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Preopen Information Content of Option Volume and Trading Strategies: Evidence from the Taiwan Index Market

Wen-liang G. Hsieh Huimin Chung Huei-Ru He*

Abstract

This paper examines the ability of preopen index option trading to predict subsequent stock index returns. Using the imbalance between positive volume (long calls and short puts) and negative volume (short calls and long puts) as a proxy of trading intention, we find that on days of index decline, foreign institutions' option volume imbalance facilitates predicting the subsequent spot index opening returns up to 25 min after spot market opening. This suggests that foreign institutions are informed traders in Taiwan. When engaging in informed trading, foreign institutions prefer medium-sized trades, out-of-the-money options, and medium-term options to balance the trade-off among leverage, liquidity, and the option characteristic of value decay over time. The predictive ability of foreign institutions is enhanced significantly for days on which the NASDAQ index drops severely during the previous overnight interval, a finding that indicates that preopen option trading serves as the front line of the overseas contagion effect prior to the spot market opening. The informational role of options is found at the preopen interval but not during the regular trading session when options are traded side by side with spot assets, which indicates a unique price discovery role for options during the preopen trading session.

Keywords: preopen option trading; index options; option volume imbalance; informed trading; foreign institutions

JEL classification: G14

I. Introduction

Derivatives markets often open earlier and close later than do the market for the underlying spot asset, with the primary purpose of facilitating hedging activities and portfolio rebalancing when the spot market is closed. The earlier derivatives trading interval also allows traders who possess information during the overnight period to exploit informational advantages in the market of the underlying asset ahead of time. Derivatives trading during the preopen session may therefore involve price discovery on subsequent spot prices.

The extant literature provides evidence that the extension of trading hours in the index futures market enhances informed trading and results in a leading role for preopen index futures in price discovery.[1] However, little research focuses on the informational role of index options during the extended trading period which also facilitate informed trading beyond regular spot trading hours. To fill this gap, we examine the information content of option volume during the preopen interval (the option trading session prior to the spot market opening) and the postclose interval (the option trading session after the spot market closes). We identify the type of traders who possess valuable information by examining the predictive power of

[1] A number of studies have provided evidence for informed traders' activity on the extended futures market. For example, Hiraki, Takato, Maberly, and Takezawa (1995) and Cheng, Jiang, and Ng (2004) have found that unexpected returns from the extended futures trading could facilitate predicting stock returns and have thus suggested that the extended futures trading sessions contained useful private information. Chan, Chan, and Cheng (2002) and Chan (2005) have found that futures returns surrounding the market opening are relatively less volatile and have suggested a stronger information flow from the cash market to the futures market. Chang, Hsieh, and Lai (2013) documented a high proportion of informed traders during the preopen period, and found that their futures trading volume had a significant influence on subsequent spot price changes.

option volume contributed by various trader types during the postclose session of the previous day and the preopen session of the current day. The study furthermore investigates the various trading decisions faced by traders who are likely to possess superior information, including that regarding contract selection, trade size selection, and the extent to which their informed trading is contingent on overseas information.

Understanding the informational role of index options during the period when no trading takes place in the spot market has important practical implications. For investors who seek to benefit from observing others' trading, learning signals by tracing or mimicking order flows in the early opening arrangement of options is useful. Market makers can manage adverse selection risk by undertaking more effective hedging strategies in advance, especially when they face a large overnight information impact transmitted from overseas markets. Our finding of informed trading prior to the spot market opening also indicates that regulators should shift their attention to the preopen option market because of the associated potential for misuse of private information.

There have been two major strands of research on the impact of extended derivatives trading on spot price discovery. The first strand focuses on the information flow between the futures market and the spot market since the futures market was allowed to open earlier and close later than the spot market. These studies conducted before-versus-after comparisons of this regulation change and proposed that informed traders shift their trades from the spot market to the extended opening session of the futures market. Studies have generally reported an increase in trading volume, a reduction in volatility, and a lower correlation between the volatilities in the first 15 min of trading for both markets after the regulation change (Cheng and Cheng, 2000; Chan, Chan, and Cheng, 2002; Chan, 2005). Studies have also documented more concentrated informed trading during the preopen period than during the postclose period (Cheng, Jiang, and Ng, 2004; Lee, Chien, Chen, and Huang, 2009). Because new information arrives during the overnight period, a portfolio that is optimal at the previous close is no longer optimal when the market reopens. This causes traders with superior information to tend to exploit their advantages through the use of opening futures transactions.

The second strand concerns the ability of the information content of extended futures trading in explaining or predicting subsequent spot returns. Hiraki, Takato, Maberly, and Takezawa (1995) analyzed this issue and found a significant and positive relationship between the unexpected components of end-of-day Nikkei 225 index futures returns and overnight spot returns. Cheng, Jiang, and Ng (2004) extended the model of Hiraki et al. (1995) and examined the information content of Hang Seng index futures during both the preopen session and the postclose session. They suggested that preopen return innovations are useful in either explaining the overnight spot returns or predicting the subsequent regular hour spot returns. Similar results with regard to the instructiveness of preopen return innovations on the Taiwan index futures market were published by Lee, Chien, Chen, and Huang (2009).

Our work is closely related to the second strand of literature, and differs from previous studies in that we examine the predictive power of index options rather than index futures. The literature suggests that the option market attracts informed trading by providing high leverage (Black, 1975), low transaction costs (Fleming, Ostdiek, and Whaley, 1996), and the flexibility to engage in volatility-related trading strategies that are unavailable on the futures market (Chaput and Ederington, 2005; Ni, Pan, and Poteshman, 2008). Option trading during the preopen period can thus generate rich information content regarding spot prices at opening

if informed traders choose to exploit their overnight information on the option market first.

Previous studies on the information content of options have focused almost exclusively on the regular trading session during which the spot asset and the option are traded side by side, with much less emphasis on the extended trading activity when no trading occurs on the spot market. Chang, Hsieh, and Lai (2013) first analyzed this issue, with their findings indicating little or no information on the option volume of extended trading. However, they found a temporary price impact on subsequent stock index returns when the aggregate option volume was divided into trade size, investor classes, and option types. In this study, we target extended option volume and examine its ability to predict subsequent stock index returns in order to interpret the informational role of options when no trading takes place on the spot market.

We employ a negative-to-total volume ratio for newly opened option positions as the measure of informed trading, similar to the measures used in Pan and Poteshman (2006) and Chang, Hsieh, and Lai (2009). Specifically, we separate the aggregate open volume into positive volume (long calls and short puts) and negative volume (long puts and short calls). To analyze the trading intention of various trader types, the signed volume ratio is constructed separately for individual investors, market makers, foreign institutions, and domestic institutions. We then construct the negative-to-total volume ratio for each class of investors during the preopen and the postclose sessions, and examine the ability of volume ratios to predict subsequent stock index returns during the overnight and the spot market opening periods.

