the usefulness of option volume in identifying informative insider purchases varies with the level of market volatility. We again use a volatility measure from option prices, in this case, the CBOE VIX. In each calendar week *t*, we calculate the 26-week trailing average VIX ($\overline{\text{VIX}}$) using the daily VIX from week *t*−26 to *t*. To avoid look-ahead bias, we categorize each week as a high VIX period if this trailing $\overline{\text{VIX}}$ average exceeds the median of the $\overline{\text{VIX}}$ over the previous 12 months.

Similar to our previous analyses, in each calendar week, we construct an *O/S*-based long-short strategy for stocks with insider purchases. We compare the risk-adjusted returns of this strategy during the high VIX periods and the remaining low VIX periods. It is important to note that our calendar-time portfolios include stocks with insider purchases during the past 26 weeks. Therefore, we use the high/low VIX designation of each week based on the trailing 6-month average of daily VIX, which includes the insider purchase week.

Table 9 Panel C reports the alphas for each calendar-time portfolio during the high and low uncertainty periods, together with the difference. The difference in alpha between the high and low *O/S* groups is larger when the $\overline{\text{VIX}}$ is high relative to its past median (0.25%) than when the $\overline{\text{VIX}}$ is low relative to its past median (0.19%).

6. Conclusion

In this paper, we develop a novel approach to utilize the options market as an effective screening mechanism to identify informative insider trades and quantify the information value of corporate insider trades. Our results indicate that the information value of insider trades is curtailed in the presence of other informed traders, particularly in the options market. Insider purchases are less frequent in stocks with relatively high options trading activity, and these less frequent insider trades are associated with negligible abnormal monthly returns.

Our results also indicate that corporate insider purchases have information value, particularly for stocks with less active informed traders. In particular, we find that less active trading activities in the options market signal scarce competition for private information by potentially informed outside investors, which in turn increases the information value and frequency of insider purchases. The usefulness of options trading activity in identifying informed insider purchases is heightened during periods after earnings announcements and when we focus on opportunistic purchases. Furthermore, the relation between insider purchases and option trading activity largely attenuates after RegFD, suggesting the information competition as a main channel that explains our result.

Our analysis also highlights that the negative relation between option volume and future stock returns manifests predominantly among stocks with insider purchases. This reflects the asymmetry in trading costs between buying and selling, i.e., the competition to exploit positive private information is more intense with the lower cost of buying vs. shorting stocks. Lastly, our results provide a tractable approach to identify informed purchases of corporate insiders, which may be incorporated into the detection procedure of fraudulent or manipulative insider trades.

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Figure 1. Frequency of Insider Purchases and *O/S*: Long-run Analysis

This figure reports the odds ratio on *O/S* from panel logit regressions predicting net insider purchases in month *t*+*i* (*i*=1⋯12) using *O/S* in month *t*. The regression specification is identical to Column 1 in Table 2. *O/S* of a stock in month *t* is defined as the number of option contracts on that underlying stock that are traded in month *t*, divided by the total number of shares traded on that stock in month *t*. The dependent variable is a dummy variable that takes a value of one if there is a net insider purchase in month *t*+*i* and zero otherwise. A solid line reports odds ratio on *O/S*. Dashed lines report 95% confidence interval.

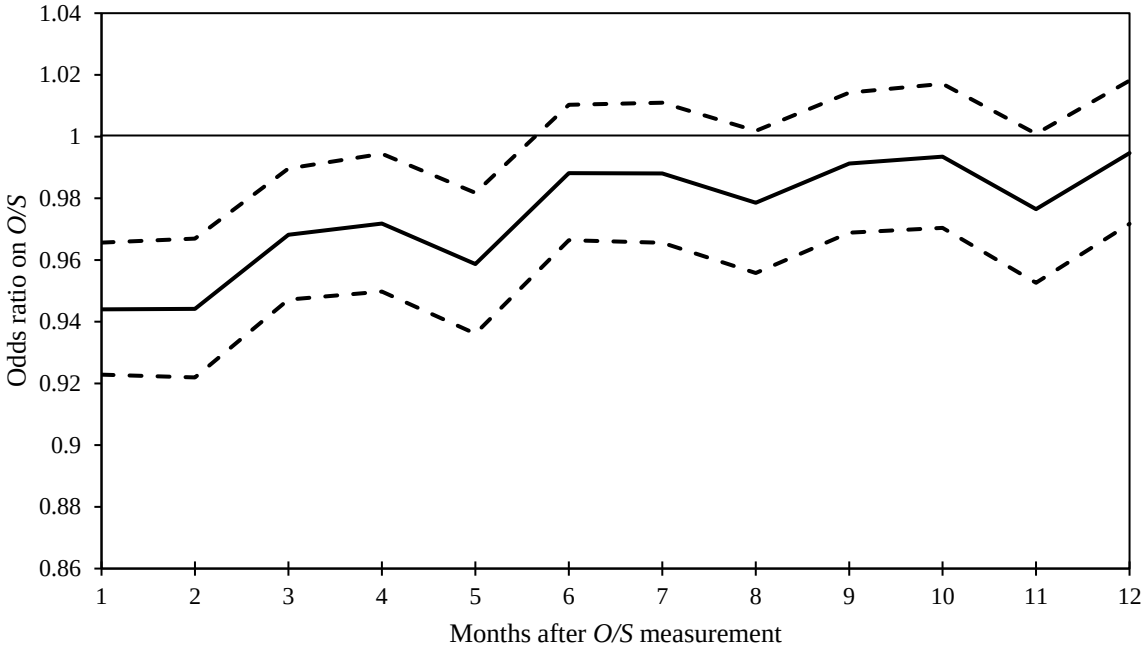


Figure 2. BHAR after Insider Purchases

This figure reports the buy-and-hold abnormal returns (BHAR) calculated using weekly returns over 26 weeks (i.e., 6 months) following net insider purchases. A stock's BHAR is defined as its cumulative raw return minus its corresponding benchmark portfolio's cumulative raw return. To construct a benchmark portfolio, we sequentially group stocks into quintiles based on size, book-to-market ratio, and past 12-month return, which results in 5×5×5 = 125 equal-weighted portfolios. A particular stock's benchmark portfolio is one of the 125 portfolios to which the stock belongs. Week 0 indicates the net insider purchase week.

