Journal of Banking and Finance 76 (2017) 65–73

Contents lists available at ScienceDirect

Journal of Banking and Finance

journal homepage: www.elsevier.com/locate/jbf

Insider trading, stock return volatility, and the option market's pricing of the information content of insider trading

Chin-Han Chiang[a], Sung Gon Chung[b,*], Henock Louis[c]

[a] The World Bank Group, 10 Marina Boulevard, Marina Bay Financial Center, Singapore 018983, Singapore
[b] Wayne State University, 5229 Cass Avenue, 112 Rands Annex, Detroit, MI 48202, United States
[c] Pennsylvania State University, 380 Business Building, University Park, PA 16802, United States

ARTICLE INFO

Article history:
Received 26 March 2015
Accepted 29 November 2016
Available online 29 November 2016

Keywords:
Insider trading
Stock return volatility
Option pricing
Earnings announcements

ABSTRACT

We find strong evidence that net insider selling is positively associated with future stock return volatility, consistent with insider selling increasing outside investors' uncertainty. The positive effect of net insider selling is significantly stronger when the volatility is measured around the earnings announcement. Apparently, option prices do not fully reflect the information content of insider trading for future volatility. More specifically, we find no evidence that option traders adjust the implied volatility for the insider trading effect in a timely manner. Consequently, net insider selling is significantly associated with future option straddle returns and delta neutral returns.

1. Introduction

We examine the association between insider trading and subsequent changes in stock return volatility, and the option market's pricing of the information content of insider trading for future volatility. Because of insiders' incentives to diversify their portfolios, they are likely to purchase their firms' stocks only when they have positive private information about the firms' future prospects.[1] Therefore, the information conveyed by insider purchases is generally clear and likely to reduce an outside investor's uncertainty about a firm's prospects. In contrast, while insiders can sell their firms' stocks when they have negative private information about the firms' prospects, they can also sell for several reasons unrelated to firm valuation. In particular, insiders can sell their firms' stocks for liquidity and/or portfolio diversification reasons. Therefore, the information conveyed by insider sales is generally ambiguous and could thus increase an outside investor's uncertainty about a firm's prospects. We posit that, at least, insider selling should reduce uncertainty less than insider purchases.

The empirical evidence is consistent with our conjecture. More specifically, we find a significantly positive (negative) association between insider sales (purchases) and subsequent changes in stock return volatility, resulting in a positive association between net insider selling and changes in stock return volatility. We conjecture that, if insider selling increases stock return volatility, the effect is likely to be stronger around earnings announcements. An earnings announcement is one of the most important corporate information events; it is relatively frequent and regular, and substantially increases stock return volatility. The level of uncertainty is generally the greatest before, and trading volume is generally the highest around, earnings announcements (Ni et al., 2008; Cao and Ou-Yang, 2009; Alldredge et al., 2011). Because the information content of insider selling is more ambiguous, investors would generally head into earnings announcements with relatively higher levels of uncertainty following insider selling than following insider purchases, and the heightened uncertainty associated with earnings announcements could amplify the volatility effect of insider trading. Accordingly, we find that the positive effect of net insider sales on stock price volatility is significantly stronger when volatility is measured around the earnings announcement.

A unique feature of options, relative to stocks, is that they allow investors to bet not only on the direction of stock price movements but also on future stock price volatility. Stein (1989) actually assimilates the option market to a speculative market in volatility, and Goyal and Saretto (2009) argue that "volatility misestimation is the most obvious source of options mispricing" (p. 310). We therefore examine whether option traders anticipate the implications of insider trading for future volatility. The evidence suggests that option

* Corresponding author.
E-mail addresses: chinhan.chiang@gmail.com (C.-H. Chiang), sgchung@wayne.edu (S.G. Chung), hul4@psu.edu (H. Louis).

[1] Insiders typically have their human capital as well as large shares of their financial capital tied to their firms. Therefore, they generally do not want to increase their holdings of their firms' stocks, unless they have private information indicating that the stocks will do well. In fact, Ofek and Yermack (2000) find that insiders routinely hedge their equity holdings by selling off shares following grants of stock options and restricted stocks.

http://dx.doi.org/10.1016/j.jbankfin.2016.11.027
0378-4266/

prices do not fully reflect the information content of insider trading for future volatility in a timely manner. More specifically, we find no evidence that the net insider selling effect is reflected in the implied volatility impounded in the one month at-the-money call and put option premiums immediately after the disclosure of insider trading. The net insider selling effect is reflected in the implied volatility only one month after the disclosure of insider trading, after the effect had already been realized in stock returns. The fact that actual stock price volatility increases but implied volatility does not seem to change in a timely manner suggests that option market participants do not properly incorporate the information content of insiders selling for future volatility into option prices. Supporting this inference, we also find a significantly positive association between net insider selling and future option straddle and delta neutral returns.

Our study makes several contributions to the insider trading and option literatures. It is the first to document a positive (negative) association between insider sales (purchases) and subsequent changes in a firm's stock return volatility. Du and Wei (2004) analyze the cross-country association between insider trading and stock market volatility. They argue that the value of private inside information is greater in an environment where stock prices are volatile. Accordingly, they find that countries with more prevalent insider trading have more volatile stock markets. Our analysis is different from theirs on two important dimensions. First, while they examine cross-country differences, we examine firm-level differences. Second, and more importantly, they do not distinguish between insider sales and insider purchases. They predict a positive association between volatility and insider trading in general, irrespective of the direction of the trade. We instead predict and document (1) a positive association between volatility and insider sales and (2) a negative association between volatility and insider purchases, resulting in a positive association between volatility and net insider selling.

To the best of our knowledge, our study is also the first to examine the option market's response to insider trades. Most prior studies focused on the stock market's response and generally find that insider trades are significantly associated with future stock returns (e.g., Lin and Howe, 1990; Rozeff and Zaman, 1988; Seyhun, 1988, 1998; Lakonishok and Lee, 2001; Fidrmuc et al., 2006). We document the effect of insider trades on subsequent stock return volatility and provide evidence suggesting that the insider trading volatility effect is not impounded into option prices in a timely manner. Moreover, option traders are generally believed to be more sophisticated investors than stock market investors (e.g., Amin and Lee, 1997; Easley et al., 1998; Cao et al., 2005; Pan and Poteshman, 2006; Chakravarty et al., 2004; Xing et al., 2010). However, a few recent studies question the superiority of option market investors (Lemmon and Ni, 2011; Alldredge et al., 2011; Choy and Wei, 2012; Milian, 2014). The evidence that, apparently, option traders do not efficiently process the information content of insider trading for future volatility contributes to this line of research.