Our results show that foreign institutions' option trading during the spot preopen period is informative regarding future changes in the index, whereas transactions by other classes of traders are largely uninformative. This is generally consistent with the finding in many of the emerging derivative markets that foreign institutions played an aggressive informational role (Chou and Wang, 2009; Grinblatt and Keloharju, 2000; Kang and Park, 2008). Our analysis discovers new evidence that foreign institutions use option preopen transactions to capitalize on their informational advantages prior to other actors in the stock market; as a result, their option preopen volume conveys useful information regarding future spot index returns.

The volume imbalance measure of foreign institutions during the preopen period provides richer information content in a downward market than in an upward market. The foreign institutions' volume imbalance markedly predicts the first-minute opening returns of the spot index when the spot market moves downward but not when it moves upward. This is consistent with the suggestion of Chan, Chang, and Lung (2009) that the short-sale constraints imposed on the Taiwan equity markets hinder transactions that are initiated upon bearish information. As a result, informed traders tend to switch their trading to index options, particularly when they wish to adopt short positions.

When we examine preopen option trades across different trade sizes, we discover that medium-sized trades contain richer information regarding future changes in the index. The evidence is consistent with the stealth-trading theory that states that informed traders prefer to use medium-sized trades to conceal their trading intentions and to reduce the market impact costs associated with large trades.

We find that foreign institutions are likely to choose out-of-the-money (OTM) and medium time-to-maturity options to engage in their information-based transactions, because both types of options provide richer information for subsequent index movements at opening than

do options of other moneynesses and maturities. The contract selections of informed traders reflect a reasonable consideration among various desirable option characteristics, including high leverage, optimal liquidity, high sensitivity (large delta on OTM options), and slower time decay (low theta on medium-term options).

We find that the predictive ability of foreign institutions' option imbalance increases substantially on days on which the NASDAQ index drops severely during the overnight interval, indicating that preopen option trading incorporates information from foreign markets. When intensive information is transmitted from overseas major markets, foreign institutions' option volume imbalance can predict the subsequent spot index up to 25 min after spot market opening. The results suggest that the preopen option trading serves as the front line of the overseas contagion effect by updating information prior to the spot market opening. Finally, this informational role for options is found to be exclusive at the preopen interval but not during other intraday intervals of the regular trading session when options are traded side by side with spot assets.

The remainder of this paper is organized as follows: The predictive regression model used to examine the information content of the option volume ratio is presented in Section II, followed in Section III by an introduction to the trading mechanism for Taiwan index options (TXOs) and a description of the data adopted in our analysis. The empirical results are subsequently presented in Section IV. Finally, the conclusions drawn from this study are presented in Section V.

II. Methodology

In this study, we examine the ability of preopen option volume to predict subsequent index returns as evidence of informed trading beyond the regular trading session. Option signed volume is used as the indicator for the process of price discovery: if traders possess positive information on future prices, they can buy a call or sell a put for an increase in the future stock price; otherwise, they can sell a call or buy a put to obtain a downside profit. Easley, O'Hara, and Srinivas (1998) and Pan and Poteshman (2006) have provided direct evidence in support of this linkage. Their findings indicate that the signed trading volume in the option market can facilitate forecasting stock returns. Cao, Chen, and Griffin (2005) subsequently found abnormal call volume prior to takeover announcements; thus, they concluded that option trading is driven to a specific direction ahead of an extreme information shock. Numerous studies have examined this phenomenon and used the signed volume ratio to test informed trading in the option market (Chang, Hsieh, and Lai, 2009; Hsieh and He, 2014; Pan and Poteshman, 2006).

Following Schlag and Stoll (2005), we divide new opening option positions into positive volume and negative volume to extract the information content from trading imbalance. We focus on new opening options instead of existing option positions because Pan and Poteshman (2006) advocated that newly opened positions can reflect the information possessed by traders who have superior information, whereas closure transactions are used to realize profits or stop losses in their existing positions. Positions already opened, either long or short, do not reflect the most recent change in their view as the newly entered positions do. The new purchase of a call and the sale of a put are categorized as positive volume because both types of trade indicate that the traders are optimistic about the subsequent index value. The new sale of a call and the purchase of a put are categorized as negative volume because traders enter such positions when they predict downward movement of the underlying asset.[2]

[2] A number of studies applied the Lee and Ready (1991) approach to identify buyer- and seller-initiated traders on the basis of the transaction price above or below the mid-point of the prevailing bid-ask spread. Accordingly,

We construct the negative-to-total volume ratio (hereafter NR) by dividing the negative volume of new opening positions (open-buy puts and open-sell calls) by the sum of positive and negative open volume to extract the information content from trading imbalance. The NR volume ratio is defined as

$$NR_t^j = \left(\frac{NV_t^j}{PV_t^j + NV_t^j} \right) \quad (1)$$

where NV_t^j and PV_t^j are the respective numbers of the open volume for negative and positive positions during session j (j = preopen, postclose) on day t.

One potential concern with the NR ratio is that some traders could consistently hold a higher NR ratio for reasons irrelevant to new information.[3] To address this concern, we measure the information content in trading imbalance using the ΔNR, the difference between the daily NR ratio and its rolling monthly average.[4] The ΔNR is defined as

$$\Delta NR_t^j = \frac{NR_t^j - \overline{NR^j}}{\overline{NR^j}} \quad (2)$$

where $\overline{NR^j}$ is the average NR ratio in the preceding month (4 weeks) for session j (j = preopen, postclose). We choose the 1-month baseline NR level because the TXO contract is settled in a monthly cycle, which forces the TXO traders to roll over their positions and reconstruct option portfolios. By adopting the change-based specification for calculating abnormal levels of NR, we mitigate the influence of persistent trading characteristics that may arise when sorting options on the basis of the level of NR. A positive ΔNR indicates that traders are less optimistic about the index value, thus selling more calls and buying more puts. We separately calculate the ΔNR during the preopen and the postclose session for every trading day, denoted as $\Delta NR_{i,t}^{pre-open}$ and $\Delta NR_{i,t}^{post-close}$.

Chakravarty (2001) noted that orders submitted by individual and institutional investors generate different price impacts. Chen, Johnson, Lin, and Liu (2009) argued that, given equal access to the same public information, foreign institutions more effectively use such information and thus obtain greater positive abnormal returns than other traders do. We separately calculate the ΔNR volume ratios using trade records of four investor classes: foreign institutions, domestic institutions, market makers, and individual traders. We also separately measure the option information in up versus down markets. Figlewski and Webb (1993) and Danielsen and Sorescu (2001) have suggested that options are more convenient

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only aggressive informed traders were recorded, whereas those with greater patience (submitting limit orders) were omitted. In this study, detailed records on open versus close and buy versus sell options enable us to directly identify motivations behind each transaction, and thus, we can extract more precise information comprehended in option volume.