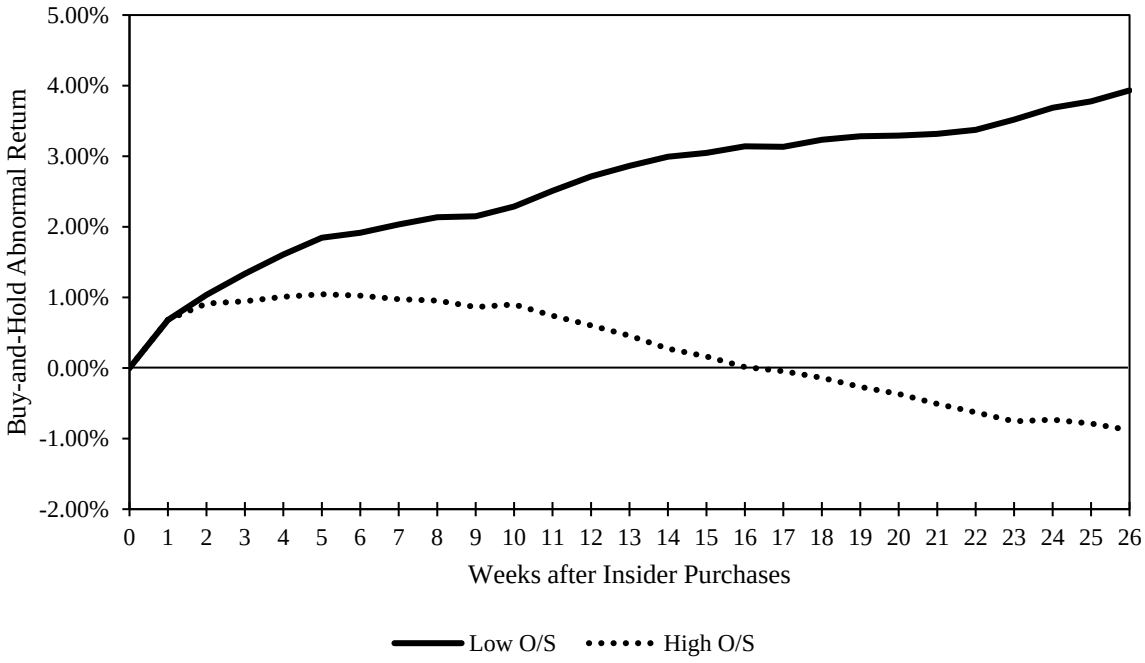


Figure 3. CAR around Earnings Announcements after Insider Purchases

This figure reports the cumulative abnormal return (CAR) around the first earnings announcement after insider purchases. For each stock with an insider purchase, we assign it to the top or bottom *O/S* quintile based on the *O/S* measured during the four weeks preceding the insider purchase. We then calculate its CAR during the following earnings announcement period. This figure reports the average CAR for stocks in the bottom (solid line) and top (dashed line) *O/S* quintiles. CAR is defined as the cumulative sum of market-adjusted return (raw stock return minus CRSP value-weighted index return). Day 0 is the earnings announcement day.

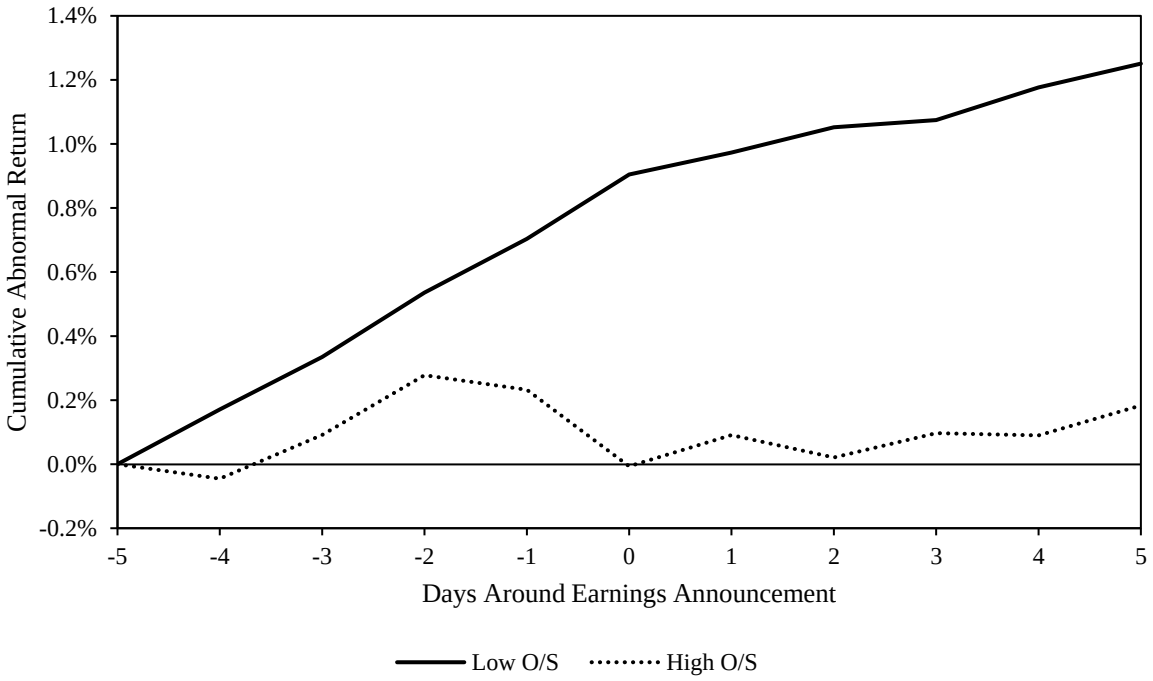


Table 1. Frequency of Insider Purchases, Stock Characteristics, and *O/S*.

This table reports the frequency of insider purchases among stocks in each *O/S* quintile. In each month *t*, stocks are grouped into quintiles based on *O/S* in month *t*. *O/S* of a stock in month *t* is defined as the number of option contracts on that underlying stock that are traded in month *t*, divided by the total number of shares traded on that stock in month *t*. The first row ('All') reports the average characteristics (including the fraction of stocks with net insider purchases) among all stocks. The rest of the table reports the average values of various stock characteristics in each *O/S* quintile. The stock characteristics include the fraction of stocks that experience net insider purchases in month *t*+1, as well as market beta (*Beta*), idiosyncratic volatility (*Ivol*), log of market equity (ln(*ME*)), lagged one-month stock return (lag(*Ret*)), lagged twelve-month stock return (*Momentum*), call-put implied volatility spread (*CPSpread*), and options order imbalance (*OOI*). The 'L−H' row reports differences in the values between the bottom and the top *O/S* quintiles. Newey-West corrected *t*-statistics with 6 lags are reported in parentheses.