The remainder of the paper is organized as follows. The next section describes the research design. Section 3 describes the data and provides relevant summary statistics. The results are reported in Section 4. Section 5 concludes.

2. Research design

2.1. The effect of insider trading on future stock return volatility

To analyze the effect of insider trading on future stock return volatility, we use the following regression model:

$$\begin{aligned}\Delta VOL_{it+1} &= \beta_0 + \beta_1 NET\_SALES_{it} + \beta_2 LNMV_{it} + \beta_3 BM_{it} \\ &+ \beta_4 LAGRET_{it} + \beta_5 EA_{it} + \beta_6 EA\_PRE_{it} + \text{year fixed effects}_{it+1} \\ &+ \text{industry fixed effects}_{it+1} + \varepsilon_{it+1} \end{aligned} \quad (1)$$

where ΔVOL is the difference in the log value of the annualized stock return volatility during Month $t+1$ and the annualized stock return volatility during Month $t-1$, with Month t being the month when insider trading is measured; *NET_SALES* is the number of shares sold minus the number of shares purchased by insiders and disclosed in Month t, scaled by the number of shares outstanding at the end of the month; *LNMV* is the natural log of the market capitalization at the end of Month *t; BM* is the book-to-market ratio at the end of Month *t; LAGRET* is the market-adjusted returns over the six months prior to Month *t; EA* is an indicator variable that takes the value one if Month $t+1$ has an earnings announcement and zero otherwise; *EA_PRE* is an indicator variable taking the value one if Month $t-1$ has an earnings announcement and zero otherwise.

We measure monthly realized volatility (*VOL*) as the standard deviation of the daily stock returns over a month and then annualize it. We compute monthly *NET_SALES* using the trades of officer-rank insiders, consistent with Skaife et al. (2013).[2] We use monthly aggregated insider trades because insiders often trade their companies' stocks over many days and prior insider trading studies generally measure insider trades over a certain period, such as a month or a quarter (e.g., Seyhun, 1998; Lakonishok and Lee, 2001; Frankel and Li, 2004; Jagolinzer et al., 2011; Chen et al., 2013). We conjecture that insider trading affects stock price volatility and test whether option prices reflect the potential insider trading effect on volatility. To ensure that the variables used in the two tests are measured consistently, following Goyal and Saretto (2009), we define insider trading using monthly windows starting on the option expiration date (the third Saturday of the month).[3]

We control for market capitalization (*LNMV*) and book-to-market ratio (*BM*) because prior studies find a significant association between insider trades and these variables (see, e.g., Seyhun, 1998; Lakonishok and Lee, 2001; Jeng et al., 2003). Specifically, they find that insider purchases are more prevalent in small and value firms whereas insider sales are more prevalent in large and growth firms. Prior studies also find that insiders tend to be contrarian traders, who buy stocks after their prices have fallen and sell after their prices have increased. Accordingly, we control for the past six-month stock returns (*LAGRET*). The inclusion of *LAGRET* in the model is also intended to control for the potential effect of other information that might have been released before the insider trades. Stock return volatility increases before earnings announcements and decreases afterward. Therefore, the change in volatility would be positive if Month $t+1$ has an earnings announcement and negative if Month $t-1$ (the base month) has an earnings announcement. To control for the effect of earnings announcements on the change in the volatility, we include *EA* and *EA_PRE* in the model.

2.2. The effect of insider trading on option prices

We also test whether option prices reflect the potential insider trading effect on volatility. We conduct this analysis by examining whether the insider trading effect is reflected in the option implied volatility and whether insider trading is associated with future option straddle and delta neutral returns. To examine the

[2] All the results are qualitatively similar to those reported in the paper when we limit our definition of insider to the top five executives (Chief Executive Officer, Chief Financial Officer, Chief Operating Officer, President, and Chairman of the Board).

[3] Measuring insider trades and realized volatility using calendar months does not change our inferences.

potential effect of insider trading on the implied volatility, we replace the future change in volatility (ΔVOL) on the left-hand side of Model (1) by change in implied volatility (ΔIV), straddle returns, or delta neutral returns. If option traders expect net insider selling to induce future volatility, then we would expect them to respond to net insider selling by increasing the option implied volatility. If they do not fully respond to net insider selling, we expect to observe a positive association between net insider selling and straddle returns and delta neutral returns after the insider trading.

We define the change in implied volatility (IV) as the difference in the log values of the implied volatility measured at the beginning of Month $t+1$ (right after the insider trading disclosure window) and the implied volatility measured in Month $t-1$ (right before the insider trading disclosure window), with *IV* being the average implied volatility from one at-the-money (ATM) call and one ATM put options that expire at the end of Month $t+1$, the month after the insider trade disclosure window (Month t). Because ATM options are the most liquid options, their implied volatility is regarded as the most accurate measure of future realized volatility. Feinstein (1989) shows that implied volatility from ATM options with near expiration provide the closest estimation of the volatility over the life of the option.

To compute the straddle returns, we follow the method suggested by Goyal and Saretto (2009). Each month, on the first trading day (usually a Monday) after the month's option expiration date, we form straddles with one ATM call and one ATM put options that expire in the next month (on the third Saturday of the month). Given that perfect ATM options with moneyness of one is almost nonexistent, we use nearest-the-money options with the same strike on the straddle formation dates that have moneyness between 0.95 and 1.05. We establish the delta neutral position by purchasing one put option contract and the delta shares of the underlying stocks on the first trading date after the insider trade disclosure window.[4]

We use the same control variables as in Model (1), except that we do not include *EA_PRE* in the return regressions because *EA_PRE* is not relevant to the returns measured in Month $t+1$. In the change in implied volatility regression, we replace *EA_PRE* by *EA_PRE2*, an indicator variable taking the value one if Month t has an earnings announcement, and zero otherwise. We control for *EA_PRE2* because implied volatilities gradually increase prior to earnings announcements and decrease sharply afterward (Patell and Wolfson, 1979, 1981). Thus, if earnings are announced in Month t, Month $t-1$ will have a higher implied volatility, and the change in the implied volatility from Month $t-1$ to Month $t+1$ will be low.

