The Intraday Behavior of Information Misreaction across Investor Categories in the Taiwan Options Market

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Abstract

Following the analysis framework of Poteshman (2001), we use a unique dataset including the complete history of all transactions in the Taiwan options market to investigate the patterns of investor misreaction from the marketwise observations and the transactions of four different investor categories. Overall, investors initiate their reaction to unexpected information from short-horizon options and then adjust their positions in long-horizon options with a certain degree of delay because of the liquidity concern. Both of short- and long-horizon reactions are insufficient. Although investor misreaction tends to increase in the quantity of previous similar unexpected shocks, the misreaction to the current unexpected shocks still dominates the effect of increasing misreaction. The comparison for alternative investor categories shows that foreign institutional investors have the lowest degree of misreaction and institutional investors correct their misreaction more promptly.

JEL classification: G14

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1. Introduction

Investor misreaction has been an acceptable explanation of stock market anomalies such as short- and mediate-horizon momentum and long-term reversal. For example, Barberis et al. (1998), Daniel et al. (1998) and Hong and Stein (1999) theoretically present that investors tend to underreact in the short horizon and overreact in the long horizon. In particular, Barberis et al. (1998) argue that the underreaction and overreaction are driven by conservatism and representativeness heuristic, respectively and the interaction of investors' short-horizon conservatism and long-horizon representative heuristic leads to increasing misreaction in the stock markets.[1] Namely, investors tend to underreact (overreact) to information that follows a small (large) quantity of similar information.[2]

While there have already been many studies of stock market investor misreaction, our understanding on the misreaction in options markets is still quite lacking. Investor misreaction should not be restricted to occur in stock markets. In an early article, Stein (1989) documents long-horizon overreaction in the S&P 100 index options

[1] The conservatism theory states that investors cling too strongly to prior beliefs and thus tend to underreact to single piece of information, while the representativeness heuristic argument shows that investors find patterns in information too readily and hence overreact to mostly similar information.

[2] A review of the studies that investigate stock market investor misreaction is referred to Shleifer (2000).

market by finding evidence that the implied volatility of long-horizon options is higher than short-horizon options. Poteshman (2001) provides a comprehensive investigation for the S&P 500 index options and finds that investors not only overreact to information on long-maturity options, but also underreact to information on short maturity options. In addition, evidence is also provide to support the existence of increasing misreaction in the options market.[3]

Although previous studies have documented the existence of short-horizon underreaction, long-horizon overreaction, and increasing misreaction in the US options markets, whether investors have the same patterns of misreaction in a less matured market is still unanswerable. In addition, all of these studies use daily data and therefore impose a strong assumption that investors attend to changes in information once per day. This assumption may not be realistic especially when nowadays the information flow and the ease of trading have been incredibly boosted by modern technology. Using daily data could disallow us to look at investors' instant reaction when just receiving information and at how investors dynamically adjust

[3] Furthermore, Cao et al. (2005) study S&P 500 index options and long-dated S&P 500 LEAPS and find that the underreaction lasts for 3 trading days and that the increasing misreaction reaches the peak after four consecutive daily variance shocks with the same sign. Based on the identified misreaction patterns, option trading strategies are constructed and found to produce economically significant abnormal returns in the range of 1% to 3% per day.

their reaction afterwards. Our study tries to fill these gaps by using a compete record of all transactions in the Taiwan options markets to investigate the issues on investor misreaction. Therefore, in addition to providing more insights for the investigated issues, our findings from the market also have important implications for other developing markets that have similar characteristics such as a high turnover rate and a high participation rate by individual investors.[4]

Our empirical investigation is implemented not only on the marketwise base, but also for the transactions of four different investor categories, domestic institutional investors, foreign institutional investors, individual investors and market makers.[5] Our empirical results include the following general findings. First, investors initiate their reaction to unexpected information from short-horizon options and then adjust their positions in long-horizon options with a certain degree of delay. Second, investors underreact to the information on both short- and long-horizon options with the latter being more severe. Although they try to correct the misreaction afterwards,

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[4] According to the statistics published by the Tawin Stock Exchange, in 2005 individual investors, domestic institutional investors and foreign investors take about 68%, 13% and 17 % of the transactions, respectively. The total turnover rate for 2005 is about 127.27% in the Taiwan stock market.

[5] Several studies document that there exist some sophisticated investors that can make profits in either the Taiwan stock or options markets. See for example, Barber et al. (2007), Mahani and Poteshman (2008), Chang et al. (2009) and Bing et al. (2010).

but the correction is still insufficient. Third, the misreaction to the current unexpected shocks still dominates the effect of increasing misreaction although investors' misreaction tends to increase in the quantity of previous similar unexpected shocks. We conjecture that the inexistence of long-horizon overreaction is caused by the poor liquidity of long-maturity options in the Taiwan options market.[6]

Moreover, some findings are derived from the comparison among the transactions of alternative investor categories. First, foreign institutional investors have the lowest degree of misreaction. Second, domestic and foreign institutional investors correct their misreaction more promptly. The results in this paper are robust to different sampling frequencies and also to difference measures for the quantity of previous similar information.

The remainder of this paper is organized as follows. Section 2 describes the data used for our empirical investigation. Section 3 details the empirical methods employed in this study. Section 4 illustrates the empirical results and some robustness tests. Finally, we conclude this study in Section 5.

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[6] According to the statistics summarized from our data, the near-month contracts take more than 90% of the transactions. Investors may therefore be reluctant to trade their information on the other contracts with poor liquidity.

2. Data Description

The primary dataset for our empirical investigation contains the complete record of transactions of the options written on the Taiwan Stock Exchange Capitalization Weighted Stock Index (hereafter TAIEX). The TAIEX option contracts are traded in Taiwan Futures Exchange (hereafter TAIFEX) with the ticker symbol TXO. Our dataset is obtained directly from the TAIFEX and contains a highly detailed history of transactions, such as the identifications of traders, the contract characteristics and the transaction contents. We also obtain the complete record of transactions of the TAIEX futures from the TAIFEX.

The motivation to study the TAIEX options is not only supplied by the availability of a complete and sophisticated dataset, but also further enhanced by the fact that the Taiwan market shares several common characteristics with other developing markets, such as a high turnover rate and a high participation rate by individual investors. These characteristics are markedly different from those of the major option markets in the US and Europe. Therefore, in addition to providing more insights for the investigated issues, our findings from the market also have important implications for other developing markets.

Our dataset covers the trading dates from 2 January 2002 to 31 December 2005 and maturity months from January 2002 to June 2006. Following some standard data-filtering criteria employed by previous studies such as Aït-Sahalia and Lo (1998) and Poteshman (2001), we exclude the contracts with a time to expiration less than 6 calendar days due to the liquidity concern or with a Black-Scholes implied volatility (hereafter BSIV) lower than 0 or higher than 0.7 to avoid extreme option prices. Moreover, we exclude in-the-money (ITM) options because in general they are less actively traded and thus less informative than their corresponding out-of-the-money (OTM) contracts.[7] We define short-horizon options as the most nearby contracts and long-horizon ones as the contacts with the other maturities. The risk free rates are proxied by the three-month deposit rates and obtained from the website of the Central Bank of Taiwan.