[3] For example, Lakonishok, Lee, and Poteshman (2004) suggested that hedgers tended to open-sell call options for the purpose of generating covered calls, and thus their portfolios are consistently larger in short call positions relative to long call positions.

[4] For similar reasons, Johnson and So (2012) constructed the option-to-stock (O/S) volume ratio for the predictability of bearish information content. To prevent bias of their information variable because of some firms consistently employing a higher O/S volume ratio, they standardized the O/S ratio by dividing the difference between the daily O/S and the average O/S in the prior 6 months by the same average O/S in the prior 6 months. The authors claimed that the ΔO/S mitigates the influence of persistent firm characteristics and enhances the robustness of the prediction to future returns.

trading vehicles than spot assets in a downward market because of the short-sale restrictions on spot markets. With the ability to create short positions without first borrowing shares, options may be used as a vehicle for trading in response to bad news and thus reflect bad news more quickly than they do good news. Our empirical model incorporates such asymmetric responses to up versus down markets.

If informed traders use the extended trading sessions of option markets to exploit their superior information before the spot market opening, we expect that the postclose option volume of the previous day ($\Delta NR_{i,t-1}^{post-close}$) and preopen option volume of the current day ($\Delta NR_{i,t}^{pre-open}$) are related to the next opening spot returns. Alternatively, if option traders do not possess superior information, then their trading during the extended sessions reflects the current information but not the future index movement. In this case, the option volume imbalance during the preopen interval should be related to the overnight spot returns but not the after-open subsequent spot returns. We used the following regression model to test whether option volume during the preopen trading period conveys future information or merely reflects past information.

$$\begin{aligned} R_t = {} & \alpha + \beta_{i,t,up}^{pre-open} \Delta NR_{i,t}^{pre-open} \times D_t + \beta_{i,t-1,up}^{post-close} \Delta NR_{i,t-1}^{post-close} \times D_t \\ & + \beta_{i,t,down}^{pre-open} \Delta NR_{i,t}^{pre-open} \times (1 - D_t) + \beta_{i,t-1,down}^{post-close} \Delta NR_{i,t-1}^{post-close} \times (1 - D_t) + \varepsilon_t \end{aligned} \quad (3)$$

$$D_t = \begin{cases} 1, & R_t > 0; \\ 0, & otherwise \end{cases}$$

where the dependent variable R_t could be the overnight index returns ($R_t^{overnight} = ln\, S_t^{open} - ln\, S_{t-1}^{close}$) or the intraday index returns within 1 min of opening ($R_t^{1\ min} = ln\, S_t^{1\ minute\ of\ opening} - ln\, S_t^{open}$); $\Delta NR_{i,t}^{pre-open}$ is the negative-to-total option volume ratio as defined in equation (2), calculated from the transactions of trader class i during the preopen session on day t; $\Delta NR_{i,t-1}^{post-close}$ is the negative-to-total option volume ratio during the postclose session on the previous day t-1; and D_t is a dummy variable that distinguishes the market as upward or downward, and is equal to 1 if the dependent variable R_t is positive and 0 otherwise.[5]

A negative and significant β_{up} (β_{down}) suggests that higher index returns are associated with an increase in the positive option volume ratio (or a decrease in the negative option volume ratio) during extended sessions. A statistically significant β_{up} (β_{down}) when $R_t^{1\ min}$ is used as the regression dependent variable indicates the tendency for using option extended trading to realize the informational advantages when the stock market remains closed. If the ΔNR volume ratio of a particular trader class, say, foreign institutions, reflects concurrent index movements or predicts the subsequent index returns, then we would observe significantly

[5] Because options are often used for downside profits to avoid equity short-sale constraints, the separation of up and down markets on the basis of the index returns on day *t* can directly facilitate examining the effect of short-sale constraints on option informed trading. The up/down dummy variable is widely applied in numerous studies concerning asymmetric informed trading in up versus down markets. For example, Chordia, Roll, and Subrhmanyam (2002) examined the relationship between the provision of aggregate market liquidity and order imbalances, while controlling for daily positive versus negative index movements; Hameed, Kang, and Viswanathan (2010) investigated the effect of market returns on the stock bid-ask spread, conditional on an up or down market return dummy on day *t*. Other examples for the effect of short-sale constraints in up versus down markets have been provided by Chang, Cheng, and Khorana (2000), Brockman and Chung (2008), and Chen and Rhee (2010).

negative β coefficients in the corresponding regressions.

III. Institutional Background and Data

The TXO contract was launched on the Taiwan Futures Exchange (TAIFEX) in December 2001, and it has quickly become one of the most actively traded derivatives in the world.[6] The contract is a European-style option that is based on the most popular stock index: the TAIEX index, a broad-base, value-weighted index consisting of all listed stocks on the Taiwan Stock Exchange (TWSE). Five delivery months are available on any trading day: the spot month, the next two calendar months, and the next two quarter months. The exchange offers contracts with strike prices in every 100 index points for the spot month and the next two calendar months and every 200 index points for the additional two quarter months. The final trading day is the third Wednesday of the delivery month. The notional value of each option is based on a multiplier of NT$50 per index point.

The option market opens at 8:45 a.m., 15 min earlier than does the underlying TWSE spot market, and closes at 1:45 p.m., 15 min later than does the spot market, as shown in Figure 1. Traders who possess information during the spot nontrading period can trade on the postclose session or preopen session of the option market to reconstruct their portfolio in advance before other traders start to trade on the following trading day. Although the TWSE also accepts order submissions prior to its open, from 8:30 a.m. to 9:00 a.m., and after the regular spot trading closes, from 2:00 p.m. to 2:30 p.m., no trade takes place on the spot market during these periods.[7] Thus, the earlier opening and later closing of the option market potentially enable price discovery regarding the underlying spot assets. Traders who possess superior information can choose the extended derivatives session rather than choose the regular spot trading session to capitalize on their informational advantages. As a result, derivatives trading during the extended sessions may contain more complete information for the subsequent price changes on the following trading day.

Refer Figure 1

Our data comprises the complete history of trade executions of the TXO index option from January 1, 2007 to June 30, 2008, provided by the TAIFEX. The trade execution file records information concerning every matched trade for both sides (buy and sell), including the date, time, investor account ID, investor class (individual, domestic institution, foreign institution, or market maker), a buy or sell indicator, trade price, volume, and option characteristics (a call or put indicator, maturity month, and strike price). One unique feature of the dataset is that it reveals whether the transaction is to open a new position or to close (the offsetting) an existing position. The open or close indicator, together with the buy or sell indicator enables us to divide the aggregate option volume into four groups: open buying calls, open selling puts, close buying calls, and close selling puts. Because traders are likely to use open trades to reflect their informational advantages, we expect that open option trades contain more complete information than closure trades, which are often used as a means of realizing profits or stopping losses in their existing positions.