3. Sample selection and descriptive statistics

3.1. Data

Our sample covers the period January 1996 to October 2010. We restrict the sample to this period because part of our analysis involves option data and we have access to option data only for this period. More specifically, we conjecture that insider trading affects stock price volatility and test whether option prices reflect the potential insider trading effect on volatility. We obtain option data from the OptionMetrics Ivy DB database. The dataset contains information on the entire U.S. equity option market, with strike prices, types of options, expiration dates, open interest, option trading volume, option prices, and option implied volatilities starting in January 1996.[5] We apply a series of filters to select the nearest-the-money options listed under each stock. We use only nearest-the-money options because they are the most liquid; this same practice is widely applied in the option literature. Further, we eliminate observations with bid prices smaller than 50 cents or larger than the ask prices. We also remove all observations with zero option open interest. We only consider options that have reported deltas. Finally, we restrict the sample to options that have moneyness (strike-to-stock price ratios) between 0.95 and 1.05, selecting for each stock the call option and the put option that are nearest-the-money.

We obtain insider trading data from the Thomson Reuters Insider Filings Data Feed (TRIFDF). Consistent with prior insider trading studies (e.g., Cheng and Lo, 2006; Marin and Olivier, 2008; Veenman, 2012), we use only open market purchases (transaction code P) and open market sales (transaction code S). We exclude small transactions involving fewer than 100 shares. We also eliminate transactions with reported transaction prices greater than 20% of the CRSP closing price on the day or those involving more than 20% of the number of shares outstanding (Lakonishok and Lee, 2001; Marin and Olivier, 2008). To minimize the effect of penny stocks and measurement errors, we use only stocks that have prices larger than $2 at the beginning of the calendar year.

We obtain stock returns from the Center for Research in Security Prices (CRSP) database. We use the Compustat database for information on the earnings announcement dates and the accounting variables used in the cross-sectional analysis.

3.2. Summary statistics

Panel A of Table 1 reports some relevant summary statistics. The average net insider sales (*NET_SALES*) is positive, which is consistent with the fact that insiders are more likely to sell than to buy shares of their companies. They generally receive the shares as part of their compensations. The percentage of shares sold (*SHARES_SOLD*) is much larger than the percentage of shares purchased (*SHARES_BOUGHT*): 0.313% vs. 0.002%. Untabulated statistics indicate that 29% of the sample firm-months have insider sales, whereas only 3.3% have insider purchases. The sample firms are relatively large. Their average market capitalization is $9542 million, compared to an average market capitalization of $2368 million for the COMPUSTAT universe over the same sample period. The sample firms tend to be large because we limit the sample to optioned firms and delete firms that have prices below $2.

Because we analyze the impact of earnings announcements on the association between insider trading and volatility, we condition the insider trading and change in volatility statistics on the timing of earnings announcements in Panel B of Table 1. We create an indicator variable, *EA*, that takes the value one if the month immediately after the insider trading month has an earnings announcement and zero otherwise. We label a firm-month an EA observation if *EA* is one and a non-EA observation if *EA* is zero. One third of the sample firms are EA observations, consistent with the fact that firms announce earnings every three months. The statistics are different across the EA and the non-EA observations. In particular, the EA observations have lower average *NET_SALES* than the non-EA observations, which is consistent with the fact that many firms allow unscheduled insider trading only after earnings announcements (e.g., Jeng, 1998; Bettis et al., 2000). However, we still observe a substantial amount of insider trading activity for the EA observations. The average *NET_SALES* is 0.231% and 0.349% of the number of shares outstanding for the EA and the non-EA observations, respectively. In terms of frequency, 23.8% (2.3%) of the EA

[4] We tabulate results using put options; however, we obtain similar results if we instead establish the delta neutral position by purchasing one call contract and shorting delta shares of the underlying stock.

[5] We end the sample in October 2010 because we do not have access to option data after this date.

Table 1
Summary statistics.
Panel A provides summary statistics for the full sample. In Panel B, the sample is divided into months with and months without earnings announcements (EA months vs. Non-EA months). We label a firm-month an EA observation if the month immediately after the insider trading month has an earnings announcement and a non-EA observation otherwise. *NET_SALES* is the number of shares sold minus the number of shares purchased by insiders and disclosed in Month t, scaled by the number of shares outstanding at the end of the month; *SHARES_SOLD* (*SHARES_BOUGHT*) is the number of shares sold (purchased) by insiders and disclosed in Month *t*, scaled by the number of shares outstanding at the end of the month; ΔVOL is the difference in the log value of the annualized daily stock return volatility (standard deviation) during Month $t+1$ and the annualized stock return volatility during Month $t-1$; ΔIV is the difference in the log values of the implied volatility measured at the beginning of Month $t+1$ (right after the insider trading disclosure window) and the implied volatility measured in Month $t-1$ (right before the insider trading disclosure window), with *IV* being the average implied volatility from one at-the-money (ATM) call and one ATM put options that expire at the end of Month $t+1$; *FV-IV* is the difference between the log value of the annualized future realized volatility in Month $t+1$ and the log value of the implied volatility computed from options purchased at the beginning of Month $t+1$; ΔFIV is the difference between the log values of the implied volatility measured at the beginning of Month $t+2$ (one month after the insider trading disclosure window) and the implied volatility measured at the beginning of Month $t+1$ (right after the insider trading disclosure window); *STRAD_RET* is the straddle return computed with one call and one put options purchased at the beginning of Month $t+1$ and expiring at the end of Month $t+1$; *DN_RET* is the delta neutral return in Month $t+1$, with the delta neutral position being established by purchasing one put option contract and the delta shares of the underlying stocks on the first trading date after the insider trade disclosure window; *EA* is an indicator variable that takes the value one if Month $t+1$ has an earnings announcement and zero otherwise; *LNMV* is the natural log of the market capitalization at the end of Month *t; BM* is the book-to-market ratio at the end of Month *t*; and *LAGRET* is the market-adjusted returns over the six months prior to Month *t*. The monthly window is defined relative to each calendar month's option expiration date (the third Saturday of the month). All the option-implied volatilities and returns are computed with options that have moneyness between 0.95 and 1.05. *NET_SALES, SHARES_SOLD*, and *SHARES_BOUGHT* are winsorized in the top and bottom 1 percentile given that we find some extreme outliers in the distributions.