Our intraday investigation is based on the trading interval of five minute; in total there are 59,640 trading intervals in our sample.[8] For each interval, we select all

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[7] Moneyness is defined as the ratio of a strike price over the corresponding futures price.
[8] Some results from 15-, 30- and 60-minute and daily observations are also provided later for the robustness check.

qualified contacts traded two minutes before the ending timestamp. Whenever necessary in our analysis, we match every contract with its corresponding futures price from the dataset of futures transactions. The summary statistics for our final sample are showed in Table 1. The number of observations for call options (6,047,083) is much larger than that for put options (4,826,047). The averaged BSIVs for call and put options are 21.9% and 23.1%, respectively. The time to maturity and the moneyness range from 6 to 212 days and from 0.633 to 1.62, respectively.

< Table 1 is inserted about here >

Since our dataset allows us to identify the types of traders for each transaction, we classified the market participants into four main categories, which are domestic institutional investors, foreign institutional investors, individual investors and market makers. We follow the same data filtering criteria mentioned above to select the observations for each investor category. Table 2 shows the summary statistics of our sample across investor classifications, which reveal the trading behavior of different categories of investors. Obviously, foreign institutional investors trade more put options, while individual investors trade more call options. The time to maturity for foreign institutional investors' positions on average is longest, while that for domestic institutional investor's is shortest. Obviously, the trading pattern is different across investor categories, which is likely due to distinct reactions to information.

< Table 2 is inserted about here >

3. Empirical Methods

Following the analysis framework of Poteshman (2001), our investigation on investors' reaction to information is based on a sequence of instantaneous variance that represents the corresponding series of option prices. Based on the decomposition of the instantaneous variance into expected and unexpected components, the measures for investors' misreaction are defined by the interaction between the changes in instantaneous variance and the differences between the variance changes from long- and short-maturity options. Therefore, in this section we detail how to generate the high-frequency series of instantaneous volatility and how to measure investors' misreaction to new information.

3.1. Estimation of instantaneous variance

As the inclusion of stochastic volatility, even without other complicated features like jumps, is the most crucial step in the development of literature in option pricing models, we presume the underlying asset price follows Heston's (1993) stochastic volatility model to generate instantaneous variance. The model under the real-world measure is specified as follows:

$$\frac{dS_t}{S_t} = \mu(S_t, V_t, t)dt + \sqrt{V_t}dW_t^S \tag{1}$$

$$dV_t = k(\theta - V_t)dt + \eta\sqrt{V_t}dW_t^V \tag{2}$$

where k, θ and η are constant parameters. In the system, the time t price and instantaneous variance of the underlying asset are respectively denoted by S_t and V_t and driven by the two standard Wiener processes with increments dW_t^S and dW_t^V that have correlation ρ. $\mu(S_t, V_t, t)$ denotes the mean level of the underlying asset returns. The market price of variance risk is represented by λ. The risk-free interest rate and the continuously compounded dividend yield of the underlying asset are denoted by r and δ, respectively.

For option pricing, the risk-neutral process of the model is obtained as follows:

$$\frac{dS_t}{S_t} = (r - \delta)dt + \sqrt{V_t}dW_t^S \tag{3}$$

$$dV_t = k^*(\theta^* - V_t)dt + \eta\sqrt{V_t}dW_t^V \tag{4}$$

where $k^* = k + \lambda$ and $\theta^* = k\theta/(k+\lambda)$. The correlation between dW_t^S and dW_t^V remains ρ. The resulting price of a call option with strike price X is derived as:

$$C = Se^{-\delta T}P_1 - Xe^{-rT}P_2 \tag{5}$$

where P_2 is the probability for $S_T > X$ under the risk-neutral Q measure and P_1 is the probability for the same event under another measure, say Q^*. The details regarding the functions P_1 and P_2 are referred to Heston (1993).

The model is estimated with a two-stage procedure from option prices. Since the model describes the dynamic process of the underlying asset price, the parameters should not rely on the data frequency. Therefore, in the first stage we use the weekly closing prices of options selected on Wednesdays over our sample period and then generate the estimates of the risk-neutral parameters, k^*, θ^*, η and ρ, by minimizing the sum of squared option pricing errors.[9]

Essentially, the prices for a spot option and a futures option with the same underlying asset, maturity and strike price should be identical if both are European and the futures contract has the same expiration date as the option contracts do. As a

[9] In total, the marketwise sample for the first-stage estimation includes 198 observations. Following Bakshi et al. (1997), we set the initial value of the parameters as k_0^*=1.15, θ_0^*=0.04, η_0=0.39 and ρ_0=-0.64 for the estimation.

result, in order to avoid the challenge of determining the underlying asset price and dividend yield separately, we replace the underlying asset with futures contract under the assumption of spot-futures parity. The parameters are estimated from our marketwise sample as k^*=1.13, θ^*=0.12, η=0.65 and ρ=-0.64.

Taking the parameter estimates as given, in the second stage we generate the high-frequency series of instantaneous variance in which each observation minimizes the cross-sectional sum of squared pricing errors of options at the corresponding timestamp. The series of instantaneous variance is generated not only on the marketwise base, but also from the transactions of the four investor categories individually.

Let $\{V_t\}$, t=1, 2, …, T be the high-frequency series of instantaneous variance, where T is the total number of observations in our sample. Given that the price dynamic of the underlying asset is correctly specified by the model, the change in instantaneous variance from trading time t-1 to t can be decomposed into expected and unexpected parts, which are respectively denoted as $\Delta V_t^{\text{Expected}}$ and $\Delta V_t^{\text{Unexpected}}$ and formulated as follows:

$$\Delta V_t^{\text{Expected}} = V_{t-1}e^{-k\tau} + \theta(1 - e^{-k\tau}) - V_{t-1} \tag{6}$$

$$\Delta V_t^{\text{Unexpected}} = (V_t - V_{t-1}) - \Delta V_t^{\text{Expected}} \tag{7}$$

where τ is the number of years for an observation interval. Given that the price dynamic of the underlying asset follows Heston's (1993) model, the formula of $\Delta V_t^{\text{Expected}}$ follows from the equation (19) in Cox et al. (1985). The values of k and θ respectively follow from the relationships of $k^* = k + \lambda$ and $\theta^* = k\theta/(k + \lambda)$ with the parameters k^* and θ^* estimated in the first stage. As suggested by Poteshman (2001), we assume that the volatility risk parameter $\lambda = -k^*/2$.[10]

3.2. Measures of misreaction

As stated in Poteshman (2001), a variable called $FarMisProj_t$ measures the extend to which the unexpected change in instantaneous variance from trading time t-1 to trading time t is overprojected into the far future. It is defined as:

$$FarMisProj_t \equiv \text{sign}(\Delta V_t^{\text{Unexpected}})(\Delta V_t^{\text{Long}} - \Delta V_t^{\text{Short}}) \tag{8}$$

where ΔV_t^{Long} is the change in the instantaneous variance from long-maturity options from trading time t-1 to t and $\Delta V_t^{\text{Short}}$ is the change in the instantaneous

[10] Poteshman (2001) also shows the robustness of alternative settings such as λ=0 and $\lambda=-k^*$. Basically, the results do not substantially change.

variance from short-maturity options from trading time t-1 to t.

While there is no reason for the price changes of options with different maturities to be the same, the price changes measured in instantaneous variance should be exactly the same if the Heston's (1993) option pricing model is appropriate. Intuitively, if the current unexpected change in instantaneous variance is positive (negative), we would observe a positive $FarMisProj_t$ which means that it is projected too much into the far future when the current change in instantaneous variance from long maturity options is greater (less) than those from short maturity options.