[6] The trading volume of TXO contracts was ranked the fourth in 2007 and fifth in 2008 among all index options traded worldwide, according to the annual report of the World Federation of Exchanges.

[7] Orders submitted during the postclose interval are batched and matched once at 2:30 p.m. using the 1:30 p.m. spot market close price. Because the orders are matched at the pre-existing close price, the postclose trade at 2:30 p.m. on the spot market provides no price discovery and facilitates liquidity trading but not informed trading.

In this study, we focus on the information content of directional trades only, that is, trades that are based on examining either upward or downward movement of the underlying index. Thus, we select trades that involve purely plain-vanilla option positions, and exclude straddle, strangle, money spread, and calendar spread trade transactions. We further remove trading of options with maturities of fewer than 5 days to mitigate the expiration day effect.

We divide the option trading session into three periods: the preopen period (from 8:45 a.m. until 9:00 a.m.), the regular hours trading period (from 9:00 a.m. until 1:30 p.m.), and the postclose period (from 1:30 p.m. to 1:45 p.m.) (Figure 1). The positive and negative option volume, within each trading period, is measured separately for four types of investors: foreign institutions, domestic institutions, individual investors, and market makers. Figure 2 depicts the positive volume and negative volume within every 15-min interval for each investor class, with a finding of the largest volume contribution from individual investors, followed by market makers and foreign institutions, and the smallest from domestic institutional investors.

Refer Figure 2

The intraday option volume exhibits a U-shaped pattern, indicating greater activity around the pretrading interval, the spot market opening, and the postclose interval; the U-shaped pattern is the most discernible for individual traders but the least discernible for foreign institutions. The greater volume at market opening, according to Brock and Kleidon (1992) and Gerety and Mulherin (1992), reflects the demand for rebalancing portfolios in response to information that emerged overnight. Informed trading conducted by traders who obtained private information during the overnight interval can also contribute to the large opening volume. The greater volume at market close, according to Cheng, Jiang, and Ng (2004) and Chang, Hsieh, and Lai (2013), can be largely attributed to liquidity-motive trading. Because high volume attracts traders to exploit their informational advantages without incurring large market impact costs, in this study, we focus on the high-volume periods and examine the traders' possession of superior information.

Figure 2 shows that institutional traders tend to contribute a greater negative volume (short calls plus long puts) than positive volume (long calls and short puts), whereas individual investors prefer positive volume. This suggests that institutional investors are the major traders that use options to realize their bearish view. The finding is consistent with Lee and Wang (2012), who demonstrated that institutional investors that possess superior trading skills are likely to trade on negative information, whereas individual investors' trades are primarily long position trades.

In Table I, the option volume of each trader class during the extended trading sessions is divided into proportions in long call, short call, long put, and short put, with the proportions summing to unity within each trader class. As shown in Panel A, foreign institutions prefer to engage in open-buy option trading, exhibiting the greatest proportion (among all trader classes) of such trading, which sums to 72.37% of their total volume (38.17% in long calls and 34.20% in long puts). Pan and Poteshman (2006) asserted that, because long calls (puts) yield greater profits than do short puts (calls) if the underlying index moves upward (downward), the aggressive open buying can be deemed to signify possession of superior information.[8] Our finding of the aggressive open buying of foreign institutions therefore

[8] Pan and Poteshman (2006) reported that information exploitation is closely related to long calls or long puts, rather than short puts or short calls, essentially because the worse-case scenario in buying an option is the loss of

indicates that they possess valuable information. In subsequent sections, we examine whether the aggressive open buying of foreign institutions correctly predicts subsequent stock index returns at opening.

Refer Table I

In Panel B, each aggregate volume proportion in Panel A is allocated to three trade size groups: "small" for fewer than 5 option contracts, "medium" for 5–10 contracts, and "large" for more than 10 contracts. There are significant differences across the three size groups and across the four types of investors. Foreign institutions and market makers engage in a large proportion of medium-sized trades; domestic institutions and individual investors, however, trade more equally between small and medium groups. Large trades are rare for all types of investors. The heavy usage of medium-sized trades (as opposed to large trades) by foreign institutions implies the need for an order-splitting strategy during the preopen interval. This is different from what was suggested by Blau, Van Ness, and Van Ness (2009), who demonstrated that the high liquidity at market opening provides an ideal means for information exploitation, so that informed trading can be executed using larger sizes at market opening. To verify the tendency and the need for order splitting during the preopen period, we compare the predictive ability of option trades in the three size groups in section IV.B. If medium-sized trades consist of more information content, then the result suggests that option-informed traders use fragmented orders to conceal their informed trading during the preopen session.

In Panel C, the proportion of aggregate volume is categorized according to option moneyness: in- or near-the-money (INTM) options are calls and puts with strike-to-spot ratios of between 0.98 and 1.02; OTM options are calls with strike-to-spot ratios of between 1.02 and 1.07 and puts with strike-to-spot ratios of between 0.93 and 0.98; and the remainder is classified as deeply out-of-the-money (DOTM) options. As can be observed from this panel, foreign institutions have the largest volume proportion (51.8%) of OTM contracts. Panel C thus indicates that foreign institutions, the potential informed traders, attempt to maximize potential profits by using high-leverage OTM options.

In Panel D, the aggregate volume proportion is separated into short-term (fewer than 30 days), medium-term (30–90 days), and long-term (more than 90 days) options. Short-term options clearly attract the largest share of trading for every investor class, perhaps because the short-maturity options are more effective instruments for hedging traders' equity exposure (Han, Lee, and Liu, 2009). Foreign institutions have a greater interest in medium-term options, devoting 24.76% of their trading to medium-term options, whereas other traders contribute only roughly 10% of their trading volume to medium-term options. Because foreign institutions are plausible informed traders, their greater trading proportion in medium-term options may afford such options higher predictive ability. Section IV.C provides empirical evidence regarding this conjecture.

IV. Empirical Results

A. Identifying informed traders during the stock market preopen period

Table II presents the regression results of Equation (3) obtained using the current day's preopen ΔNR volume ratio and the previous day's postclosing ΔNR volume ratio as

the option premium, whereas the upside gain is substantially large if the underlying asset moves toward the anticipated direction. By contrast, the best-case scenario of selling an option is the option premium, but the downside loss is quite substantial if the underlying asset moves against the anticipated direction.

regressors against the overnight index returns and the first-minute index returns at spot market opening. The regression is separately performed for option ΔNR ratios of four investor classes, with explanatory power for the past overnight index returns shown in Panel A and the predictive result for the subsequent index returns within 1 min of opening shown in Panel B. A significant and negative β coefficient indicates the informativeness of option volume during the specific trading interval.