Panel A: Full sample

Variable	Mean	Std. dev.	Lower quartile	Median	Upper quartile
NET_SALES	0.310	1.040	0.000	0.000	0.034
SHARES_SOLD	0.313	1.042	0.000	0.000	0.036
SHARES_BOUGHT	0.002	0.016	0.000	0.000	0.000
ΔVOL	0.004	0.456	−0.294	−0.011	0.292
ΔIV	0.003	0.165	−0.091	−0.006	0.083
STRAD_RET	−0.028	0.809	−0.627	−0.206	0.370
DN_RET	−0.003	0.093	−0.055	−0.017	0.031
EA	0.331	0.471	0.000	0.000	1.000
MV (in $ millions)	9542	26,288	912	2342	7317
LNMV	7.913	1.482	6.815	7.759	8.898
BM	0.380	0.336	0.188	0.319	0.501
LAGRET	0.105	0.541	−0.129	0.034	0.224

Panel B: Mean statistics: EA vs. non-EA observations

Variable	EA months	Non-EA months	*t*-Value for mean difference
NET_SALES	0.349	0.231	20.76
SHARES_SOLD	0.353	0.233	20.93
SHARES_BOUGHT	0.003	0.002	12.69
ΔVOL	−0.063	0.141	−83.50
ΔIV	−0.019	0.049	−52.28
STRAD RET	0.021	−0.052	16.45
DN RET	0.003	−0.005	15.62

observations and 31.5% (3.8%) of the non-EA observations have insider sales (purchases).

Stock return volatility is higher for the EA observations than for the non-EA observations. Consequently, the change in stock return volatility (ΔVOL) is positive for the EA observations and negative for the non-EA observations. *STRAD_RET* and *DN_RET* are significantly higher for the EA observations.

4. Results

We first report results on the effect of insider trading on future stock price volatility and then on whether option prices reflect the potential insider trading effect on volatility.

4.1. The effect of insider trading on future stock return volatility

We analyze the effect of insider trading on future stock price volatility in general, which we label the main effect of insider trading. We then analyze the potential impact of earnings announcements on the insider selling effect.

4.1.1. Main effect

Table 2 reports the results for the analysis of the effect of insider trading on stock return volatility. The results reported in Column (1) of Table 2 show a significantly positive association between net insider sales (*NET_SALES*) and the change in stock return volatility (ΔVOL), with a *t*-value of 4.27. To assess whether the insider trading effect is driven by insider sales, insider purchases, or both, we split *NET_SALES* into the number of shares sold (*SHARES_SOLD*) and the number of shares purchased (*SHARES_BOUGHT*), scaled by the number of shares outstanding at the end of the insider trading month. The results are reported in Column (2) of Table 2. We find a significantly positive coefficient on *SHARES_SOLD* and a significantly negative coefficient on *SHARES_BOUGHT*, indicating that both insider sales and insider purchases contribute to the net insider sales effect. The magnitude of the coefficient on *SHARES_BOUGHT* is much larger than that on *SHARES SOLD* (−0.263 vs. 0.005). The averages of *SHARES_SOLD* and *SHARES_BOUGHT* are 0.313 and 0.002, respectively (as shown in Panel A of Table 1), which partly explains the difference in the magnitudes of the coefficient. Overall, the results in Table 2 are consistent with our conjecture that insider purchases reduce uncertainty, whereas insider sales increase uncertainty, about future stock performance.

4.1.2. Impact of earnings announcements

An earnings announcement is one of the most important corporate information events and tends to induce stock return volatility. Investor uncertainty generally increases prior to earnings announcements and decreases after earnings announcements. We therefore conjecture that the heightened uncertainty associated with earnings announcements could amplify the volatility effect

Table 2
The effect of insider trades on stock return volatility.
This table reports the coefficient estimates from a regression of stock return volatility on insider trades and control variables. All the variables are defined in Table 1. *t*-Values are reported in parentheses. The standard errors are clustered by firm.

Dependent variable (ΔVOL)	(1)	(2)
NET_SALES	0.005	–
	(4.27)	
SHARES_SOLD	–	0.005
		(4.17)
SHARES_BOUGHT	–	−0.263
		(−3.57)
LNMV	0.008	0.008
	(14.36)	(13.85)
BM	−0.000	−0.000
	(−0.04)	(−0.03)
LAGRET	0.017	0.017
	(6.08)	(6.04)
EA	0.171	0.171
	(58.99)	(58.89)
EA_PRE	−0.108	−0.107
	(−36.27)	(−36.18)
Industry fixed effects	Yes	
Year fixed effects	Yes	
Adjusted R^2	0.081	0.081
N	150,318	150,318

Table 3
The effect of earnings announcements on the association between insider trades and stock return volatility.
This table reports the coefficient estimates from a regression of stock return volatility on insider trades and control variables, conditional on whether there was an earnings announcement (EA) in the month after the trade. All the variables are defined in Table 1. *t*-Values are reported in parentheses. The standard errors are clustered by firm.

Dependent variable (ΔVOL)	(1)	(2)
NET_SALES	0.003	–
	(2.10)	
NET_SALES × *EA*	0.008	–
	(3.16)	
SHARES_SOLD	–	0.003
		(2.04)
SHARES_BOUGHT	–	−0.156
		(−1.89)
SHARES_SOLD × *EA*	–	0.008
		(3.13)
SHARES_BOUGHT × *EA*	–	−0.480
		(−2.82)
LNMV	0.008	0.008
	(14.34)	(13.82)
BM	−0.000	0.000
	(−0.01)	(0.01)
LAG RET	0.017	0.017
	(6.08)	(6.03)
EA	0.169	0.169
	(57.06)	(56.96)
EA_PRE	−0.108	−0.108
	(−36.29)	(−36.20)
Industry fixed effects	Yes	
Year fixed effects	Yes	
Adjusted R^2	0.081	0.081
N	150,318	150,318

of insider trading.[6] To test this conjecture, we interact the insider trading variables with the earnings announcement indicator (*EA*), which takes the value one if the month immediately after the insider trading month has an earnings announcement.

The results are presented in Table 3. The results reported in Column (1) show that the coefficient on *NET_SALES* is significantly positive (0.003), with a *t*-value of 2.10, indicating that net insider trading affects stock return volatility even when there is no earnings announcement in the month after the insider trading month. However, consistent with our conjecture that an earnings announcement is likely to exacerbate the insider trading effect, we find a significantly positive coefficient on the interaction between *NET_SALES* and *EA* (0.008), with a *t*-value of 3.16. Column (2) reports the regression results using *SHARES_SOLD* and *SHARES_BOUGHT*, instead of *NET_SALES*. Consistent with the *NET_SALES* results, the incremental effects of *SHARES_SOLD* and *SHARES_BOUGHT* on the future change in volatility are positive and negative, respectively.