According to the definition of the $FarMisProj_t$ variable, it is increasing in the extent to which the investors misproject the unexpected changes in instantaneous variance into far future. Therefore, if investors underreact to the unexpected changes in instantaneous variance, the $FarMisProj_t$ variable would be decreasing in the magnitude of the unexpected change in instantaneous variance and we can examine whether the investors have short-horizon underreaction by investigating the relationship between $FarMisProj_t$ and $|\Delta V_t^{\text{Unexpected}}|$.

Stein (1989) reveals the investors' long-horizon overreaction by documenting that the prices of long maturity options are too high. If the overreaction exists, we would expect a positive relationship between the level of instantaneous variance and the difference between the changes in instantaneous variance from long-maturity options and those from short-maturity options. Therefore, $V_t^{\text{Long}} - V_t^{\text{Short}}$ can serve as a measure to explore the issue of long-horizon overreaction.

4. Empirical Results

Different from previous studies, we use intraday, rather than daily, data to investigate information misreaction. Potentially we can provide more insights on the issue of investors' misreaction particular when we are having very powerful technology to help trading and thus traders can trade on their information promptly. We first look at whether there exists any intraday pattern for the $FarMisProj_t$ variable in the Taiwan options markets and then test for the existence of short-horizon underreaction, long-horizon overreaction and increasing misreaction, respectively. Some robustness analyses are provided finally.

4.1. The intraday patterns of investors' misreacttion to new information

After generating the five-minute series of marketwise $FarMisProj_t$, we calculate the averages of the variable levels for each intraday interval. Figure 1 shows the intraday pattern of the variable across observation intervals. Different from the findings of previous studies using daily data for the US markets, we find that all of the intraday averages of the variable are negative. While we also find the existence of investor misreaction to the current unexpected information in the high-frequency data, investors project the unexpected changes in instantaneous variance relatively more into short-maturity options than into long-maturity options. Whether the signs of unexpected changes in instantaneous variance are positive or negative, the reactions in instantaneous variance from short-maturity options are larger than those from long-maturity options. This finding from high-frequency data may reveal that investors usually trade short-maturity options first when they receive unexpected information since in the Taiwan options markets nearby contacts are much more liquid than the others.[11] Hence, the instant adjustments from long-maturity options are always relatively smaller and it may take time for long-maturity options to be adjusted comparably.

[11] In almost all of the options markets around the world, nearby contracts are usually most liquid. However, the difference between the liquidity of nearby and non-nearby contracts in the Taiwan options market is extremely large. This huge difference in liquidity could make the prices of non-nearby contracts insensitive to information flow.

In addition to the negative $FarMisProj_t$, we also find that the magnitude of the misreaction is particularly high when the market is open (8:45-9:15) and during the noon time (12:00-12:30). For the larger misreaction during the open time, we conjecture that it is due to the relatively higher level of information asymmetry caused by the long non-trading overnight period. For the larger misreaction during the noon time, it may be owing to the relatively higher level of information asymmetry caused by some participants' absence for lunch for a while.

< Figure 1 is inserted about here >

4.2. Short-horizon underreaction

Intraday data is particularly ideal for the investigation on short-horizon misreaction. We can explore not only how investors instantly react to unexpected shocks, but also how investors adjust their reaction afterwards. If investors underreact to the unexpected changes in instantaneous variance, the $FarMisProj_t$ variable would be decreasing in the magnitude of the unexpected change in instantaneous variance. Therefore, a regression test for the relationship between $FarMisProj_t$ and $|\Delta V_t^{\text{Unexpected}}|$ can ascertain whether the short-horizon underreaction to information exists in the Taiwan options market. The model is specified as:

$$FarMisProj_t = \alpha + \sum_{i=0}^{6} \beta_i \,|\, \Delta V_{t-i}^{\text{Unexpected}} \,| + \sum_{j=1}^{3} \gamma_j \cdot D_{j,t} \cdot |\, \Delta V_t^{\text{Unexpected}} \,| + \varepsilon_t \qquad (9)$$

where $FarMisProj_t$ and $\Delta V_t^{\text{Unexpected}}$ are defined in Equations (8) and (7), respectively. In addition to the contemporaneous relationship between the two variables, we further consider the time investors may spend to fully react to the unexpected shock and the frequently found autocorrelation in intraday financial time series by adding the absolute value of the unexpected changes in instantaneous variance in previous 30 minutes into the model.

As shown in Figure 1, the $FarMisProj_t$ variable shows a particular intraday pattern with a higher absolute value during the open and noon intervals. Moreover, many studies that investigate the intraday patterns of financial variables often find some particular patterns for the close time. Therefore, in the model we also control for the intraday effect by including three dummy variables, D_1, D_2 and D_3, which are equal to 1 for the open, noon and close intervals, respectively and 0 otherwise. To adjust for serial correlation and heteroskedasticity, we use the Newey-West robust standard errors in our empirical regressions.

The regression results from the marketwise observations and the transactions of the four investor classifications are shown in Table 3. Consistent with previous studies using daily data, we also find strong evidence for the existence of short-horizon underreaction and this finding is valid across investor categories since all the estimates of β_0 are negatively significant at the 1% of significance level. For all samples except the market makers' transactions, some of the estimates for lagged absolute instantaneous variances turn to positive although they may not be statistically significant. It seems that investors try to correct their underreaction, but according to the size of the coefficients, the correction is obviously insufficient. Moreover, this insufficient adjustment can also be supported by the significantly negative coefficient in the model using daily observations.[12]

When further comparing the results among the four investor categories, we find that the magnitude of the underreaction for foreign institutional investors are smallest as the value of the β_0 estimate is just half of those for the other investor categories. This finding may signal that foreign institutional investors are the most sophisticated investors in the Taiwan options markets, which is consistent their superior

[12] The results are shown in the section of robustness analysis.

profit-making ability and information advantage found in previous studies.

According to the size and significance of the estimates of the dummy coefficients, it seems that the higher magnitude of the marketwise $FarMisProj_t$ during the open and noon intervals mainly comes from individual investors' transactions. Although the estimate of γ_2 for individual investors is marginally insignificant at the 10% of significance level, the size of the estimate value is much larger than those for the other investor classifications. We conjecture that it is due to less attention paid to the market by individual investors when the market is close and during the lunch time. Consistent with our previous discussion with Figure 1, there is no particular pattern of misreaction during the close time as all estimates of γ_3 are statistically insignificant.

<Table 3 is inserted about here >

4.3. Long-horizon overreaction

Using daily data, Stein (1989) and Poteshman (2001) present the evidence of long-horizon overreaction in the OEX and SPX options markets, respectively. However, using the daily observation frequency may not be able to allow us to see investors' instant reaction when they receive unexpected shocks and what we can see from daily data is just the outcome resulted from some corrections made by investors.

If the long-horizon overreaction exists, we would expect a positive relationship between the level of instantaneous variance and the difference between the changes in instantaneous variance from long-maturity options and those from short-maturity options. Therefore, a regression model of regressing $V_t^{\text{Long}} - V_t^{\text{Short}}$ on V_t can serve as an channel to explore the issue of long-horizon overreaction. With the same concerns on including lagged instantaneous variance and dummy variables for the model used to test for short-horizon underreaction, the regression model for the long-horizon overreaction is specified as follow:

$$V_t^{\text{Long}} - V_t^{\text{Short}} = \alpha + \sum_{i=0}^{6} \beta_i V_{t-i} + \sum_{j=1}^{3} \gamma_j \cdot D_{j,t} \cdot V_t + \varepsilon_t \qquad (10)$$

where V_t^{Long} is the instantaneous variance implied from long-maturity options, V_t^{Short} is the instantaneous variance implied from short-maturity options, V_t is the instantaneous variance for the corresponding trade interval, and D_1, D_2 and D_3 have identical definitions to those in Equation (9). We also use the Newey-West robust standard errors to adjust for serial correlation and heteroskedasticity.