Refer Table II

In Panel A, the preopen option trading is found to significantly explain the overnight spot returns. This is true for all types of institutional investors but not for individual investors' option volume. The finding is unsurprising because the preopen option session overlaps the last 15 min of the spot market overnight interval (Figure 1). The preopen option trading ought to reflect the information that already occurs during the overnight interval, namely, the overnight returns of the spot index. The significant $\beta_t^{pre-open}$ here merely indicates that the spot and option markets during the same period reflect similar information.

A significant $\beta_{t-1}^{post-close}$ in Panel A, however, suggests that option trading during the postclose interval on day t-1 predicts subsequent overnight spot returns because the option postclose session takes place in the first 15 min of the spot market overnight interval. This is evident in the trading volume of foreign institutions but not in that of any other trader types, suggesting a stronger predictive ability of foreign institutions' option trading than that of trading by other option market participants.

In Panel B of Table II, which shows the results of regressing the 1-min opening index returns against option volume information variables, we again find that foreign institutions' option volume can significantly predict the 1-min spot market opening returns. This indicates that some foreign institutions that possess more superior information than do other types of traders exploit their informational advantage by trading options during the preopen interval. The predictive power of foreign institutions, nevertheless, is present only on days of downward index movement but not on days of upward index movement. The asymmetric predictive ability of the option market, according to Figlewski and Webb (1993), may be a result of the short-sale restrictions on the spot market, which makes derivatives more informative in a downward market than in an upward market. In Panel B, we find that market makers' preopen option trading is also significantly related to the opening 1-min spot index, showing a significantly negative coefficient. Note that market makers in Taiwan are obligated to fulfill the liquidity demand of other traders; their trades thus cannot be categorized as informed trading.[9] Because market makers provide much liquidity to individual traders, who tend to trade in the opposite direction of the opening spot index and have a significantly positive $\beta_{down}^{pre-open}$, the coefficient of market makers' preopen option volume thus tends to be negative.

In sum, we observe that the preopen option volume is more informative than the postclose option volume in Panel B. This finding is consistent with Brock and Kleidon (1992) and Gerety and Mulherin (1992), who argued that the new information arriving during the

[9] Market makers in the Taiwan option market are subject to TAIFEX rules that aim to strengthen the function of liquidity provision. The rules require a market maker to maintain a minimum response ratio to quotation queries, a short validating time for their quotes, and minimum quote delay. Market makers who fail to satisfy the minimum requirements do not qualify for a transaction fee reduction.

nontrading period renders a portfolio that was optimal in the previous close no longer optimal. Traders thus rush to adjust their portfolio at market opening. Our findings suggest that informed traders use the early opening of index options to exploit the information they received during the overnight period. Moreover, we identify foreign institutions as the primary informed traders during the preopen option trading session, with their preopen volume predicting the subsequent opening stock index returns and their postclose volume predicting the subsequent overnight index returns. Their information-based transaction in the preopen period is more prevalent in a downward market than it is in an upward market. Our subsequent analysis therefore focuses entirely on the predictive ability of foreign institutions in a downward market, exploring the trade size and the type of contract (moneyness and maturity) preferred by the informed foreign institutional traders.

B. Stealth trading and predictive ability of options in the preopen period

Kyle (1985) posited that informed traders are likely to engage in dynamic trading strategies or spread their orders over time to reduce the impact on prices and impede the process of disclosure of their valuable information. Barclay and Warner (1993) reported that medium-sized trades, as opposed to small or large trades, convey the richest information because informed traders conceal their information using mid-size trades. So far evidence consistent with the stealth trading hypothesis has been provided on stock markets (Alexander and Peterson, 2007; Chakravarty, 2001), index futures (Chou and Wang, 2009), equity options (Anand and Chakravarty, 2007), and index options (Hsieh and He, 2014). We are interested in whether mid-size trades during preopen option trading contain more information and thus more accurately predict future index movements, as postulated by the stealth trading hypothesis.

To investigate informed traders' stealth trading during the TXO preopen session, we examine the predictive ability of foreign institutions' option volume for three groups of trade sizes: small (fewer than 5 contracts), medium (5–10 contracts), and large (more than 10 contracts). The ΔNR volume ratio is calculated for each group of trade sizes, and the regression analysis is performed using Equation (3) for each size group. Any findings of a significantly negative β coefficient indicate that the ΔNR volume ratio is informative regarding the past overnight index returns or the first-minute opening spot returns.

Panel A of Table III illustrates how well preopen and postclose option volumes explain the overnight index returns and indicates that the preopen volume is closely related to the overnight index returns for every trade size group, with significantly negative β coefficients. The information effect is again more pronounced in the downward market than it is in the upward market because the $\beta_{down}^{pre-open}$ is more negative than $\beta_{up}^{pre-open}$. However, there is no discernible difference among the three trade size groups.

Refer Table III

Panel B of Table III shows the predictive regression of stock index returns in the first minute of market opening on the option preopen volume information variable. The preopen volume of medium-sized trades exhibits stronger predictive power for the first-minute stock index returns at opening, showing a negative $\beta_{down}^{pre-open}$ with statistical significance at a 5% level, followed by small trades, with marginal predictive ability at a 10% level of significance. Foreign institutions' large trades during the preopen period do not predict the subsequent opening spot index returns. The results are consistent with the predictions of Barclay and

Warner's (1993) stealth trading hypothesis, that traders with superior information use medium-sized trades for their information-based transactions to conceal their information and mitigate market impact costs. Our findings are also consistent with Anand and Chakravarty (2007), who demonstrated that option-informed traders favor fragmenting large trades into medium-sized trades.

C. Contract selection and predictive ability of preopen option volume

Multiple series of options are available to foreign institutions for their informed trading. When they focus more on greater profits, OTM options are their first choice because of the high leverage of these options (Black, 1975; Easley, O'Hara, and Srinivas; 1998). However, when informed traders are concerned mostly about transaction costs, in-the-money options appeal to them because of their narrow bid-ask spreads (Kaul, Nimalendran, and Zhang, 2004). In addition to option leverage, liquidity is another crucial consideration in contract selection for informed trading. Contracts with sufficient liquidity not only reduce market impact costs but also provide an ideal environment for hiding informed trading and thus are likely to be chosen as the means of informed trading. Admati and Pfleiderer (1988) suggested that informed traders prefer to camouflage their trades through large-volume liquidity trading. Table I shows that option liquidity is highly correlated to the time to maturity, with greater liquidity associated with shorter-term options. We therefore use time to maturity as a proxy for option liquidity. The predictive ability of option volume over different maturity ranges is provided in Table V.