4.2. Do option prices impound information content of insider trading for future volatility?

We examine whether option traders anticipate the implications of insider trading for future volatility. We conduct this analysis by examining whether the insider trading effect is reflected in the option-implied volatility and whether insider trading is associated with future option returns.

4.2.1. The impact of insider trading on option-implied volatility

To examine the effect of insider trading on the implied volatility, we replace the future change in volatility (ΔVOL) on the left-hand side of Model (1) by the change in implied volatility (ΔIV). The results presented in Table 4 provide no evidence of a significant association between *NET_SALES* and the change in implied volatility around the insider trade disclosure window, whether we consider the main effect in Column (1) or the earnings announcement effect in Column (2). Hence, it appears that option traders do not adjust their volatility estimation for the effect of insider trading, even prior to earnings announcements.

The sample size used in the implied volatility analysis is much smaller than the sample size used in the realized volatility analysis. To ensure that the difference that we observe in the insider trading effect across the two sets of analyses is not due to sample differences, we repeat the change in realized volatility analysis on the same reduced sample used for the change in implied volatility analysis. As the results reported in Column (3) of Table 4 show, we still find a significantly positive association between the change in realized volatility (ΔVOL) and *NET_SALES*. In fact, if anything, the association becomes stronger in the reduced sample. The coefficient on *NET_SALES* is 0.008 (*t*-value = 5.21) for the reduced sample, while it is 0.005 (*t*-value = 4.27) for the full sample in Table 2. In column (4), we interact *NET_SALES* with *EA*. Again, we find a strong earnings announcement effect.

We also analyze the association between insider trading and the difference between the log value of the realized volatility (*FV*) and the log value of the option implied volatility (*IV*), *FV-IV*. The results are reported in Column (5) of Table 4. Consistent with net insider trading inducing higher stock return volatility and option traders failing to anticipate the increase, the association between *NET_SALES* on *FV-IV* is significantly positive, with the effect being higher when the insider trade is followed by an earnings announcement.

Finally, we examine whether option traders adjust their expected volatility after observing the change in the realized volatility, as captured in the change in future implied volatility (ΔFIV). We define ΔFIV as the difference between the log values of the implied volatility measured at the beginning of Month $t+2$ (one month after the insider trading disclosure window) and the implied volatility measured at the beginning of Month $t+1$ (right after the insider trading disclosure window). The results reported in Column (6) of Table 4 show a significantly positive association

[6] As shown in the summary statistics in Panel B of Table 1, there is a sizable amount of insider trading in the month prior to the earnings announcement.

Table 4
The effect of net insider trading on implied volatility.
This table reports the coefficient estimates from a regression of implied volatility on net insider sales and control variables in Columns (1) and (2). To facilitate comparison, results from the regression of stock return volatility on net insider sales are reported in Columns (3) and (4) using the same reduced sample. Results using FV-IV and ΔFIV are reported in Columns (5) and (6), respectively. All the variables are defined in Table 1. *t*-Values are reported in parentheses. The standard errors are clustered by firm.

Dependent variable	(1) *ΔIV*	(2) *ΔIV*	(3) *ΔVOL*	(4) *ΔVOL*	(5) *FV-IV*	(6) *ΔFIV*
NET_SALES	−0.000	−0.000	0.008	0.006	0.007	0.004
	(−0.60)	(−0.63)	(5.21)	(3.27)	(7.86)	(6.34)
NET_SALES × EA	_	0.000	_	0.008	0.010	_
		(0.25)		(2.39)	(5.39)	
LNMV	−0.001	−0.001	0.008	0.008	0.016	−0.000
	(−3.22)	(−3.23)	(7.75)	(7.74)	(19.53)	(−0.40)
BM	0.007	0.007	−0.001	−0.001	−0.005	0.005
	(2.96)	(2.96)	(−0.17)	(−0.14)	(−1.18)	(1.88)
LAG RET	0.008	0.008	0.023	0.023	0.020	−0.002
	(5.76)	(5.76)	(5.20)	(5.19)	(8.58)	(−1.35)
EA	0.068	0.067	0.170	0.168	0.057	0.073
	(41.53)	(40.24)	(44.73)	(43.02)	(28.57)	(38.49)
EA_PRE	_	_	−0.112	−0.112	_	_
			(−28.36)	(−28.38)		
EA_PRE2	−0.015	−0.015	_	_	_	−0.011
	(−8.62)	(−8.62)				(−5.46)
Industry fixed effects				Yes		
Year fixed effects				Yes		
Adjusted R^2	0.074	0.074	0.087	0.087	0.050	0.084
N	79,725	79,725	79,576	79,576	151,722	59,389

Table 5
The effect of net insider sales on option straddle and delta neutral returns.
This table reports the coefficient estimates from regressions of option straddle returns and delta neutral returns on net insider sales and control variables. All the variables are defined in Table 1. *t*-Values are reported in parentheses. The standard errors are clustered by firm.

Dependent variable	(1) *STRAD_RET*	(2) *DN_RET*
NET_SALES	0.002	0.001
	(0.95)	(1.99)
NET_SALES × EA	0.014	0.003
	(2.94)	(3.74)
LNMV	0.000	0.001
	(0.26)	(4.91)
BM	0.014	0.002
	(1.93)	(1.70)
LAG RET	0.023	0.002
	(5.62)	(3.14)
EA	0.072	0.008
	(14.55)	(13.70)
Industry fixed effects	Yes	
Year fixed effects	Yes	
Adjusted R^2	0.010	0.012
N	151,193	151,194

between net insider trading and change in future implied volatility. This evidence indicates that the net insider selling effect is reflected in the implied volatility one month after the disclosure of the insider trading, after the effect had already been realized in stock returns.

4.2.2. Option straddle and delta neutral returns

To test whether option traders fully respond to net insider selling, we also analyze the association between net insider selling and (1) straddle returns and (2) delta neutral returns over the month after the insider trading month. We report the results for the straddle returns in Column (1) of Table 5 and the results for the delta neutral returns in Column (2) of Table 5. The results in Column (1) show that the coefficient on *NET_SALES*, which captures the effect of net insider selling on the straddle returns when there is no earnings announcement in the month after the insider trading announcement month [although statistically insignificant (*t*-value = 0.95)]. The effect is very significant when there is an earnings announcement in the month after the insider trading announcement month. The coefficient on the interaction between net insider trading and earnings announcements, *NET_SALES × EA*, which captures the incremental effect of earnings announcements, is significantly positive (*t*-value = 2.94).