Using intraday data, we run the regression model not only for the marketwise observations, but also for the four investor categories individually. In general, the long-horizon overreaction is not present in the Taiwan options market. As shown in Table 4, there is strong evidence against the hypothesis of instant long-horizon overreaction since all of the β_0 estimates are negatively significant at the 1% of significance level. This finding is consistent with our previous discussion in Section 4.1. When investors receive unexpected shocks, their instant reactions on long-horizon options are relatively insufficient since short-horizon contracts are often much more liquid. However, for all samples except foreign institutional investors, almost all of the coefficients of lagged instantaneous variance are positive and many of them are statistically significant. It may indicate that those investors adjust their perception on long-horizon options after they finish their trading activities on short-horizon contracts, but this adjustment is still insufficient since all of the coefficients of lagged instantaneous variance are much smaller than those of concurrent variance and the coefficient of instantaneous variance is still significantly negative even when we use daily data.[13]

When further comparing the results among different investor classifications, we

[13] The results are shown in the section of robustness analysis.

find that the absolute value of β_0 estimate for foreign institutional investors are much smaller than those for the other investor classifications. It indicates that foreign institutional investors are relatively more rational although the instant reaction on long-maturity contracts is also insufficient. Moreover, all of the estimates of lagged instantaneous variance for foreign institutional investors are also negatively significant at the 5% of significance level. It may reveal that foreign institutional investors do not delay their information projection on long-maturity options. By contrast, all of the estimates of lagged instantaneous variance for individual investors are positively significant at 5% of significance level. It reveals that individual investors are relatively more irrational and delay their reaction to unexpected shocks on long-maturity contracts most severely. Since in the Taiwan options market individual investors take the largest proportion of total trading volume, the marketwise findings are similar to those from individual investors' transactions. Moreover, we find no consistent and significant intraday pattern for the difference between the instantaneous variance from long-horizon and short-maturity options.

<Table 4 is inserted about here >

Different from the findings for the US options markets, there is no long-horizon overreaction in the Taiwan options market. Instead, compared to the reaction on short-maturity options, the reaction on long-maturity options is far more insufficient. We conjecture that this insufficient reaction on long-maturity options is caused by the poor liquidity of non-nearby option contracts. During our sample period, the nearby contracts take more than 90% of the total transactions in the Taiwan option markets. Therefore, when receiving unexpected shocks, investors usually project their reaction to highly liquid nearby contracts instantly. More sophisticated investors may simply choose not get involved too much in non-nearby contracts, while less sophisticated investors may still want to adjust their positions in long-maturity options afterwards. As a result, investors' reaction on long-maturity options is far more insufficient than that on short-maturity options, although the short-horizon underreaction is still existent.

4.4. Increasing misreaction

Barberis et al. (1998) reconcile short-horizon overreaction and long-horizon underreaction in the stock market by providing evidence that investors tend to underreact to information that is preceded by a small quantity of similar information and overreact to information that is preceded by a large quantity of similar information. In other words, investors' misreaction to information is increasing in the quantity of previous similar information. Investigating whether the extent to which investors misproject the unexpected component of a current change in instantaneous variance into the far future is an increasing function of the quantity of previous similar unexpected changes in instantaneous variance, Poteshman (2001) designs a system of regression models with daily data to support the existence of increasing misreaction in the SPX options markets. The quantity of previous similar unexpected changes in instantaneous variance is measured by the $QPrevSim_t^w$ variable defined as:

$$QPrevSim_t^w \equiv \text{sign}(\Delta V_t^{\text{Unexpected}})\sum_{i=1}^{w}\text{sign}(\Delta V_{t-i}^{\text{Unexpected}}) \qquad (11)$$

where $\Delta V_t^{\text{Unexpected}}$ is the unexpected change in instantaneous variance defined in Equation (7). If the current unexpected change in instantaneous variance is positive (negative) , the variable value is equal to the number of positive (negative) minus the number of negative (positive) unexpected changes in the instantaneous variance over the previous *w* trading periods.

Using daily data actually imposes an assumption that market participants react to information changes once a day. In this study, we use intraday data to try to capture the potential that market participants attend to information changes much more frequently. Following the analysis framework of Poteshman (2001), the regression model is specified as:

$$\begin{aligned} FarMisProj_t = \alpha + \beta QPrevSim_t^w + \sum_{i=1}^{3} \gamma_i \cdot D_{i,t} \cdot QPrevSim_t^w \\ + \theta V_t + \delta \,|\, \Delta V_t^{\text{Unexpected}} \,|\, + \varepsilon_t \end{aligned} \tag{12}$$

where D_1, D_2 and D_3 have identical definitions to those in Equation (9) and are used to control for the intraday pattern in the $FarMisProj_t$ variable, V_t and $|\Delta V_t^{\text{Unexpected}}|$ are respectively used to control for the impact of long- and short-horizon misreaction discussed previously. With several sets of constraints on some particular parameters, we also run three alternative models for the marketwise observations and the transactions of the four investor classifications. The parameter constraints for these three models are detailed as follows:

Model 1: Base model: $\theta = \delta = 0$.

Model 2: Controlling for the impact of long-horizon misreaction: $\delta = 0$.

Model 3: Controlling for the impact of short-horizon misreaction: $\theta = 0$.

We refer Model 4 to the full model specified in Equation (12), which controls for impact of both misreactions. To adjust for serial correlation and heteroskedasticity, we also use the Newey-West robust standard errors in our empirical analysis. Following the same criteria for the inclusion of lagged information in the investigations on short-horizon underreaction and long-horizon overreaction, we select a tracking window of 30 minutes for the calculation of the $QPrevSim_t^w$ variable, i.e. w=6.

The estimation results of the four alternative models from marketwise observations are shown in Table 5. The estimates of β coefficients are positively significant at the 1% of significance level for all window sizes in Models 1 and 2. It indicates that investors' misreaction to information increases in the quantity of similar unexpected changes in instantaneous variance even though it is controlled for the impact of the overall level of instantaneous variance. However, the result is not robust to controlling for the size of the magnitude of the current unexpected changes in instantaneous variance. The estimates of β coefficients in Models 3 and 4 turn to insignificant, while the estimates of δ coefficients are still negatively significant at the 1% of significance level. This result indicates that the effect of short-horizon underreaction dominates the effect of increasing misreaction although the later does exist in terms of marketwise transactions. Namely, compared with previous similar information, the current unexpected shock is the most influential factor to drive investors' reaction.

<Table 5 is inserted about here >

The estimation results of the four alternative models for the four investor categories are shown in Tables 6.[14] As shown in Panels C and D, the findings for individual investors and market makers are similar to those from marketwise observations. These two types of investors tend to increase their misreaction when receiving more similar unexpected information, but the effect of misreaction to the current information is still more influential than to previous similar information. Therefore, after controlling for the effect of the short-horizon underreaction in Models 3 and 4, the effect of increasing misreaction almost disappears.