In this section, we explore the contract choices of informed traders by examining the predictive ability of preopen option volume with respect to two characteristics of option contracts: moneyness and time to maturity. Specifically, we calculate the ΔNR volume ratio and compare the informativeness for three moneyness categories: DOTM, OTM, and INTM. Similarly, we divide preopen option trades according to three option maturities: short term (expiring within 30 days), medium term (expiring between 30 and 90 days), and long term (expiring after more than 90 days), and then perform the Equation (3) regressions for each option maturity category.

Table IV presents the results of the Equation (3) regressions for option trading in three moneyness categories. In Panel A, where overnight spot index returns are regressed against preopen and postclose option volume information variables, the DOTM and OTM options can more effectively explain the direction of overnight index movements than can the INTM options. In Panel B, significant predictability of the first-minute spot opening returns is found for trading in OTM options but not for that in INTM or DOTM options. The results suggest that foreign institutions prefer OTM options, perhaps because the high leverage of the OTM options can boost potential profits for trades that carry information about the future spot price.

Refer Table IV

Informed traders' selection of option time to maturity is unexpected. The medium-term options (with medium liquidity) exhibit significant ability to explain the overnight index returns and predict the subsequent 1-min opening index returns, whereas the most liquid contract, the short-term options, exhibit virtually no predictive ability. This finding is, nevertheless, consistent with those of Han, Lee, and Liu (2009) and Chang, Hsieh, and Lai (2009), who analyzed the TXO options and discovered more useful information content in medium- than in short-term options. The preference for informed trading in medium- rather

than short-term options is ostensibly odd because the short-term options possess sufficient liquidity, which assists informed traders in concealing their trading intentions. The disadvantage of short-term options may be related to the time-decay nature of options, the fact that the option value diminishes exponentially as the expiration date approaches. Informed traders who intend to avoid the value decaying over time prefer options with longer time to maturity when engaging in information-based transactions.

Refer Table V

Tables IV and V together show that informed trading during the TXO option preopen interval concentrates on OTM options and medium-term options. As suggested by Bakshi, Cao, and Chen (2000), OTM options have a greater delta when the options have a longer time to maturity. This prompts informed traders to select OTM options with a medium time to maturity to maximize payoffs from options given their information about the underlying asset. Our results indicate that informed traders carefully choose option contracts to balance the trade-offs between leverage, liquidity, sensitivity (delta), and time decay (theta).

D. Overseas contagion effect and option predictive ability

In the previous section, we present evidence of informed trading by foreign institutions during the preopen option trading session. In this section, we hypothesize that such informed trading is more likely to take place on days when crucial information is transmitted during the overnight interval from major overseas markets than on days without discernible information. On the basis of the argument of the information contagion effect (Bae, Karolyi, and Stulz, 2003; King and Wadhwani, 1990), new information released in one country is transmitted to other markets that are closed at the time. Traders who receive the information earlier then attempt to maximize their profits through preopen trading in the derivatives market, instead of waiting until normal trading hours in the stock market. Evidence supporting the overseas contagion effect has been provided by Cheng, Jiang, and Ng (2004) and Lee, Chien, Chen, and Huang (2009), who demonstrated that the return innovations of index futures during the preopen session were able to correctly predict the subsequent index returns during normal trading hours.

We identify the NASDAQ market as the primary overseas market that influences the preopen trading in TXOs, because stocks in high-tech-, electronic-, communication-, and computer-related industries account for a dominant proportion of the market capitalization of the TWSE. Many Taiwanese firms play a crucial role in the global supply chain in those industries and are profoundly affected by changes in the stock value of NASDAQ firms. In Table VI, we separate our sample period into two subsamples, one for days on which the NASDAQ index moves upward overnight (188 trading days), and another for days when the NASDAQ index moves downward (179 trading days). We report the results of regression using Equation (3) on each sample in Panels A and B. In Table VI, we extend the prediction horizon from 1 min to longer horizons up to 60 min after the spot market opens.

Refer Table VI

In Panel B of Table VI, which lists the days on which the NASDAQ index declines during the previous overnight interval, we find strong predictive ability for foreign institutions' preopen options trading on the subsequent spot index movements up to within 25 min of the spot market opening. However, option volume imbalance during the preopen interval cannot predict the spot opening returns on days of NASDAQ index rises (Panel A). The finding that

preopen informed trading using index options is particularly active following a decline in the NASDAQ index indicates that informed traders respond to pessimistic information originating from overseas markets but not optimistic information; in accordance with our previous findings, their trading during the preopen interval corresponds to subsequent downward movement of the spot index. Evidence supports the existence of the overseas contagion effect in the TXO preopen market and demonstrates that the effect is particularly strong following bad news.

Surprisingly, a negative contagion effect can persist for up to 25 min after the spot market opening. This suggests that informed trading moves the index gradually rather than instantaneously, so that informed traders' public information (shown in their $\Delta NR^{pre-open}$) remains valuable for a short period of time. However, there is no guarantee that other investors, such as individual investors, can also profit by mimicking foreign institutional traders' preopen option trading. This is because the foreign institutions' aggregate volume shown in this study is not instantaneously summarized and published by the exchange during the preopen interval. Other traders have no knowledge about the volume imbalance of overall foreign institutions immediately after the 15-min preopen interval. Even when they do, their trading positions can be constructed only during the regular session after spot market opening, rather than at the preopen session as foreign institutions do. Such a time lag could inhibit profit.

We also examine whether the negative contagion effect on the predictive ability of preopen options varies by the degree of information intensity. In Table VII, the predictive regression is repeated for three levels of the downward NASDAQ index. We split the subsample for which the NASDAQ index moves downward into three groups according to the tertiles of the negative index returns. The low tertile group contains 62 trading days for which the previous-day NASDAQ index drops by fewer than 58.72 basis points, the high tertile group contains 58 trading days for which the previous-day NASDAQ index drops by more than 166.73 basis points, and the medium tertile group contains 59 trading days. A larger negative downward return signifies more intensive information transmitted from the overseas major market. Where informed traders are more responsive to larger overseas impact, we observed a more negative $\beta_{down}^{pre-open}$ coefficient.

Refer Table VII

As shown in Table VII, the $\beta_{down}^{pre-open}$ coefficients are statistically insignificant for days with low and medium downward movement of the NASDAQ index (Panels A and B), whereas they are significantly negative for days on which the NASDAQ index experiences a larger decline (Panel C). The findings suggest that informed traders respond only to negative overseas impacts that are large and intensive. For medium NASDAQ index changes with lesser information content, the overseas information does not trigger discernible informed trading in the preopen option market. The results here reveal that the major market movement during the overnight interval is an important information source for informed traders on the TXO market.