	# of Stocks	*% of Net Insider Purchases*	*Beta*	*Ivol*	ln(*ME*)	lag(*Ret*)	*Momentum*	*CPSpread*	*OOI*
All	2,204	6.63	1.3143	0.0227	21.00	0.0095	0.1547	−0.0088	0.0041
Q1 (Lowest)	440	8.78	1.1472	0.0205	20.33	−0.0010	0.0315	−0.0003	0.0044
Q2	441	7.14	1.2338	0.0214	20.67	0.0063	0.0923	−0.0071	0.0075
Q3	441	6.33	1.3189	0.0227	20.91	0.0110	0.1443	−0.0094	0.0072
Q4	441	5.80	1.3982	0.0238	21.27	0.0143	0.2019	−0.0103	0.0045
Q5 (Highest)	441	5.07	1.4729	0.0248	21.80	0.0169	0.3073	−0.0163	0.0014
L−H		3.71	−0.3257	−0.0043	−1.47	−0.0179	−0.2758	0.016	0.0030
		(−8.89)	(−4.41)	(−4.96)	(−13.16)	(−5.07)	(−4.87)	(6.13)	(0.62)

Table 2. Frequency of Insider Purchases and *O/S*: Logit Regression

This table reports the odds ratio from panel logit regressions predicting net insider purchases in the next month (t+1) using *O/S* in month t. *O/S* of a stock in month t is defined as the number of option contracts on that underlying stock that are traded in month t, divided by the total number of shares traded on that stock in month t. The dependent variable is a dummy variable that takes a value of one if there is a net insider purchase in month t+1 and zero otherwise. Columns 2 through 4 use dummy variables, one for each of the *O/S* quintiles uniquely denoting membership to that *O/S* quintile. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5 (Highest Quintile)* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. All regressions control for various stock characteristics including the once-lagged value of the dependent variable. In column 3, we drop stocks with net insider purchases in month t, to focus on "fresh" insider purchases. In column 4, we include four dummy variables that indicate a positive sign of *CPSpread*, *OOI*, *OOI_C*, and *OOI_P*. Every independent variable is winsorized at the top and bottom 1%. ***, **, * represents statistical significance at 10%, 5%, and 1% confidence level, respectively, based on firm-clustered standard errors. Please see Appendix A for the full list of control variables.

	(1)	(2)	(3)	(4)
O/S	0.944***			
O/S:Q1 (Lowest Quintile)		1.350***	1.417***	1.270***
O/S:Q2		1.157***	1.212***	1.117***
O/S:Q3		1.088***	1.132***	1.066**
O/S:Q4		1.046*	1.071**	1.036
lag(*Net Purchase*)	4.985***	4.938***		4.910***
Beta	0.906***	0.910***	0.906***	0.914***
Ivol	1.006	1.022**	1.061***	1.003
ln(*ME*)	0.933***	0.950***	0.974	0.953***
lag(*Ret*)	0.734***	0.734***	0.708***	0.734***
lag(*Ret*)^2	1.064***	1.063***	1.050***	1.065***
Momentum	0.810***	0.809***	0.779***	0.801***
Momentum^2	1.113***	1.116***	1.131***	1.119***
Amihud	1.044***	1.034***	1.025***	1.033***
Positive(Cpspread)				1.030**
Positive(OOI)				0.989
Positive(OOI_C)				1.079***
Positive(OOI_P)				0.994
# of Observations	516,927	516,927	479,535	516,927
Pseudo R^2 (%)	7.66	7.75	2.88	7.86

Table 3. Frequency of Insider Purchases and *O/S*: Reduction in Informed Trading

This table reports the odds ratio from panel logit regressions predicting net insider purchases in the next month (t+1) using *O/S* in month t. *O/S* of a stock in month t is defined as the number of option contracts on that underlying stock that are traded in month t, divided by the total number of shares traded on that stock in month t. The dependent variable is a dummy variable that takes a value of one if there is a net insider purchase in month t+1 and zero otherwise. The main independent variables of interest are dummy variables, one for each of the *O/S* quintiles uniquely denoting membership to that *O/S* quintile. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5 (Highest Quintile)* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. In Panel A, to gauge the effect of Regulation Fair Disclosure implemented in October 2000, we restrict our sample periods from October 1999 to October 2001. The dummy variable *Post* takes a value of 1 for observations after October 2000. Then, *Post* is interacted with *O/S*. In Panel B, sample periods are from October 2008 to October 2010, based on the arrest of Raj Rajaratnam in October 2009. All regressions control for various stock characteristics described in Table 2. Every independent variable is winsorized at the top and bottom 1%. ***, **, * represents statistical significance at 10%, 5%, and 1% confidence level, respectively, based on firm-clustered standard errors. Please see Appendix A for the full list of control variables.

	Panel A: Regulation FD		Panel B: Raj Rajaratnam	
	(1)	(2)	(3)	(4)
O/S:Q1 (Lowest Quintile)	1.517***	1.723***	1.494***	1.640***
O/S:Q2	1.302***	1.446***	1.146*	1.297***
O/S:Q3	1.270***	1.360***	1.034	1.213**
O/S:Q4	1.162**	1.240**	1.029	1.096
O/S:Q1×Post		0.737***		0.802*
O/S:Q2×Post		0.788**		0.732**
O/S:Q3×Post		0.858		0.665***
O/S:Q4×Post		0.878		0.858
Post		0.756***		0.998
Stock Controls	Yes	Yes	Yes	Yes
# of Observations	47,545	47,545	52,292	52,292
Pseudo R^2 (%)	8.96	9.60	8.82	8.94

Table 4. Predicting Insider Purchases with *O/S* – After Earnings Announcements

This table reports the odds ratio from panel logit regressions predicting net insider purchase in the next month (t+1) using *O/S* in month *t,* conditional on whether the month t+1 is the month immediately following the firm's latest earnings announcement. *O/S* of a stock in month *t* is defined as the number of option contracts on that underlying stock that are traded in month *t*, divided by the total number of shares traded on that stock in month *t*. The dependent variable is a dummy variable that takes a value of one if there are net insider purchases in month t+1 and zero otherwise. The main independent variables of interest are dummy variables, one for each of the *O/S* quintiles uniquely denoting membership to that *O/S* quintile. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5 (Highest Quintile)* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. We interact these dummy variables with an indicator variable, *PostEA*, which takes the value of 1 for the month immediately following the earnings announcement, and zero otherwise. All regressions control for various stock characteristics described in Table 2. In column 2, we include four dummy variables that indicate a positive sign of *CPSpread*, *OOI*, *OOI_C*, and *OOI_P*. Every independent variable is winsorized at the top and bottom 1%. ***, **, * represents statistical significance at 10%, 5%, and 1% confidence level, respectively, based on firm-clustered standard errors. Please see Appendix A for the list of control variables.