The estimation results for domestic and foreign institutional investors are shown in Panels A and B, respectively. The estimates of β coefficients in Model 1 where we

[14] As the estimation results of γ_1, γ_2, γ_3 and θ are similar to those from marketwise observations and similar across investor classifications, they are not reported in Table 6 to avoid providing redundant information. Nonetheless, they are available upon request.

control for the intraday effect only are also positively significant at the 1% of significance level for almost all window sizes. Essentially, these two types of investors' misreaction to unexpected information also increase in the quantity of similar unexpected information. However, after controlling the impact of the unexpected shocks in Models 3 and 4, the estimates of β coefficients become not just negative but also significant at 5% of significance level for all window sizes. It means that these two types of investors actually learn from previous unexpected shocks to lower the levels of their misreaction although their trading behavior is still dominated by the short-horizon underreaction. Moreover, for foreign institutional investors, the phenomenon of increasing misreaction vanishes after we control for the impact of the level of current instantaneous variance, but without controlling for the impact of short-horizon underreaction.

<Table 6 is inserted about here >

4.5. Robustness analyses

The main results of our empirical investigation are based on the observation frequency of 5 minutes. To check the robustness of our results, we also implement the tests of short-horizon underreaction and long-horizon overreaction for the observations with alternative sampling frequencies such as 15, 30 and 60 minutes and one day. The size and significance of the coefficient estimates are very similar across sampling frequencies. The results from daily marketwise observations are shown in Table 7.

Poteshman (2001) also suggests an alternative variable to measure the quantity of previous similar shocks, which is denoted as $QPrevSim_t^{2w}$ and defined as:

$$QPrevSim_t^{2w} \equiv \text{sign}(\Delta V_t^{\text{Unexpected}}) \sum_{i=1}^{w} \Delta V_{t-i}^{\text{Unexpected}} . \qquad (13)$$

This measure modifies $QPrevSim_t^{w}$ by taking into account both the sign and magnitude of previous unexpected changes in instantaneous variance. We also run the tests for increasing misreaction with this modified measure. The new results are in general consistent with their corresponding ones discussed previously.

5. Concluding Remarks

Using a unique dataset that contains the complete record of transactions in the Taiwan options market, this paper examines options market investors' reaction to the information contained in intraday changes in instantaneous variance under the assumption that the stochastic volatility option pricing model is appropriate. The empirical investigation is implemented not only for the marketwise observations, but also for the transactions of four different classifications of investors individually.

This paper provides evidence to support the following general findings. First, investors initiate their reaction to unexpected information from short-horizon options and then adjust their positions in long-horizon options with a certain degree of delay. Second, investors underreact to the information on both short- and long-horizon options with the latter being more severe. Although they try to correct the misreaction, but the correction is still insufficient. Third, the misreaction to the current unexpected shocks still dominates the effect of increasing misreaction although investors' misreaction tends to increase in the quantity of previous similar unexpected shocks.

This paper also provides some findings from the comparison among the transactions of alternative investor categories. First, foreign institutional investors have the lowest degree of short-horizon underreaction. Moreover, institutional investors correct their misreaction more promptly.

The results in this paper are robust to different sampling frequencies and also to difference measures for the quantity of previous similar information. Using high-frequency data relaxes the assumption that investors react to information changes once a day and investigating the Taiwan market enhances our knowledge about investors’ misreaction to information in a less matured market. Therefore, the findings in this paper provide not only further understanding on the patterns of investor misreaction, but also more insights on how investors react to information change and how to correct the reaction. In addition, this paper also provides some interesting findings on the comparison of misreaction patterns across alternative categories.

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Figure 1 The Intraday Pattern of Investors' Misreaction

This figure exhibits the averages of the $FarMisProj_t$ variable levels for each intraday interval. The variable is defined as

$$FarMisProj_t \equiv \text{sign}(\Delta V_t^{\text{Unexpected}})(\Delta V_t^{\text{Long}} - \Delta V_t^{\text{Short}})$$

where $\Delta V_t^{\text{Unexpected}}$ is the unexpected component of change in the instantaneous variance, ΔV_t^{Long} is the change in the instantaneous variance from long maturity options and $\Delta V_t^{\text{Short}}$ is the change in the instantaneous variance from short maturity options from trading time t-1 to t. The sample period covers from January 2, 2002 to December 31, 2005.

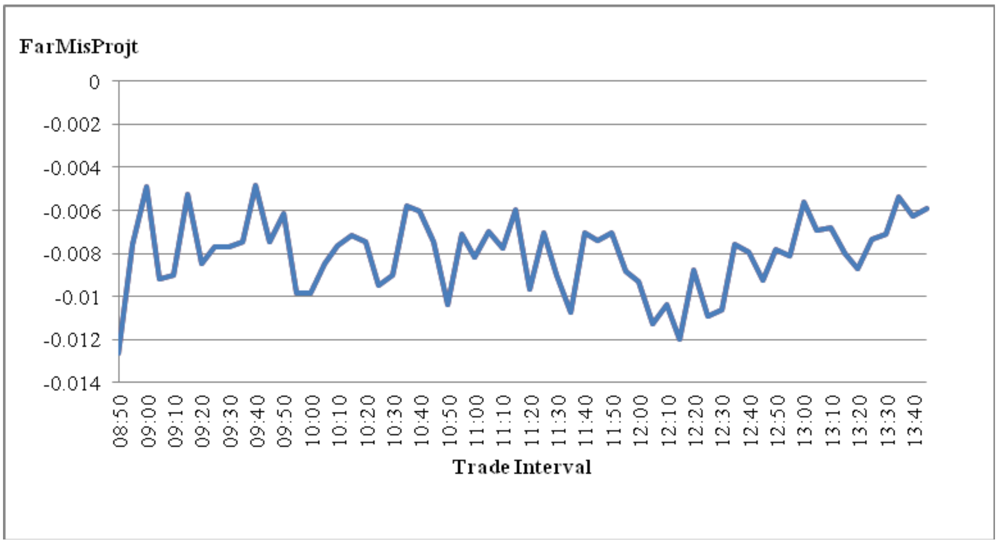

Table 1 Summary statistics of the entire sample

This table consists of the summary statistics of our final sample for the intraday observations of the options written on the Taiwan Stock Exchange Capitalization Weighted Stock Index. The sample period covers from January 2, 2002 to December 31, 2005. The sample excludes the contracts with a time to expiration less than 6 calendar days, with a Black-Scholes implied volatility lower than 0 or higher than 0.7, or with a moneyness of in-the-money. Moneyness is defined as the ratio of a strike price over the corresponding futures price. The risk free rates are proxied by the average three-month deposit rates and obtained from the website of the Central Bank of Taiwan.

					Percentiles					
Variables	Obs.	Mean	S.D.	Min	1%	10%	50%	90%	99%	Max
Panel A: Calls										
Price (NT$)	6047083	59.180	41.016	0.100	3.000	14.000	51.000	113.000	194.000	600.000
B-S implied vol.	6047083	0.219	0.086	0.010	0.085	0.129	0.199	0.342	0.473	0.700
Time to maturity	6047083	0.064	0.042	0.016	0.016	0.022	0.060	0.099	0.197	0.581
Strike price	6047083	6075	551	3800	4400	5400	6100	6700	7300	7300
Risk-free rate	6047083	0.013	0.002	0.011	0.011	0.011	0.012	0.016	0.018	0.022
Moneyness	6047083	1.034	0.030	1.000	1.001	1.005	1.026	1.070	1.142	1.620
Panel B: Puts										
Price (NT$)	4826047	56.094	44.542	0.100	2.600	12.000	47.000	109.000	210.000	1050.000
B-S implied vol.	4826047	0.231	0.093	0.038	0.104	0.144	0.204	0.359	0.569	0.700
Time to maturity	4826047	0.066	0.051	0.016	0.016	0.022	0.060	0.101	0.268	0.581
Strike price	4826047	5690	562	3500	4000	5000	5800	6300	6800	7200
Risk-free rate	4826047	0.013	0.002	0.011	0.011	0.011	0.012	0.016	0.018	0.022
Moneyness	4826047	0.964	0.030	0.633	0.862	0.924	0.972	0.994	0.999	1.000

Table 2 Summary statistics across investor categories

This table consists of the summary statistics of our final sample for the intraday observations of the options written on the Taiwan Stock Exchange Capitalization Weighted Stock Index by four investor categories, which are domestic institutional investors, foreign institutional investors, individual investors and market makers. The sample period covers from January 2, 2002 to December 31, 2005. The sample excludes the contracts with a time to expiration less than 6 calendar days, with a Black-Scholes implied volatility lower than 0 or higher than 0.7, or with a moneyness of in-the-money. Moneyness is defined as the ratio of a strike price over the corresponding futures price. The risk free rates are proxied by the average three-month deposit rates and obtained from the website of the Central Bank of Taiwan.