E. Informed traders' contract selection under extreme market conditions

Section IV.D documents enhanced information role of informed preopen option trading when overseas markets experience extreme downward movement. In this section, we analyze foreign institutions' contract selection in cases of an extreme decline in the NASDAQ index

overnight to understand how informed traders use their knowledge under drastic overseas market conditions. Tables III, IV, and V show that foreign institutions' mid-size trades, OTM options, and medium-term options are particularly informative during the preopen session. Here, we analyze their trade size and contract selection when their private information is concrete.

Table VIII lists the predictive results of Equation (3) for the subsample for days on which the NASDAQ index drops by more than 166.73 basis points from the previous day (highest tertile group in Table VII). We observe the predictive ability of foreign institutions' preopen option trading in mid-trade size (Panel A), OTM options (Panel B), and medium-term options (Panel C). For brevity, the table lists only $\beta_{\cdot}^{pre-open}$ and omits $\beta_{\cdot}^{post-close}$, for which all coefficients are non-significant.

Refer Table VIII

In Panel A, the preopen medium-sized option trades exhibit significant ability to predict the spot index returns up to 25 min after the spot market opens. Note that the $\beta_{down}^{pre-open}$ coefficients here are much larger in absolute terms than that (−4.6) in Table III for medium trade size, and the adjusted R-squared is substantially higher than that (1.7%) in Table III for mid-size trades. These differences suggest that informed trading takes place primarily when strong impacts are transmitted from the overseas market. We also conduct the same predictive regressions on small and large trades but discover no significant predictive ability.[10]

Panel B shows the predictive ability of OTM options, which is examined for sample days on which the previous-day NASDAQ index drops substantially. The results show strong information content of preopen trading using OTM options. The volume imbalance of such options can facilitate predicting the subsequent index up to 25 min after the spot market opens. Again, the coefficients and adjusted R-squared in this panel are much greater than those (−3.20 and 2.38%, respectively) in panel B of Table IV, which again stresses the enhanced information role of preopen option trading when there is a large information impact during the overnight interval.[11]

The predictive ability of medium-term contracts with a time to maturity of between 30 to 90 days is reported in Panel C. The preopen trading on such contracts shows nontrivial ability to predict the subsequent index movements up to 25 min after the spot market opens. The regression R-squared values are surprisingly high, with some exceeding 30%, which indicates a strong association between preopen volume imbalance in medium-term options and the subsequent changes in the spot index.

The results illustrated in Table VIII confirm our previous findings that medium-sized trades, OTM options, and medium-term options are favored by informed traders. Furthermore, Table VIII shows that the predictive ability of such trades and options increases substantially when an extreme downturn in the NASDAQ index during the overnight interval provides beneficial opportunities to informed traders to trade in preopen index options.

[10] Reports on these results are available upon request.
[11] When we examine the subgroups respectively for INTM options and DOTM options, we find that the DOTM options also exhibit a strong (but less than the OTM options) information role when the NASDAQ index decreases substantially overnight. The results are available upon request.

F. Predictive ability of options within each 15-min period during regular sessions

Previously, we document the significant predictive ability of option trading during the preopen interval. We argue that the predictive ability of options is discernible only before the spot market opens but does not prevail in the regular trading session during which spot assets are traded side by side with options. If so, the extended trading session of derivatives markets renders options a special information role, a role that is absent in the regular sessions. To analyze whether the predictive ability of options can be determined in the preopen session but not the regular session, we conduct similar predictive regressions for 17 non-overlapping 15-min intervals in the regular session, from 9:00 a.m. to 9:15 a.m., 9:15 a.m. to 9:30 a.m., and so forth. For every 15-min interval, we regress the subsequent 1-min spot returns against foreign institutions' option volume imbalance (ΔNR), calculated during the preceding 15-min interval. Any finding of a significant and negative β coefficient indicates information-based transaction during the regular session.

In Table IX, none of the β coefficients are significantly negative at any interval. Our findings in regular trading sessions are consistent with Schlag and Stoll (2003), who showed that the price impact of the index option volume within each 5-min interval is largely temporary, implying that the index options provide no price discovery regarding the underlying asset. The results indicate that there is a unique information role of options during the preopen interval, as the predictive ability of options reported in Tables II–VIII is observable only in the preopen interval but does not occur during the regular trading session.

Refer Table IX

V. Conclusions

For this paper, we examine the information content of the Taiwan index options during the extended trading sessions using the option signed volume imbalance ratio. We discover that the preopen option volume of foreign institutions is informative for the subsequent opening index returns. Individuals, domestic institutions, and market makers do not possess such informational advantages. The predictive power of the option positions of foreign institutions is more pronounced in a downward market than in an upward market. The asymmetry can be explained by the short-sale constraints imposed on the spot market, which encourage informed traders to act on their bearish view through the use of index options.

Our study reveals several interesting patterns in the informed trading by foreign institutions. First, foreign institutions tend to employ medium-sized trades to reduce market impact costs and conceal trading intentions. OTM options and medium-term (30- to 90-day) options are found to be more informative than the most liquid at-the-money and short-term options. The contract selection reflects the preference of informed traders for the high leverage of OTM options and the low theta risk of medium-term options.

We additionally discover that information-based transactions conducted by foreign institutions during the preopen session largely depend on the overseas contagion impact: as the overnight NASDAQ index declines sharply, the predictive ability of the preopen option volume increases significantly even up to 25 min after spot market opening. Predictive ability of foreign institutions' option volume imbalance is found in the preopen session but not in the regular trading session, which indicates a unique price discovery role for options during the preopen trading session.