	(1)	(2)
O/S:Q1 (Lowest Quintile)	1.280***	1.203***
O/S:Q2	1.133***	1.094***
O/S:Q3	1.058*	1.037
O/S:Q4	1.053	1.043
O/S:Q1 ×PostEA	1.172***	1.166***
O/S:Q2 ×PostEA	1.059	1.053
O/S:Q3 ×PostEA	1.072*	1.068
O/S:Q4 ×PostEA	0.984	0.982
PostEA	1.192***	1.203***
Stock Controls	Yes	Yes
Positive trading direction dummies	No	Yes
# of Obs.	516,927	516,927
Pseudo R^2 (%)	7.91	8.03

Table 5. Frequency of Opportunistic Insider Purchases and *O/S*

This table reports the odds ratio from panel logit regressions predicting opportunistic insider purchases in the next month (t+1) using *O/S* in month t. *O/S* of a stock in month t is defined as the number of option contracts on that underlying stock that are traded in month t, divided by the total number of shares traded on that stock in month t. The dependent variable is a dummy variable that takes a value of one if there was at least one opportunistic insider purchase in month t+1 and zero if there were only routine insider purchases in month t+1. Opportunistic and routine insider purchases are classified following Cohen et al. (2012). Columns 3 and 4 use dummy variables, one for each of the *O/S* quintiles uniquely denoting membership to that *O/S* quintile. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5 (Highest Quintile)* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. All regressions control for various stock characteristics described in Table 2. In columns 2 and 4, we include four dummy variables that indicate a positive sign of *CPSpread*, *OOI*, *OOI_C*, and *OOI_P*. Every independent variable is winsorized at the top and bottom 1%. ***, **, * represents statistical significance at 10%, 5%, and 1% confidence level, respectively, based on firm-clustered standard errors. Please see Appendix A for the list of control variables.

	(1)	(2)	(3)	(4)
O/S	0.948***	0.925***		
O/S:Q1 (Lowest Quintile)			1.257***	1.387***
O/S:Q2			1.092	1.152**
O/S:Q3			1.090*	1.121**
O/S:Q4			1.080	1.089*
Stock Controls	Yes	Yes	Yes	Yes
Positive trading direction dummies	No	Yes	No	Yes
# of Observations	49,504	49,504	49,504	49,504
Pseudo R^2 (%)	0.90	1.26	0.93	1.32

Table 6. Stock Returns after Insider Purchases – Sorted by Option Volume.

This table reports weekly alphas of calendar time portfolios constructed among stocks that had experienced net insider purchases, conditional on options trading volume. Stocks with net insider purchases in week *t* are included in the test portfolio for the next 26 weeks (*t*+1 to *t*+26). In each calendar week, stocks in the test portfolio are divided into quintiles based on the options trading volume during the four weeks preceding the insider purchase (*t*−1 to *t*−4). Equal-weighted quintile portfolios are formed and held until the next calendar week. We report the Fama-French five-factor alpha of each quintile portfolio (in percent) sorted by *O/S* and *ΔO/S* in Panel A. *O/S* of a stock is defined as the number of option contracts on that underlying stock that are traded during the four weeks before insider purchases, divided by the total number of shares traded on that stock in the same period. *ΔO/S* is defined as the percentage change in *O/S* relative to its past 12-month moving average (*pO/S*). The 'All' column in Panel A reports the average alphas of all stocks in the test portfolio. The 'L−H' column reports the difference in alphas between the bottom and the top *O/S* (or *ΔO/S*) quintile portfolios. In Panel B, stocks are sequentially sorted into quintiles firstly on the past level of *O/S* (*pO/S*) and secondly on *ΔO/S* in each calendar week. The 'Average' row at the bottom of the panel reports the alpha of each *ΔO/S* quintile averaged across five different *pO/S* quintiles. The 'L−H' column reports the difference in alphas between the bottom and the top *ΔO/S* quintiles, for each of the *pO/S* quintiles, as well as averaged across the *pO/S* quintiles in the last row. All numbers are in percentages. Newey-West corrected *t*-statistics with 26 lags are reported in parentheses. An average number of unique stocks in each portfolio is reported in brackets.

Panel A: Univariate sort

	All	Q1 (Lowest)	Q2	Q3	Q4	Q5 (Highest)	L−H
O/S	0.09 (1.92) [699]	0.20 (3.44) [163]	0.08 (1.62) [190]	0.07 (1.36) [198]	0.08 (1.72) [193]	0.01 (0.16) [170]	0.19 (3.50)
ΔO/S	0.08 (1.81) [638]	0.21 (2.89) [161]	0.11 (2.14) [191]	0.06 (1.08) [200]	0.03 (0.81) [200]	0.02 (0.47) [181]	0.19 (3.57)

Panel B: Bivariate sort

		ΔO/S					
		Q1 (Lowest)	Q2	Q3	Q4	Q5 (Highest)	L−H
pO/S	Q1 (Lowest)	0.25 (2.88) [34]	0.14 (2.65) [40]	0.11 (2.80) [41]	0.11 (2.91) [41]	0.03 (0.65) [39]	0.22 (2.90)
	Q2	0.21 (2.38) [36]	0.07 (1.07) [41]	−0.02 (−0.35) [42]	−0.01 (−0.15) [42]	0.02 (0.42) [40]	0.19 (2.28)
	Q3	0.21 (2.82) [35]	0.16 (2.29) [41]	0.09 (1.42) [42]	0.04 (0.65) [42]	0.01 (0.11) [40]	0.21 (3.19)
	Q4	0.16 (1.78) [35]	0.16 (2.09) [41]	0.15 (2.16) [42]	0.06 (0.99) [42]	−0.02 (−0.30) [38]	0.18 (2.17)
	Q5 (Highest)	0.09 (1.16) [32]	0.08 (1.23) [39]	0.01 (0.17) [40]	0.02 (0.25) [41]	−0.02 (−0.27) [37]	0.11 (1.22)
	Average	0.19 (2.66)	0.12 (2.24)	0.07 (1.41)	0.04 (1.06)	0.00 (0.10)	0.18 (3.48)

Table 7. Stock Returns after Insider Purchases – Sorted by Option Volume and Options Trading Direction.