Variables		Types of Investors			
		Domestic Institutional Investors	Foreign Institutional Investors	Individual Investors	Market Makers
Panel A: Calls					
Obervations		350498	83121	4653312	960152
Price (NT$)	mean	48.154	68.118	60.466	56.197
	S.D.	37.793	45.858	40.643	42.643
B-S implied vol	mean	0.207	0.213	0.222	0.209
	S.D.	0.083	0.087	0.086	0.087
Time to maturity	mean	0.056	0.087	0.064	0.067
	S.D.	0.034	0.063	0.040	0.051
Strike price	mean	6131	6051	6069	6087
	S.D.	457	523	554	572
Risk-free rate	mean	0.013	0.013	0.013	0.013
	S.D.	0.002	0.002	0.002	0.002
Moneyness	mean	1.034	1.034	1.034	1.034
	S.D.	0.029	0.026	0.031	0.030
Panel B: Puts					
Obervations		361059	141230	3403151	920607
Price (NT$)	mean	49.411	64.512	56.000	57.772
	S.D.	42.116	49.584	44.112	45.860
B-S implied vol	mean	0.225	0.234	0.234	0.222
	S.D.	0.089	0.095	0.095	0.088
Time to maturity	mean	0.061	0.094	0.063	0.074
	S.D.	0.036	0.074	0.047	0.060
Strike price	mean	5755	5746	5673	5719
	S.D.	452	514	575	556
Risk-free rate	mean	0.013	0.012	0.013	0.013
	S.D.	0.002	0.002	0.002	0.002
Moneyness	mean	0.962	0.957	0.964	0.964
	S.D.	0.028	0.031	0.031	0.029

Table 3 Tests for intraday short-horizon underreaction

This table presents the estimation results for the regression specified as

$$FarMisProj_t = \alpha + \sum_{i=0}^{6} \beta_i \,|\, \Delta V_{t-i}^{\text{Unexpected}} \,| + \sum_{j=1}^{3} \gamma_j \cdot D_{j,t} \cdot |\, \Delta V_t^{\text{Unexpected}} \,| + \varepsilon_t$$

where $FarMisProj_t$ and $\Delta V_t^{\text{Unexpected}}$ are defined in Equations (8) and (7), respectively. D_1, D_2 and D_3 are dummy variables, which are equal to 1 for the open, noon and close intervals, respectively and 0 otherwise. The sample period covers from January 2, 2002 to December 31, 2005. The regression model is estimated from the marketwise observations and the four investor classifications. The coefficients and *t*-statistics are reported. The *t*-statistics are calculated using the Newey-West robust standard errors. ***, ** and * denote the significance at the 1%, 5% and 10% levels, respectively.

	Market		Domestic Institutional Investors		Foreign Institutional Investors		Individual Investors		Market Makers	
	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.
α	0.0012	5.62***	0.0011	3.25***	0.0024	5.53***	0.0017	7.23***	0.0020	6.65***
β_0	-0.8531	-24.63***	-0.8525	-43.60***	-0.4132	-8.27***	-0.8840	-41.75***	-0.8114	-43.30***
β_1	0.0098	0.49	0.0001	0.01	0.0020	0.14	0.0099	0.72	-0.0295	-2.01*
β_2	0.0410	1.83*	0.0011	0.14	-0.0127	-0.88	0.0145	0.90	-0.0313	-2.66***
β_3	-0.0134	-0.58	0.0090	0.84	0.0040	0.25	-0.0229	-1.62	-0.0068	-0.61
β_4	-0.0391	-1.96*	0.0006	0.09	-0.0170	-1.41	0.0159	0.93	-0.0156	-1.31
β_5	0.0005	0.03	-0.0257	-2.42*	-0.0138	-1.01	-0.0383	-2.08*	-0.0108	-0.88
β_6	-0.0410	0.03	-0.0014	-0.19	-0.0075	-0.57	-0.0234	-1.54	0.0030	0.26
γ_1	-0.1122	-1.93*	-0.0238	-0.58	-0.0792	-1.21	-0.0913	-2.17*	-0.0725	-2.64***
γ_2	-0.0979	-2.58**	0.0140	0.34	-0.0088	-0.11	-0.0377	-1.34	-0.0206	-0.61
γ_3	0.0694	0.88	0.0368	0.68	-0.1036	-1.31	0.0281	0.54	0.04426	0.78
Adj. R^2	29.52%		47.88%		13.99%		35.98%		40.49%	

Table 4 Tests for intraday long-horizon overreaction

This table presents the estimation results for the regression specified as

$$V_t^{\text{Long}} - V_t^{\text{Short}} = \alpha + \sum_{i=0}^{6} \beta_i V_{t-i} + \sum_{j=1}^{3} \gamma_j \cdot D_{j,t} \cdot V_t + \varepsilon_t$$

where V_t^{Long} is the instantaneous variance implied from long maturity options, V_t^{Short} is the instantaneous variance implied from short maturity options, V_t is the instantaneous variance for the corresponding trade interval, and D_1, D_2 and D_3 are dummy variables, which are equal to 1 for the open, noon and close intervals, respectively and 0 otherwise. The sample period covers from January 2, 2002 to December 31, 2005. The regression model is estimated from the marketwise observations and the four investor classifications. The coefficients and *t*-statistics are reported. The *t*-statistics are calculated using the Newey-West robust standard errors. ***, ** and * denote the significance at the 1%, 5% and 10% levels, respectively.