The results in Column (2) show that the coefficient on *NET_SALES*, which captures the effect of net insider selling on the delta neutral returns when there is no earnings announcement in the month after the insider trading announcement month, is positive (*t*-value = 1.99). Moreover, we find that the effect is significantly more positive when there is an earnings announcement in the month after the insider trading announcement month, with a *t*-value of 3.74 for the coefficient on the interaction between net insider trading and earnings announcements, *NET_SALES × EA*, which captures the incremental effect of earnings announcements. Overall, the results in Table 5 suggest that option prices do not fully incorporate the implications of insider trading for future volatility.

4.3. Robustness tests

4.3.1. Controlling for firm fixed effect

In the main tests, we control for year and industry fixed effects. In this section, we report the results after controlling for firm fixed effects. We do not include firm fixed effects in our main test because in many cases, particularly in the change in IV analysis, we do not have enough within-firm variations to capture cross-sectional differences. Many firms have only one EA or one non-EA observation.

The results of the firm fixed effect analyses are reported in Table 6. All our findings hold after controlling for firm fixed effects, with the coefficients on our main variables of interest (*NET SALES* and *NET SALES × EA*) still being statistically significant. Therefore, it is unlikely that our findings are driven by time-invariant cross-sectional heterogeneity.

Table 6
Controlling for firm fixed effects.
This table reports the regression results with firm fixed effects. All the variables are defined in Table 1. *t*-Values are reported in parentheses. The standard errors are clustered by firm.

Dependent variable	(1)		(2)		(3)	(4)
	ΔVOL		*ΔIV*		*STRAD_RET*	*DN_RET*
NET_SALES	0.004	0.002	0.001	0.001	−0.001	0.000
	(3.58)	(1.71)	(1.83)	(1.24)	(−0.41)	(0.98)
NET_SALES × EA	_	0.008	_	0.001	0.013	0.002
		(3.04)		(0.67)	(2.52)	(3.19)
Control variables	Included					
Firm fixed effects	Yes					
Adjusted R^2	0.010	0.012	0.030	0.030	0.002	0.010
N	150,682	150,682	79,915	79,915	151,565	151,565

Table 7
The effect of net insider sales conditional on M&A Announcements.
This table reports the regression results, conditional on whether there was a merger announcement (M&A) in the month after the trade, as opposed to an earnings announcement. All the variables are defined in Table 1. *t*-Values are reported in parentheses. The standard errors are clustered by firm.

Panel A: Acquiring firms			
Dependent variable	(1) *ΔVOL*	(2) *ΔIV*	(3) *DN_RET*
NET_SALES	0.005	0.001	0.001
	(4.11)	(0.95)	(2.57)
M&A	0.133	−0.016	0.012
	(4.22)	(−1.02)	(1.70)
NET_SALES × M&A	−0.005	−0.002	0.001
	(−0.98)	(−0.79)	(0.51)
Controls		Included	
Industry fixed effects		Yes	
Year fixed effects		Yes	
Adjusted R^2	0.087	0.070	0.012
N	117,421	83,399	117,922
Panel B: Target firms			
NET_SALES	0.005	0.000	0.001
	(3.32)	(0.70)	(2.85)
M&A	0.365	0.032	0.105
	(6.76)	(1.31)	(7.25)
NET_SALES × M&A	−0.000	−0.006	0.001
	(−0.03)	(−1.23)	(0.36)
Control variables		Included	
Industry fixed effects		Yes	
Year fixed effects		Yes	
Adjusted R^2	0.087	0.068	0.016
N	98,687	70,103	99,031

4.3.2. The potential effect merger and acquisition (M&A) announcements

We find that the effect of *NET_SALES* is significantly stronger when there is an earnings announcement in the month after the insider trading month. We focus on earnings announcements because they are regular pre-scheduled events and their anticipation is likely to create volatility. To assess the extent to which the uncertainty associated with the anticipation of a major event is the driver of the earnings announcement impact on the association between insider trading and future volatility, we also analyze the impact of an M&A announcement, a major but generally unanticipated event that creates large stock price movements. As shown in Table 7, consistent with our finding being driven by the uncertainty associated with the anticipation of a major event, none of the results provide evidence of an incremental (interactive) effect associated with M&A announcements, which are generally unexpected.

4.3.3. The effect of differences in insider trading reporting lags

We investigate the impact of the amount of time that elapsed between the insider trading date and the option purchase date on our main results. By design, the amount of time between the insider trade disclosure date and the option purchase date is within a month. However, the amount of time between the insider trading date and the disclosure date varies. Before the enactment of the Sarbanes-Oxley Act (SOX) in 2002, insiders were required to report their trades to the Securities and Exchange Commission by the 10th day of the month that follows the trading month. Since the enactment of SOX, they are required to report their trades within two business days. Therefore, the lag between the insider trading date and the disclosure date, as well as the lag between the insider trading date and the option trading date, varies to some extent. Because we include year fixed effects in all our regressions, it is unlikely that the reporting requirement change would greatly affect our inferences. Nonetheless, to assess whether our results could be due to reporting lag differences, we control for *NUM_ DAYS*, which is the average number of days between the insider trading date and the option purchase date, weighted by the number of shares traded. We use a weighted average because the trades are aggregated over a month (there can be several trade disclosures in a given month). Untabulated results provide no evidence that controlling for *NUM_DAYS* changes our inferences. We also interact *NET_SALES* with *NUM_DAYS* and do not find any significant interaction effect in any of the regressions. We therefore conclude that there is no evidence that the *NET_SALES* effect is due to cross-sectional differences in the reporting lag.

4.3.4. Opportunistic *vs.* routine trades

We examine whether the effect of insider trading on stock return volatility varies across opportunistic and routine traders, using Cohen et al. (2012) classification. Cohen et al. (2012) suggest that insiders who trade in the same month in the last three years (routine traders) do not trade for profiteering reasons and that their trades do not predict future stock returns. In contrast, transactions by insiders who trade in different months (opportunistic traders) are associated with future returns.

We first replicate Cohen et al. (2012) results in Column (1) of Table 8.[7] We find a significantly negative coefficient on *OPPOR_NET _SALES*, the net sale variable for the opportunistic insiders, of −0.009 (*t*-value = −3.93). In contrast, the coefficient on *ROUTINE_NET _SALES*, the net sale variable for the routine traders, of −0.003 is not statistically significant (*t*-value = −1.07). These results are consistent with Cohen et al. (2012). In Column (2), we report the association between stock return volatility and the two types of insider trades. We find significantly positive coefficients on both *OPPOR_NET_SALES* and *ROUTINE_NET_SALES*, although the

[7] Cohen et al. (2012) limit their sample to trades by insiders who traded every year over the last three years. That is, trades by insiders who did not trade every year over the last three years are removed from their sample. We follow Cohen et al. (2012)'s procedure. However, releasing this restriction does not qualitatively change the results.