This table reports weekly alphas of calendar time portfolios constructed among stocks that had experienced net insider purchases, conditional on options trading volume and options trading direction. Stocks with net insider purchases in week *t* are included in the test portfolio for the next 26 weeks (*t*+1 to *t*+26). In each calendar week, stocks in the test portfolio are sorted into two groups based on the sign of options trading direction proxies. Then, stocks are further divided into quintiles based on *O/S* measured during the four weeks preceding the insider purchases (*t*−1 to *t*−4). Equal-weighted portfolios are formed and held until the next calendar week. We report the Fama-French five-factor alpha of each portfolio (in percent). In Panel A, we use call-put implied volatility spread (*CPSpread*) as a proxy for options trading direction. In Panel B, we use option order imbalance (*OOI*) as a proxy for options trading direction. A positive sign of *OOI* indicates that the trading volume on long call and short put option positions exceeds that on short call and long put option positions. Panel C and D use call option order imbalance (*OOI_C*) and put option order imbalance (*OOI_P*). The 'L−H' column reports the difference in alphas between the bottom and the top *O/S* quintiles, for each trading direction group. All numbers are in percentages. Newey-West corrected *t*-statistics with 26 lags are reported in parentheses.

		O/S					
		Q1 (Lowest)	Q2	Q3	Q4	Q5 (Highest)	L−H
Panel A: Cpspread							
Cpspread	Negative	0.13 (3.02)	0.05 (1.10)	0.04 (0.79)	0.07 (1.61)	−0.04 (−0.73)	0.16 (3.18)
	Positive	0.23 (3.62)	0.11 (1.83)	0.12 (1.97)	0.13 (2.10)	0.09 (1.39)	0.13 (2.12)
Panel B: Option order imbalance							
OOI	Negative	0.17 (3.91)	0.07 (1.15)	0.09 (1.28)	0.06 (1.07)	−0.24 (−3.91)	0.41 (6.46)
	Positive	0.16 (2.47)	0.11 (1.90)	0.09 (1.38)	0.04 (0.82)	−0.05 (−0.74)	0.20 (3.22)
Panel C: Call option order imbalance							
OOI_C	Negative	0.18 (4.46)	0.08 (1.46)	0.11 (1.82)	0.08 (1.21)	−0.19 (−3.68)	0.37 (6.03)
	Positive	0.15 (2.19)	0.05 (0.70)	0.10 (1.49)	0.03 (0.49)	−0.10 (−1.30)	0.25 (3.78)
Panel D: Put option order imbalance							
OOI_P	Negative	0.13 (2.12)	0.07 (0.95)	0.09 (1.40)	−0.01 (−0.10)	−0.19 (−2.78)	0.32 (5.41)
	Positive	0.17 (3.38)	0.10 (1.69)	0.06 (1.00)	0.08 (1.38)	−0.10 (−1.91)	0.27 (4.18)

Table 8. Stock Returns after Insider Purchases: *O/S* and Earnings Announcements.

This table reports the results of panel regressions of BHAR on *O/S* among stocks with net insider purchases. The dependent variable is the buy-and-hold abnormal return (in percent) for 26 weeks following the week of net insider purchases. Buy and hold abnormal return of a stock is defined as the stock's 26-week cumulative raw return minus a benchmark portfolio's 26-week raw return. To construct a benchmark portfolio, we sequentially group stocks into quintiles based on size, book-to-market ratio, and past 12-month return, which results in 5×5×5 = 125 equal-weighted portfolios. A particular stock's benchmark portfolio is one of the 125 portfolios to which the stock belongs. The main independent variables of interest are dummy variables, one for each of the *O/S* quintiles uniquely denoting membership to that *O/S* quintile. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5 (Highest Quintile)* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. In column 1, we investigate the full sample of observations following insider purchases. In column 2, we restrict the sample to stocks whose insider purchases occur within the four weeks following their most recent earnings announcements. In column 3, we investigate the remaining sample of stocks with net insider purchases, but whose insider purchases do not occur in the four weeks following their most recent earnings announcements. In column 4, we report the p-values for chi-square tests to examine if the coefficients in columns 2 and 3 are different from each other. All regressions control for various stock characteristics described in Table 2. We also include four dummy variables that indicate a positive sign of *CPSpread*, *OOI*, *OOI_C*, and *OOI_P*. Each independent variable is winsorized at the top and bottom 1% and then standardized using its cross-sectional mean and standard deviation. ***, **, * represents statistical significance at 10%, 5%, and 1% confidence level, respectively, based on firm-clustered standard errors. All numbers are in percentages. Please see Appendix A for the list of control variables.

	All stocks with net insider purchases	Insider purchases in the month after EA	Other insider purchases	Significance of difference (2) vs. (3)
	(1)	(2)	(3)	(4)
O/S:Q1 (Lowest Quintile)	3.401***	3.609***	2.646	
O/S:Q2	2.295**	2.819***	1.285	
O/S:Q3	1.701*	2.207**	0.624	
O/S:Q4	1.748*	2.043**	1.347	
Stock Controls	Yes	Yes	Yes	
Positive trading direction dummies	Yes	Yes	Yes	
# of Observations	50,438	33,419	16,971	
Adj. R^2 (%)	0.60	0.76	0.35	

Table 9. Stock Returns after Insider Purchases: Cross-sectional and Time-series Variation.