	Market		Domestic Institutional Investors		Foreign Institutional Investors		Individual Investors		Market Makers	
	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.
α	0.0059	4.47***	-0.0001	-0.06	0.0080	16.64***	0.0136	15.00***	0.0139	16.86***
β_0	-0.4884	-16.84***	-0.8136	-27.15***	-0.5062	-13.96***	-0.8514	-56.25***	-0.8379	-68.77***
β_1	0.0489	2.88***	0.0103	0.92	-0.0735	-4.82***	0.0383	3.26***	0.0167	1.96*
β_2	0.0340	1.88*	0.01736	1.81*	-0.0388	-3.19***	0.05866	4.47***	-0.0006	-0.07
β_3	0.0549	3.51***	0.0220	2.18**	-0.0484	-3.82***	0.0415	3.83***	0.0182	2.12**
β_4	0.0600	3.91***	0.0057	0.70	-0.0306	-2.80***	0.0479	4.37***	0.0118	1.20
β_5	0.0222	0.19	0.0090	0.97	-0.041	-3.07***	0.0274	2.32**	0.0126	1.51
β_6	0.0620	3.34***	0.0051	0.64	-0.0311	-2.52**	0.0359	2.92***	0.0115	1.13
γ_1	-0.0113	-0.53	-0.0532	-1.33	-0.0426	-0.98	0.0065	0.33	-0.0401	-2.49**
γ_2	-0.0094	-0.44	-0.0068	-0.13	-0.0215	-0.52	-0.0233	-1.24	-0.0174	-0.90
γ_3	0.0362	1.85*	0.0024	0.05	-0.0291	-0.80	0.0388	1.78	-0.0077	-0.37
Adj. R^2	13.66%		60.38%		42.40%		40.48%		56.28%	

Table 5 Tests for increasing misreaction from marketwise observations

This table presents the estimation results to examine the existence of increasing misreaction from marketwise observations. The full model referred to Model 4 is specified as:

$$FarMisProj_t = \alpha + \beta QPrevSim_t^w + \sum_{i=1}^{3} \gamma_i \cdot D_{i,t} \cdot QPrevSim_t^w + \theta V_t + \delta \,|\, \Delta V_t^{\text{Unexpected}} \,| + \varepsilon_t$$

where D_1, D_2 and D_3 are used to control for the intraday pattern in the $FarMisProj_t$ variable, V_t is used to control for the impact of the current level of instantaneous variance, and $|\Delta V_t^{\text{Unexpected}}|$ is used to control for the impact of underreaction or overreaction. $QPrevSim_t^w$ measures the quantity of previous similar unexpected changes in instantaneous variance variable defined as:

$$QPrevSim_t^w \equiv \text{sign}(\Delta V_t^{\text{Unexpected}}) \sum_{i=1}^{w} \text{sign}(\Delta V_{t-i}^{\text{Unexpected}}) \cdot$$

With several sets of constraints on some particular parameters, we also run the following three alternative models:

Model 1: Base model: $\theta = \delta = 0$.

Model 2: Controlling for the impact of instantaneous variance: $\delta = 0$.

Model 3: Controlling for the impact of misreaction: $\theta = 0$.

The sample period covers from January 2, 2002 to December 31, 2005. The regression models are estimated from the marketwise observations. The coefficients and *t*-statistics are reported. The *t*-statistics are calculated using the Newey-West robust standard errors. ***, ** and * denote the significance at the 1%, 5% and 10% levels, respectively.

Model	Window size					
	1	2	3	4	5	6
			Panel A: β			
1	0.0019 (7.33)***	0.0015 (7.18)***	0.0009 (4.77)***	0.0009 (5.55)***	0.0006 (4.20)***	0.0006 (4.51)***
2	0.0017 (6.89)***	0.0014 (6.90)***	0.0007 (4.31)***	0.0008 (5.08)***	0.0005 (3.80)***	0.0005 (3.85)***
3	-0.0003 (-1.45)	-0.0001 (-0.41)	-0.0002 (-1.36)	-0.0001 (-0.52)	-0.0001 (-1.01)	-0.0001 (-0.60)
4	-0.0002 (-1.36)	-0.0001 (-0.32)	-0.0002 (-1.33)	-0.0001 (-0.49)	-0.0001 (-0.98)	-0.0001 (-0.62)
			Panel B: γ_1			
1	-0.0002 (-0.29)	-0.0009 (-1.62)	0.00001 (0.03)	-0.0003 (-0.85)	-0.0001 (-0.44)	-0.0001 (-0.44)
2	-0.0002 (-0.35)	-0.0008 (-1.52)	0.0001 (0.18)	-0.0003 (-0.83)	-0.0001 (-0.36)	-0.0001 (-0.26)
3	0.0001 (0.20)	-0.0003 (-0.65)	0.0002 (0.51)	0.0000 (0.11)	0.0000 (0.13)	0.0000 (0.14)
4	0.0001 (0.18)	-0.0003 (-0.65)	0.0002 (0.52)	0.0000 (0.09)	0.0000 (0.14)	0.0001 (0.16)
			Panel C: γ_2			
1	0.0013 (1.87)*	0.0006 (1.16)	0.0007 (1.38)	0.0002 (0.47)	0.0001 (0.40)	0.0002 (0.05)
2	0.0015 (2.18)**	0.0006 (1.03)	0.0006 (1.28)	0.0001 (0.30)	0.00001 (0.04)	-0.0001 (-0.36)
3	0.0005 (0.96)	0.0003 (0.73)	0.0003 (0.76)	0.0001 (0.30)	-0.0001 (-0.15)	-0.0001 (-0.24)
4	0.0006 (1.04)	0.0003 (0.72)	0.0003 (0.75)	0.0001 (0.28)	-0.0001 (-0.20)	-0.0001 (-0.32)
			Panel D: γ_3			
1	-0.0010 (-1.43)	-0.0007 (-1.23)	-0.0002 (-0.48)	-0.0002 (-0.60)	0.0000 (0.10)	-0.0002 (-0.64)
2	-0.0008 (-1.19)	-0.0006 (-1.05)	-0.0001 (-0.18)	-0.0002 (-0.46)	0.0000 (0.06)	-0.0001 (-0.47)
3	-0.0002 (-0.34)	-0.0003 (-0.73)	0.0000 (0.03)	-0.0001 (-0.17)	0.0001 (0.20)	0.0000 (0.04)
4	-0.0002 (-0.40)	-0.0003 (-0.71)	0.0000 (0.07)	-0.0001 (-0.15)	0.0001 (0.19)	0.0000 (0.06)
			Panel E: θ			
2	-0.2000 (-51.16)***	-0.2000 (-51.15)***	0.2001(-51.14)***	-0.2000 (-51.13)***	-0.2001 (-51.13)***	-0.2001 (-51.14)***
4	-0.0325 (-9.17)***	-0.0325 (-9.18)***	-0.0325 (-9.18)***	-0.0325 (-9.18)***	-0.0326 (-9.18)***	-0.0326 (-9.20)***
			Panel F: δ			
3	-0.8869 (-157.00)***	-0.8865 (-157.05)***	-0.8866 (-157.19)***	-0.8865 (-157.16)***	0.8866 (-157.23)***	-0.8864 (-157.17)***
4	-0.8691 (-145.67)***	-0.8688 (-145.73)***	-0.8690 (-145.87)***	-0.8688 (-145.85)***	-0.8689 (-145.92)***	-0.8687 (-145.86)***

Table 6 Tests for increasing misreaction of alternative investor categories

This table presents the estimation results to examine the existence of increasing misreaction of alternative investor categories. The full model referred to Model 4 is specified as:

$$FarMisProj_t = \alpha + \beta QPrevSim_t^w + \sum_{i=1}^{3} \gamma_i \cdot D_{i,t} \cdot QPrevSim_t^w + \theta V_t + \delta \,|\, \Delta V_t^{\text{Unexpected}} \,| + \varepsilon_t$$

where D_1, D_2 and D_3 are used to control for the intraday pattern in the $FarMisProj_t$ variable, V_t is used to control for the impact of the current level of instantaneous variance, and $|\Delta V_t^{\text{Unexpected}}|$ is used to control for the impact of underreaction or overreaction. $QPrevSim_t^w$ measures the quantity of previous similar unexpected changes in instantaneous variance variable defined as:

$$QPrevSim_t^w \equiv \text{sign}(\Delta V_t^{\text{Unexpected}}) \sum_{i=1}^{w} \text{sign}(\Delta V_{t-i}^{\text{Unexpected}}) \cdot$$

With several sets of constraints on some particular parameters, we also run the following three alternative models:

Model 1: Base model: $\theta = \delta = 0$.