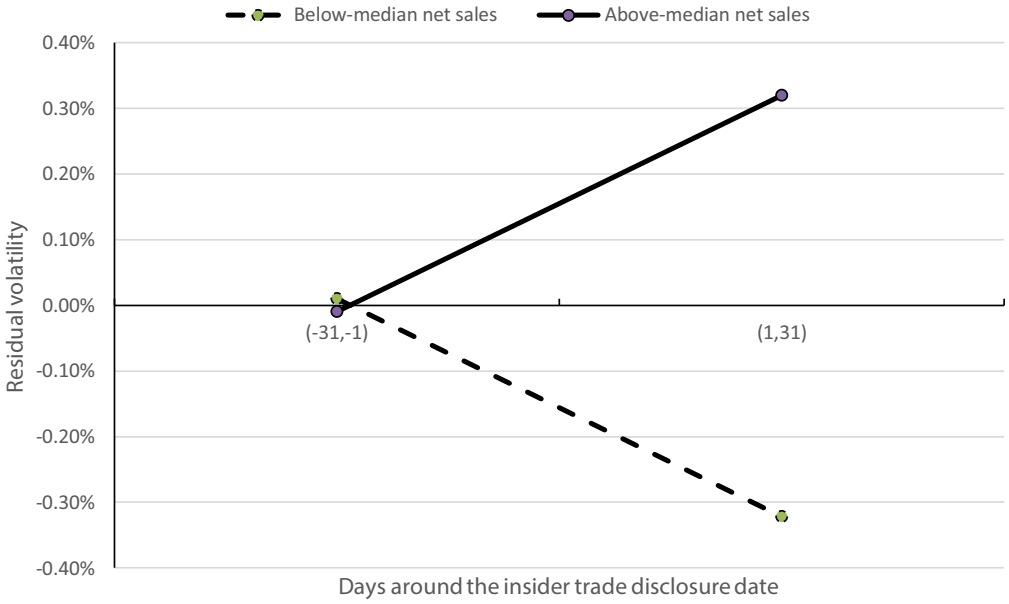

Fig. 1. Volatility movement around the insider trade disclosure dates. This figure depicts the volatilities around the insider trade disclosure dates with the earnings announcement sample. We measure one-month-stock-return volatility before and after the insider trade disclosure date, and regress the volatility on firm size, book-to-market ratio, past-six-month return, the number of days between the most recent earnings announcement date and the insider trade disclosure date, and the number of days between the insider trade disclosure date and the next earnings announcement date and obtain the residual volatility. Then, we sort the daily net sales (the number of shares sold minus the number of shares purchased by insider disclosed on a given day, scaled by the number of shares outstanding) in two groups based on whether net sales are above or below the sample median. The solid line depicts the average residual volatility for the above-median group and the dotted line depicts the average residual volatility for the below-median group.

Table 8
Opportunistic vs. routine trades.
Insiders are classified into opportunistic and routine traders based on the method developed by Cohen et al. (2012). *OPPOR_NET_SALES* (*ROUTINE_NET_SALES*) is the number of shares sold minus the number of shares purchased by opportunistic (routine) insiders and disclosed in Month *t*, scaled by the number of shares outstanding at the end of the month. *STOCK_RET* is the stock return in Month $t+1$. All the other variables are defined in Table 1. *t*-Values are reported in parentheses. The standard errors are clustered by firm.

Dependent variable	(1) *STOCK_RET*	(2) *ΔVOL*	(3) *ΔIV*
OPPOR_NET_SALES	−0.009	0.024	0.001
	(−3.93)	(3.52)	(0.38)
ROUTINE_NET_SALES	−0.003	0.015	0.005
	(−1.07)	(2.06)	(0.99)
LNMV	−0.002	0.008	−0.002
	(−7.43)	(12.64)	(−4.35)
BM	0.000	−0.002	0.003
	(0.02)	(−0.53)	(1.27)
LAG RET	0.004	0.024	0.011
	(2.77)	(5.77)	(5.72)
EA	0.003	0.175	0.072
	(3.74)	(52.87)	(38.46)
EA_PRE		−0.115	
		(−33.97)	
EA_PRE2			−0.016
			(−7.50)
Industry fixed effects		Yes	
Year fixed effects		Yes	
Adjusted R^2	0.018	0.087	0.082
N	112,702	112,154	59,580

coefficient on *OPPOR_NET _SALES* is 60 percent larger than the coefficient on *ROUTINE_NET_SALES*. The results in Column (3) provide no evidence of a significant association between the change in the option implied volatility and either type of insider trades.

At first glance, the significant association between and *ROUTINE_NET_SALES* and return volatility might seem puzzling, given that the association between *ROUTINE_NET_SALES* and returns is not statistically significant. However, although routine trades are unlikely to be opportunistic, insiders can opportunistically time the release of information around the trades (see Aboody and Kasznik, 2000), which would create uncertainty in the market. Note also that although the association between *ROUTINE_NET_SALES* and returns is not statistically significant, the *t*-statistic is relatively large.

4.3.5. Volatility movement around insider trade disclosure dates

In previous analyses, we measure disclosed insider trades over a month and investigate the change in volatilities around that month. In this section, we examine and plot the volatility changes around the insider trade disclosure date. Short term return volatility is affected earnings announcements, firm size, book-to-market ratio, and past returns. To remove the effect of these factors on the return volatility, we use the residuals from a regression of raw volatility on the number of days between the trade disclosure date and the last earnings announcement date, the number of days between the trade disclosure date and the next earnings announcement date, firm size, book-to-market ratio, and the past-six-month stock return. We sort the sample into high and low net insider selling. Net insider selling is deemed high (low) if it is above (below) the sample median. We find the increase in the residual volatility in the high net insider sales group and decrease in the low group both in the full sample and earnings announcement sample that has earnings announcements in the month following the disclosure date. But consistent with the results in Table 3, we find stronger and more noticeable pattern of the volatility changes around the disclosure date. We report those earnings announcement sample results in Fig. 1.