This table reports weekly alphas of calendar time portfolios constructed among stocks that had experienced net insider purchases, conditional on options trading volume and uncertainty. Stocks with net insider purchases in week *t* are included in the test portfolio for the next 26 weeks (*t*+1 to *t*+26). In Panel A, in each calendar week, stocks in the test portfolio are sorted into two groups based on institutional ownership. The Low (High) group includes stocks whose institutional ownership is below (above) its cross-sectional median. Then, stocks are further divided into quintiles based on *O/S* measured during the four weeks preceding the insider purchases (*t*−1 to *t*−4). Equal-weighted portfolios are formed and held until the next calendar week. We report the Fama-French five-factor alpha of each portfolio (in percent). The 'All' row reports the average alpha of all stocks in each institutional ownership group. For brevity, we report alphas of only the lowest and highest *O/S* quintiles. The 'L−H' row reports the difference in alphas between the lowest and highest *O/S* quintiles. The 'H−L' column reports the difference in alphas between the high and low institutional ownership groups. In Panel B, we replicate Panel A by sorting stocks on implied volatility instead of institutional ownership. In Panel C, in each week, stocks are divided into quintiles based on *O/S* similar to Table 6. We report average Fama-French five-factor alphas in the low and high VIX period (in percent). Low (High) period includes months whose 6-month trailing VIX is below (above) its past 12-month average. The 'All' row reports the average alpha of all stocks in each VIX period. The 'H−L' column reports the difference in alphas between the high and low VIX periods. All numbers are in percentages. Newey-West corrected *t*-statistics with 26 lags are reported in parentheses.

Panel A: Institutional Ownership

	Low IO Stocks	High IO Stocks	H−L
All	0.12 (2.27)	0.08 (1.69)	0.04 (1.53)
Q1: Lowest *O/S*	0.25 (3.21)	0.12 (2.59)	0.13 (2.09)
Q5: Highest *O/S*	0.04 (0.75)	0.02 (0.33)	0.02 (0.35)
L−H	0.21 (3.45)	0.10 (1.43)	0.11 (1.36)

Panel B: Option-implied Volatility

	Low Vol Stocks	High Vol Stocks	H−L
All	0.03 (1.23)	0.13 (1.90)	−0.09 (−1.84)
Q1: Lowest *O/S*	0.07 (2.31)	0.25 (3.06)	−0.18 (−2.49)
Q5: Highest *O/S*	−0.01 (−0.16)	−0.02 (−0.28)	0.01 (0.23)
L−H	0.08 (2.13)	0.27 (3.38)	−0.19 (−2.26)

Panel C: VIX

	Low VIX Periods	High VIX Periods	H−L
All	0.09 (2.15)	0.12 (1.97)	0.03 (0.70)
Q1: Lowest *O/S*	0.20 (3.96)	0.26 (3.28)	0.07 (1.39)
Q5: Highest *O/S*	0.01 (0.17)	0.01 (0.10)	0.01 (0.17)
L−H	0.19 (3.98)	0.25 (3.34)	0.07 (1.47)

Appendix A: Variable Definitions

Definition of Stock and Option Control Variables

Market beta (*Beta*): Sum of three betas estimated from the equation below using the past 6-month daily individual/market return data.

$$r_{i,d} = \alpha_i + \beta_{1,i} r_{M,d} + \beta_{2,i} r_{M,d-1} + \beta_{3,i} r_{M,d-2} + \varepsilon_{i,d}$$

At least 50 valid daily observations are required.

Idiosyncratic volatility (*Ivol*): Standard deviation of residuals from the daily return regression during month *t* of the following equation.

$$r_{i,d} = \alpha_i + \beta_{1,i} r_{M,d} + \beta_{2,i} r_{M,d-1} + \beta_{3,i} r_{M,d-2} + \varepsilon_{i,d}$$

Size (*ME*): Share price times the number of shares outstanding at the end of week *t*

Momentum: Cumulative returns during the past 1-year, skipping the most recent month following Jegadeesh and Titman (1993)

Amihud: Following Amihud (2002), we scale the absolute value of daily return by daily dollar trading volume and then take the average during the month.

Call-put implied volatility spread (*CPspread*): Difference in call and put option implied volatility at the last trading day of week *t*. Implied volatility is extracted from OptionMetrics volatility surface data with a delta of 0.5 and an expiration of 30 days following Cremers and Weinbaum (2010) and An et al. (2014).

Option order imbalance (*OOI*): Trading volume on long call and short put option position minus trading volume on short call and long put option position divided by the sum of the two. Trading volume on a given position is defined as the total number of contracts traded in a given option position for a given stock.

Call option order imbalance (*OOI_C*): Trading volume on long call option position minus trading volume on short call option position divided by the sum of the two. Trading volume on a given position is defined as the total number of contracts traded in a given option position for a given stock.

Put option order imbalance (*OOI_P*): Trading volume on short put option position minus trading volume on long put option position divided by the sum of the two. Trading volume on a given position is defined as the total number of contracts traded in a given option position for a given stock.

Table A1. Stock Returns after Insider Trades and Option Volume: Other Insider Trades

This table reports weekly alphas of calendar time portfolios constructed among stocks that had experienced net insider sales and no insider trades, conditional on options trading volume. Stocks with insider trades (or non-trades) in week t are included in the test portfolio for the next 26 weeks (t+1 to t+26). In each calendar week, stocks in the test portfolio are divided into quintiles based on the options trading volume during the four weeks preceding the insider trades (t−1 to t−4). Equal-weighted quintile portfolios are formed and held until the next calendar week. We report the Fama-French five-factor alpha of each quintile portfolio (in percent) sorted by *O/S* and *ΔO/S*, respectively. *O/S* of a stock is defined as the number of option contracts on that underlying stock that are traded during the four weeks before insider trades, divided by the total number of shares traded on that stock in the same period. *ΔO/S* is defined as the percentage change in *O/S* relative to its past 12-month moving average. The 'All' column reports the average alphas of all stocks in the test portfolio. The 'L−H' column reports the difference in alphas between the bottom and the top *O/S* (or *ΔO/S*) quintile portfolios. All numbers are in percentages. Newey-West corrected t-statistics with 26 lags are reported in parentheses.