Model 2: Controlling for the impact of overreaction: $\delta = 0$.

Model 3: Controlling for the impact of underreaction: $\theta = 0$.

The sample period covers from January 2, 2002 to December 31, 2005. The regression models are estimated from the marketwise observations. The coefficients and *t*-statistics are reported. The *t*-statistics are calculated using the Newey-West robust standard errors. ***, ** and * denote the significance at the 1%, 5% and 10% levels, respectively. As the estimation results of γ_1, γ_2, γ_3 and θ are similar to those from marketwise observations and similar across investor classifications, they are not reported to avoid providing redundant information.

Parameter	Model	Window size					
		1	2	3	4	5	6
Panel A: Domestic Institutional Investors							
β	1	0.0083 (31.63)***	0.0058 (29.61)***	0.0046 (29.68)***	0.0037 (28.79)***	0.0030 (27.71)***	0.0026 (27.53)***
	2	0.0057 (21.77)***	0.0033 (17.01)***	0.0024 (15.41)***	0.0017 (13.37)***	0.0012 (11.46)***	0.0010 (10.70)***
	3	-0.0005 (-2.66)***	-0.0004 (-3.01)***	-0.0003 (-2.78)***	-0.0002 (-2.33)**	-0.0002 (-3.13)***	-0.0002 (-3.09)***
	4	-0.0004 (-2.43)***	-0.0003 (-2.67)***	-0.0002 (-2.41)***	-0.0001 (-1.88)**	-0.0002 (-2.71)***	-0.0001 (-2.67)***
δ	3	-0.8583 (-228.14)***	-0.8577 (-228.77)***	-0.8576 (-228.89)***	-0.8568 (-229.11)***	-0.8576 (-229.41)***	-0.8576 (-229.59)***
	4	-0.8604 (-216.82)***	-0.8595 (-217.84)***	-0.8592 (-218.23)***	-0.8587 (-218.50)***	-0.8590 (-218.77)***	-0.8589 (-218.91)***
Panel B: Foreign Institutional Investors							
β	1	0.0027 (12.92)***	0.0020 (14.94)***	0.0015 (14.81)***	0.0012 (15.13)***	0.0010 (14.79)***	0.0008 (14.96)***
	2	0.0003 (1.46)	0.0001 (1.28)	-0.0000 (-0.07)	-0.0003 (-0.44)	-0.0001 (-1.06)	-0.0001 (-1.23)
	3	-0.0027 (-13.47)***	-0.0015 (-11.15)***	-0.0011 (-11.02)***	-0.0008 (-10.22)***	-0.0006 (-9.99)***	-0.0005 (-9.65)***
	4	-0.0037 (-17.79)***	-0.0023 (-16.79)***	-0.0018 (-17.37)***	-0.0014 (-16.97)***	-0.0011 (-16.89)***	-0.0009 (-16.72)***
δ	3	-0.4763 (-90.25)***	-0.4708 (-89.33)***	-0.4697 (-89.45)***	-0.4682 (-89.36)***	-0.4671 (-89.39)***	-0.4663 (-89.34)***
	4	-0.4508 (-83.53)***	-0.4466 (-83.20)***	-0.4455 (-83.37)***	-0.4440 (-83.31)***	-0.4427 (-83.26)***	-0.4419 (-83.21)***
Panel C: Individual Investors							
β	1	0.0020 (7.96)***	0.0020 (9.24)***	0.0013 (7.22)***	0.0011 (6.89)***	0.0009 (5.75)***	0.0007 (5.13)***
	2	0.0019 (7.43)***	0.0017 (8.35)***	0.0011 (6.13)***	0.0009 (5.84)***	0.0006 (4.50)***	0.0005 (3.75)***
	3	-0.0004 (-1.95)*	0.00003 (0.21)	-0.0001 (-0.77)	-0.0001 (-0.67)	-0.0001 (-0.97)	-0.0001 (-1.18)
	4	-0.0003 (-1.89)*	0.00003 (0.20)	-0.0001 (-0.83)	-0.0001 (-0.73)	-0.0001 (-1.08)	-0.0001 (-1.33)
δ	3	-0.9134 (-182.32)***	-0.9126 (-182.17)***	-0.9129 (-182.35)***	-0.9128 (-182.38)***	-0.9129 (-182.44)***	-0.9129 (-182.44)***
	4	-0.8987 (-170.52)***	-0.8979 (-170.42)***	-0.8982 (-170.60)***	-0.8981 (-170.63)***	-0.8982 (-170.70)***	-0.8982 (-170.68)***
Panel C: Market makers							
β	1	0.0062 (19.51)***	0.0044 (17.43)***	0.0037 (17.37)***	0.0028 (15.25)***	0.0024 (14.48)***	0.0021 (14.59)***
	2	0.0045 (14.47)***	0.0026 (10.69)***	0.0020 (9.53)***	0.0012 (6.55)***	0.0008 (5.20)***	0.0006 (4.62)***
	3	-0.0000 (-0.37)	-0.0002 (-1.23)	0.0001 (0.80)	-0.0001 (-0.58)	-0.0001 (-0.66)	-0.0000 (-0.15)
	4	-0.0003 (-1.34)	-0.0005 (-2.81)**	-0.0002 (-1.23)	-0.0004 (-2.93)**	-0.0004 (-3.23)***	-0.0003 (-2.97)***
δ	3	-0.8576 (-198.42)***	-0.8577(-198.75)***	-0.8570 (-198.85)***	-0.8576 (-199.20)***	-0.8575 (-199.27)***	-0.8574 (-199.27)***
	4	-0.8264 (-181.76)***	-0.8266 (-182.24)***	-0.8261 (-182.82)***	-0.8265 (-182.70)***	-0.8264 (-182.77)***	-0.8263 (-182.81)***

Table 7 Tests for investor misreaction with daily marketwise observations

This table presents the estimation results of the three regression models detailed in Tables 3-5 with daily marketwise observations. Since there is no periodic pattern for daily observations, the variables used to control for the autocorrelation and intraday patterns are excluded here. For the convenience of reading the reported figures, the three models are listed as follows and the details of the definitions of the included variables are referred to the notes of Tables 3-5.

$$FarMisProj_t = \alpha + \beta \,|\, \Delta V_t^{\text{Unexpected}} \,| + \varepsilon_t \quad \text{(T7-1)}$$

$$V_t^{\text{Long}} - V_t^{\text{Short}} = \alpha + \beta V_t + \varepsilon_t \quad \text{(T7-2)}$$

$$FarMisProj_t = \alpha + \beta QPrevSim_t^w + \theta V_t + \delta \,|\, \Delta V_t^{\text{Unexpected}} \,| + \varepsilon_t \quad \text{(T7-3)}$$

The sample period covers from January 2, 2002 to December 31, 2005. The coefficients and *t*-statistics are reported. The *t*-statistics are calculated using the Newey-West robust standard errors. ***, ** and * denote the significance at the 1%, 5% and 10% levels, respectively.

	Short-horizon underreaction (T7-1)		Long-horizon overreaction (T7-2)		Increasing misreaction (T7-3)	
	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.	Coeff.	*t*-Stat.
α	0.0015	1.28	0.0190	4.87	0.0005	0.22
Β	-0.9103	-9.87***	-0.6346	-8.23***	0.00001	0.01
Θ	-	-	-	-	0.0172	0.40
δ	-	-	-	-	-0.9211	-11.22***
Adj. R^2	0.3193		0.3972		0.3182	