5. Conclusion

We examine the effect of insider trading on stock return volatility and the extent to which option traders price the information content of insider trading for future volatility. We find a significantly positive (negative) association between insider sales (pur-

chases) and subsequent changes in stock return volatility, resulting in a positive association between net insider selling and changes in stock return volatility. The positive effect of net insider sales is significantly stronger when volatility is measured around the earnings announcement.

The evidence also suggests that option prices do not fully reflect the information content of insider trading for future volatility in a timely manner. In particular, we find no evidence that the insider trading effect is reflected in the implied volatility impounded in option prices immediately after the disclosure of insider trading. The effect is reflected in the implied volatility one month after the disclosure of the insider trades, after the effect had already been realized in stock returns. Further analyses also reveal that net insider sales is positively associated with future straddle and delta neutral returns, consistent with the notion that option market participants do not properly incorporate the information content of the net insiders selling for future volatility into option prices.

Overall, the evidence indicates that (1) net insider selling induces an increase in stock return volatility, (2) option traders fail to anticipate the change in volatility immediately after the insider trades, and (3) traders impound the volatility impact of insider trading into option prices only after observing the change in realized volatility induced by the insider trades, resulting in predictable option returns.

References

Aboody, D., Kasznik, R., 2000. CEO stock option awards and the timing of voluntary corporate disclosure. J. Account. Econ. 29, 73–100.

Alldredge, D., Blau, B., Pinegar, M., Information or speculation: What motivates pre-earnings announcement option activity?, Unpublished working paper, 2011.

Amin, K., Lee, C., 1997. Option trading, price discovery, and earnings news dissemination. Contemp. Account. Res. 14, 153–192.

Bettis, C., Coles, J., Lemmon, M., 2000. Corporate policies restricting trading by insiders. J. Financ. Econ. 57, 191–220.

Cao, C., Chen, Z., Griffin, J., 2005. Informational content of option volume prior to takeovers. J. Bus. 78, 1073–1109.

Cao, H., Ou-Yang, H., 2009. Differences of opinion of public information and speculative trading in stocks and options. Rev. Financ. Stud. 22, 299–335.

Chakravarty, S., Gulen, H., Mayhew, S., 2004. Informed trading in stock and option markets. J. Financ. 59, 1235–1257.

Chen, C., Martin, X., Wang, X., 2013. Insider trading, litigation concerns, and auditor going-concern opinions. Account. Rev. 88, 365–393.

Cheng, Q., Lo, K., 2006. Insider trading and voluntary disclosures. J. Account. *Res.* 44, 815–848.

Choy, S., Wei, J., 2012. Option trading: information or differences of opinion? J. Bank. Financ. 36, 2299–2322.

Cohen, L., Malloy, C., Pomorski, L., 2012. Decoding inside information. J. Financ. 67, 1009–1043.

Du, J., Wei, S., 2004. Does insider trading raise market volatility? Econ. J. 114, 916–942.

Easley, D., O'Hara, M., Srinivas, P., 1998. Option volume and stock prices: evidence on where informed traders trade. J. Financ. 53, 431–465.

Feinstein, S., 1989. The Black-Scholes formula is nearly linear in sigma for at-the–money options; Therefore implied volatilities from at-the-money options are virtually unbiased. Working paper. Fed. Reserve Bank, Atlanta.

Fidrmuc, J., Goergen, M., Renneboog, L., 2006. Insider trading, news releases, and ownership concentration. J. Financ. 61, 2931–2973.

Frankel, R., Li, X., 2004. Characteristics of a firm's information environment and the information asymmetry between insiders and outsiders. J. Account. Econ. 37, 229–259.

Goyal, A., Saretto, A., 2009. Cross-section of option returns and volatility. J. Financ. Econ. 94, 310–326.

Jagolinzer, A., Larcker, D., Taylor, D., 2011. Corporate governance and the information content of insider trades. J. Account. Res. 49, 1249–1274.

Jeng, L., Corporate insiders and the window of opportunity, Unpublished working paper, 1998.

Jeng, L., Metrick, A., Zeckhauser, R., 2003. Estimating the returns to insider trading: a performance-evaluation perspective. Rev. Econ. Stat. 85, 453–471.

Lakonishok, J., Lee, I., 2001. Are insider trades informative? Rev. Financ. Stud. 14, 79-11.

Lemmon, M., Ni, S., 2011. Differences in trading and pricing between stock and index options. Management Science 60 (2013), 1985–2001.

Lin, J., Howe, J., 1990. Insider trading in the OTC market. J. Financ. 45, 1273–1284.

Marin, J., Olivier, J., 2008. The dog that did not bark: insider trading and crashes. J. Financ. 63, 2429–2476.

Milian, J., 2014. Unsophisticated arbitrageurs and market efficiency: overreacting to a history of underreaction? J. Account. Res. 53, 175–220.

Ni, S., Pan, J., Poteshman, A., 2008. Volatility information trading in the option market. J. Financ. 63, 1059–1091.

Ofek, E., Yermack, D., 2000. Taking stock: equity-based compensation and the evolution of managerial ownership. J. Financ. 55, 1367–1384.

Pan, J., Poteshman, A., 2006. The information in option volume for future stock prices. Rev. Financ. Stud. 19, 871–908.

Patell, J., Wolfson, M., 1979. Anticipated information releases reflected in call option prices. J. Account. Econ. 1, 117–140.

Patell, J., Wolfson, M., 1981. The ex-ante and ex-post price effects of quarterly earnings announcements reflected in option and stock prices. J. Account. Res. 19, 434–458.

Rozeff, M., Zaman, M., 1988. Market efficiency and insider trading: new evidence. J. Bus. 61, 25–44.

Seyhun, H., 1988. Insiders' profits, costs of trading, and market efficiency. J. Financ. Econ. 16, 189–212.

Seyhun, H., 1998. Investment Intelligence: From Insider Trading. MIT Press, Cambridge, Mass.

Skaife, H., Veenman, D., Wangerin, D., 2013. Internal control over financial reporting and managerial rent extraction: evidence from the profitability of insider trading. J. Account. Econ. 55, 91–110.

Stein, J., 1989. Overreactions in the options market. J. Financ. 44, 1011–1023.

Veenman, D., 2012. Disclosures of insider purchases and the valuation implications of past earnings signals. Account. Rev. 87 (1), 313–342.

Xing, Y., Zhang, X., Zhao, R., 2010. What does the individual option volatility smirk tell us about future equity returns? J. Financ. Quant. Anal. 45, 641–662.