	All	Q1 (Lowest)	Q2	Q3	Q4	Q5 (Highest)	L−H
Panel A: Net Insider Sales							
O/S	0.03	−0.02	−0.01	0.05	0.06	0.08	−0.09
	(1.75)	(−0.60)	(−0.27)	(2.26)	(2.32)	(2.34)	(−2.06)
ΔO/S	0.03	0.03	0.02	0.03	0.03	0.03	0.00
	(1.57)	(0.84)	(0.89)	(1.44)	(1.71)	(1.35)	(−0.03)
Panel B: No Insider Trades							
O/S	0.00	0.02	−0.01	−0.01	0.01	−0.02	0.04
	(−0.05)	(0.49)	(−0.46)	(−0.15)	(0.41)	(−0.58)	(0.92)
ΔO/S	0.00	0.05	0.02	0.00	−0.01	−0.03	0.08
	(0.12)	(0.99)	(0.43)	(−0.07)	(−0.50)	(−2.02)	(2.11)

Table A2. Stock Returns after Insider Purchases – Sorted by Option Volume

This table reports weekly returns of calendar time portfolios constructed among stocks that had experienced net insider purchases, conditional on options trading volume. Stocks with net insider purchases in week *t* are included in the test portfolio for the next 26 weeks (*t*+1 to *t*+26). In each calendar week, stocks in the test portfolio are divided into quintiles based on the *O/S* measured from week *t*−1 to *t*−4. Then, equal-weighted quintile portfolios are formed and held until the next calendar week. We report the excess return (excess of risk-free rate), market-adjusted return, and Fama-French six-factor alpha of each quintile portfolio. The 'All' column reports the average returns of all stocks in the test portfolio. The 'L−H' column reports the difference in returns between the bottom and the top *O/S* quintile portfolios. All numbers are in percentages. Newey-West corrected *t*-statistics with 26 lags are reported in parentheses.

	All	Q1 (Lowest)	Q2	Q3	Q4	Q5 (Highest)	L−H
Excess	0.29	0.42	0.30	0.29	0.28	0.15	0.26
	(2.80)	(3.87)	(2.90)	(2.79)	(2.59)	(1.40)	(3.78)
MAR	0.14	0.27	0.16	0.15	0.13	0.01	0.26
	(2.54)	(3.64)	(2.56)	(2.32)	(2.34)	(0.20)	(3.78)
FF5+Momentum	0.13	0.24	0.12	0.11	0.13	0.05	0.19
	(4.09)	(5.76)	(3.47)	(3.14)	(3.65)	(1.02)	(3.37)

Appendix B: Additional Analysis

B.1. Information Content of Insider Trading Intensity

The information content of insider trades tends to be more prominent when the trading intensity is higher (Lakonishok and Lee, 2001). Hence the effect of *O/S* in identifying informed insider purchases should be stronger among stocks with a larger amount of insider purchases. To operationalize this analysis, we follow Cohen, Malloy, and Pomorski (2012) and define insider purchase intensity as the total dollar amount of net insider purchases during the week divided by market capitalization at the end of the week.

In Table B1, we report the alphas of calendar time portfolios double sorted by insider purchase intensity and *O/S*. In each calendar week, stocks with insider trading in the last 26 weeks are independently divided into quintiles based on purchase intensity (from "Weak" to Strong") and *O/S* (from "Low" to "High") before the insider purchase week. The table reports the Fama-French five-factor alphas of these quintile portfolios and their intersections. First, consistent with Lakonishok and Lee (2001), the alphas after insider purchases increase monotonically with insider purchase intensity: from 0.01% in the "Weak" purchase quintile to 0.14% in the "Strong" purchase quintile.

The role of *O/S* in identifying informative purchases also increases with purchase intensity. Among stocks experiencing the strongest insider purchase intensity, the average alpha is 0.35% in the lowest *O/S* quintile and decreases to −0.02% in the highest *O/S* quintile. Moreover, the positive relation between future return and the intensity of insider purchases manifests exclusively among stocks with low *O/S*. The column "Strong minus Weak (S−W)" reports differences in alphas between the strong and weak insider purchase intensity quintiles. The S−W difference in weekly alphas is a substantial 0.30% (*t*-stat=3.22) among stocks in the lowest *O/S* quintile. However, among stocks in the top *O/S* quintile, the S-W difference in

weekly alpha is insignificant at 0.04% per week.

B.2. Opportunistic Insider Sales and *O/S*

Insider sales are mostly driven by diversification needs, and they are typically not informative of future stock returns (Lakonishok and Lee, 2001). However, recent studies including Cohen et al. (2012) and Biggerstaff, Cicero, and Wintoki (2020) propose a few approaches to identify insider sales that are likely to be informed. Therefore, we aim to examine the link between informed insider sales and the *O/S* measure.

In our context, we posit that informed insider sales may be only weakly related to past option trading activity due to the asymmetry in trading costs between buying and shorting underlying stocks. Informed trading in the options market on positive information is likely to be propagated immediately onto the underlying stock price as option market-makers would hedge their option positions by purchasing stocks with negligible transaction costs. However, informed trading in the options market on negative information may propagate more slowly onto the underlying stock price due to short selling constraints (Johnson and So, 2012). In other words, high *O/S* is likely to be a better indicator of the underlying stock's price informativeness for positive news rather than negative news. Therefore, we posit a weaker relation between informed insider sales and *O/S*, relative to that between insider purchases and *O/S*.

We identify informed insider sales following the methodology proposed by Cohen et al. (2012) to identify opportunistic insider sales. We designate such opportunistic sales as informed insider sales. Conditional on the stock experiencing net insider sales in month t+1, we examine whether there are any opportunistic insider sales during that month as a function of *O/S* measured during month t. Across four different specifications in Table B2, we observe some evidence that scant option trading leads to a higher occurrence of opportunistic sales. For

example, in column (3), stocks in the bottom *O/S* quintile have 8.3% higher odds of experiencing at least one opportunistic sale in the next month, relative to stocks in the top *O/S* quintile. However, this magnitude is much lower than that for insider purchases (25.7%) and is only marginally significant (with a *t*-stat of 1.68).

We also observe weak evidence that opportunistic sales with low *O/S* are followed by lower stock returns than opportunistic sales with high *O/S*. Table B3 reports weekly alphas for calendar time portfolios constructed among stocks that had experienced opportunistic insider sales, conditional on *O/S* and change in *O/S* (*ΔO/S*), respectively. The weekly alphas after opportunistic insider sales increase from −0.02% for the low *O/S* group to 0.06% for the high *O/S*. The difference of 0.08% is less than half of the difference observed in the univariate analysis for insider purchases in Table 6. The difference is even smaller when we sort stocks into quintiles based on *ΔO/S*, with practically no evidence of increasing return with respect to option trading activity. In sum, we conclude that option trading activity is more strongly related to insider purchases rather than insider sales.

Table B1. Stock Returns after Insider Purchases: *O/S* and Insider Purchase Intensity

This table reports weekly alphas of calendar time portfolios constructed among stocks that had experienced net insider purchases, conditional on options trading volume and insider purchase intensity. Stocks with net insider purchases in week t are included in the test portfolio for the next 26 weeks (t+1 to t+26). For these net insider purchases, the purchase intensity is defined as the total dollar value of net shares purchased in week t divided by firm size at the end of week t. In each calendar week, stocks are independently divided into quintiles based on their insider purchase intensity and *O/S* measured from week t−1 to t−4. Then, equal-weighted portfolios are formed and held until the next calendar week. We report the Fama-French five-factor alpha of each portfolio (in percent). The 'All *O/S*' row reports average alphas of quintile portfolios based only on insider purchase intensity, whereas the 'All Intensity' column reports the average alphas of quintile portfolios based only on *O/S*. The 'L−H' row reports differences in alphas between the lowest and highest *O/S* quintiles. The 'S−W' column reports differences in alphas between the top and bottom quintiles of insider purchase intensity. All numbers are in percentages. Newey-West corrected t-statistics with 26 lags are reported in parentheses.

	All	*Insider Purchase Intensity*					
	Intensity	Weak	2	3	4	Strong	S−W
All *O/S*		0.01 (0.45)	0.06 (1.32)	0.09 (1.80)	0.14 (2.21)	0.14 (2.26)	−0.13 (−2.52)
Low *O/S*	0.20 (3.44)	0.05 (1.29)	0.12 (2.25)	0.16 (3.00)	0.24 (2.94)	0.35 (3.79)	−0.30 (−3.22)
2	0.08 (1.62)	−0.02 (−0.58)	0.01 (0.28)	0.10 (1.79)	0.12 (1.73)	0.17 (2.40)	−0.19 (−3.05)
3	0.07 (1.36)	0.00 (−0.05)	0.10 (2.07)	0.09 (1.24)	0.14 (1.82)	0.02 (0.26)	−0.02 (−0.32)
4	0.08 (1.72)	0.03 (0.74)	0.04 (0.70)	0.12 (1.90)	0.08 (1.14)	0.16 (2.43)	−0.14 (−2.44)
High *O/S*	0.01 (0.16)	0.02 (0.39)	0.02 (0.37)	−0.02 (−0.35)	0.07 (1.01)	−0.02 (−0.27)	0.04 (0.48)
L−H	0.19 (3.50)	0.03 (0.55)	0.10 (1.56)	0.18 (3.28)	0.18 (2.31)	0.38 (3.33)	−0.34 (−2.85)

Table B2. Frequency of Opportunistic Insider Sales and *O/S*

This table reports the parameter estimates from panel logit regressions predicting opportunistic insider sales in the next month (t+1) using *O/S* in month t. *O/S* of a stock in month t is defined as the number of option contracts on that underlying stock that are traded in month t, divided by the total number of shares traded on that stock in month t. The dependent variable is a dummy variable that takes a value of one if there was at least one opportunistic insider sales in month t+1 and zero if there were only routine insider sales in month t+1. Opportunistic and routine insider sales are classified following Cohen et al. (2012). Columns 3 and 4 use dummy variables, one for each of the *O/S* quintiles uniquely denoting membership to that *O/S* quintile. *O/S:Q1*, for example, takes a value of one if a particular stock belongs to the lowest *O/S* quintile, and zero otherwise. *O/S:Q5 (Highest Quintile)* is left out, and therefore serves as the comparison benchmark for the other quintile dummies. All regressions control for various stock characteristics described in Table 2. In columns 2 and 4, we include four dummy variables that indicate a positive sign of *CPSpread*, *OOI*, *OOI_C*, and *OOI_P*. Every independent variable is winsorized at the top and bottom 1%. ***, **, * represents statistical significance at 10%, 5%, and 1% confidence level, respectively, based on firm-clustered standard errors. Please see Appendix A for the list of control variables.

	(1)	(2)	(3)	(4)
O/S	0.989	0.931***		
O/S:Q1 (Lowest Quintile)			1.083	1.348***
O/S:Q2			1.022	1.141***
O/S:Q3			0.959	1.014
O/S:Q4			0.979	1.003
Stock Controls	Yes	Yes	Yes	Yes
Positive trading direction dummies	No	Yes	No	Yes
# of Observations	163,126	163,126	163,126	163,126
Pseudo R^2 (%)	2.56	4.34	2.56	4.45

Table B3. Stock Returns after Opportunistic Insider Sales– Sorted by Option Volume

This table reports weekly alphas of calendar time portfolios constructed among stocks that had experienced opportunistic insider sales, conditional on options trading volume. Stocks with any opportunistic insider sales in week *t* are included in the test portfolio for the next 26 weeks (*t*+1 to *t*+26). In each calendar week, stocks in the test portfolio are divided into quintiles based on the options trading volume during the four weeks preceding the insider sales (*t*−1 to *t*−4). Equal-weighted quintile portfolios are formed and held until the next calendar week. We report the Fama-French five-factor alpha of each quintile portfolio (in percent) sorted by *O/S* and *ΔO/S,* respectively. *O/S* of a stock is defined as the number of option contracts on that underlying stock that are traded during the four weeks before insider sales, divided by the total number of shares traded on that stock in the same period. *ΔO/S* is defined as the percentage change in *O/S* relative to its past 12-month moving average. The 'All' column reports the average alphas of all stocks in the test portfolio. The 'L−H' column reports the difference in alphas between the bottom and the top *O/S* (or *ΔO/S*) quintile portfolios. All numbers are in percentages. Newey-West corrected *t*-statistics with 26 lags are reported in parentheses. An average number of unique stocks in each portfolio is reported in brackets.

	All	Q1 (Lowest)	Q2	Q3	Q4	Q5 (Highest)	L−H
O/S	0.03 (1.36) [591]	−0.02 (−0.77) [157]	−0.01 (−0.60) [173]	0.05 (1.77) [175]	0.05 (1.75) [164]	0.06 (1.62) [133]	−0.08 (−1.68)
ΔO/S	0.02 (0.93) [553]	0.01 (0.27) [166]	0.00 (0.20) [185]	0.03 (1.18) [183]	0.03 (0.98) [183]	0.02 (0.79) [168]	−0.02 (−0.39)