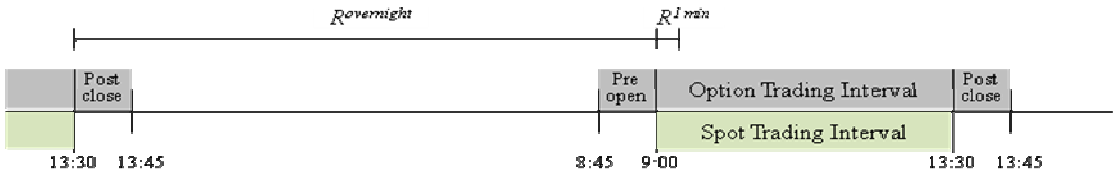

Figure 1: Open and Close Intervals on Spot and Option Markets

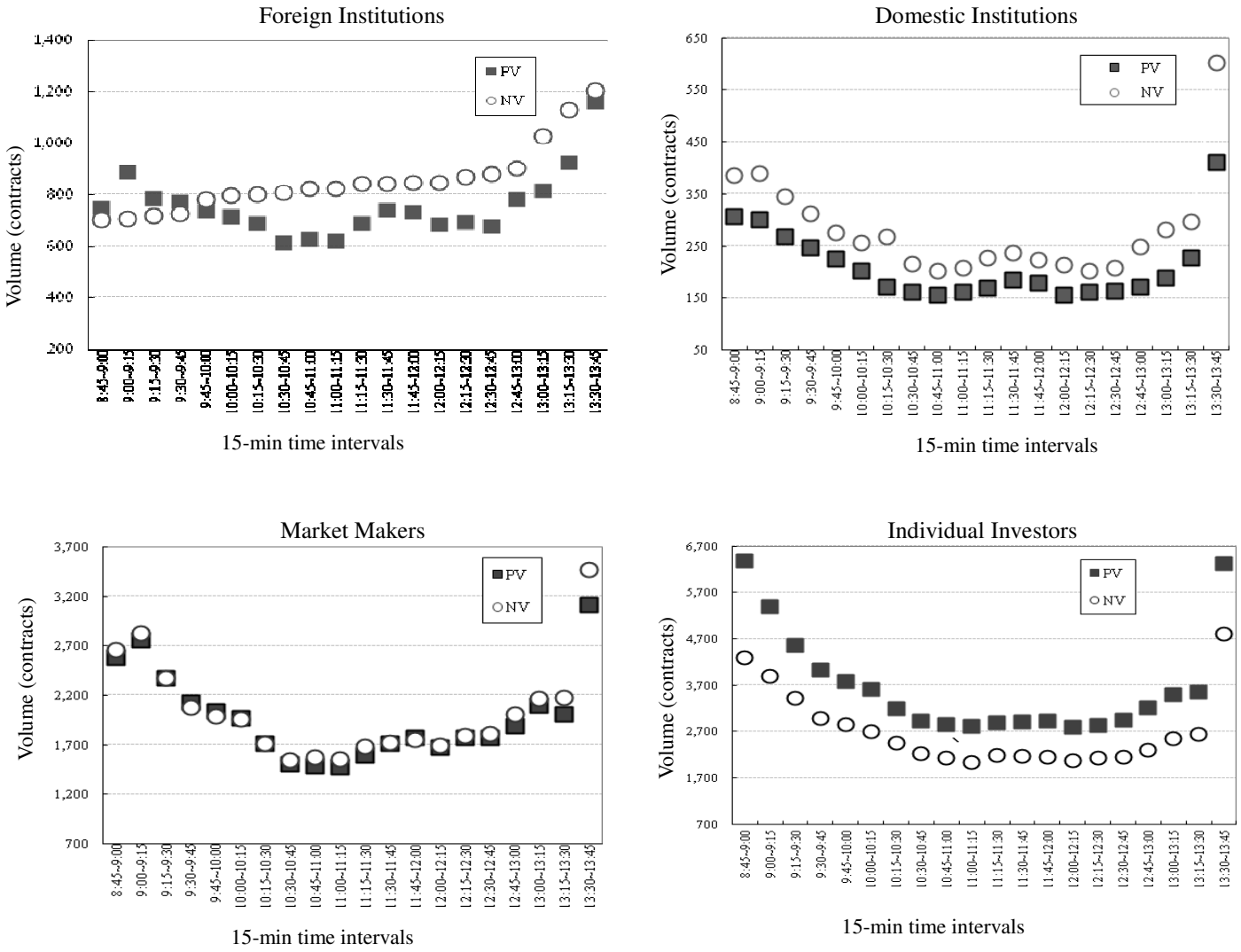

Figure 2: Intraday Option Volume by Investor Class

These figures illustrate the mean value of the aggregated open volume for each 15-min interval in a trading day, classified by foreign institutions, domestic institutions, individual investors, and market makers. Positive volume is defined as open-buy calls and open-sell puts; negative volume is defined as open-buy puts and open-sell calls.

Table I: Volume Proportions of Extended Options Across Various Classes of Investors, by Trade Size, Option Moneyness, and Time to Maturity

	Foreign Institutions				Domestic Institutions				Individual Investors				Market Makers			
	Call		Put		Call		Put		Call		Put		Call		Put	
	Buy	Sell	Sell	Buy	Buy	Sell	Sell	Buy	Buy	Sell	Sell	Buy	Buy	Sell	Sell	Buy
Panel A: aggregate volume																
	38.17	15.81	11.82	34.20	16.44	31.72	25.63	26.21	40.16	18.29	18.06	23.48	23.82	28.09	24.35	23.75
Panel B: Trade size																
Small size	11.67	3.22	2.29	10.00	5.08	12.97	10.80	7.37	19.54	9.18	9.23	11.21	4.72	5.57	4.56	4.58
Medium size	21.14	9.92	7.50	19.13	8.88	17.28	13.32	15.24	17.95	7.62	7.55	9.53	16.18	19.15	15.87	14.94
Large size	5.48	1.87	1.56	6.22	1.67	1.96	1.97	3.43	3.96	1.07	1.18	1.98	2.57	4.27	3.96	3.65
Panel C: Moneyness																
DOTM	5.57	1.80	1.96	6.37	1.53	4.93	5.61	5.27	7.39	3.60	5.12	4.39	2.11	3.88	3.90	4.23
OTM	20.24	5.97	4.77	20.10	6.96	17.13	14.36	14.03	19.46	9.14	8.95	11.31	10.46	13.45	12.55	11.47
INTM	12.48	7.24	4.63	8.88	7.08	10.11	6.19	6.79	14.60	5.13	3.88	7.01	10.90	11.67	7.93	7.46
Panel D: Time to expiration																
Short term	26.38	12.55	9.69	25.59	14.29	28.80	22.79	23.98	37.95	15.29	14.83	20.97	21.49	25.66	22.01	21.03
Medium term	11.50	2.36	1.53	9.37	1.25	3.31	3.30	2.04	3.45	2.51	2.98	1.73	1.96	3.26	2.35	2.07
Long term	0.40	0.11	0.13	0.38	0.04	0.05	0.08	0.08	0.05	0.07	0.15	0.02	0.02	0.06	0.03	0.06

This table lists the volume proportions of long and short calls and the four types of investors during extended trading sessions, conditional on trade size, option moneyness, and time to maturity. In panel A, aggregate volume is divided into four types dependent on long and short calls and puts for positive volume (PV) and negative volume (NV). In panel B, option trades are classified into small (fewer than 5 option contracts), medium (5–10 option contracts), and large (more than 10 option contracts) size groups. In panel C, option moneyness is defined as out-of-the-money (OTM) options (calls with option strike-to-spot ratios of between 1.02 and 1.07 and puts with strike-to-spot ratios of between 0.93 and 0.98), in- or near-the-money (INTM) options (calls and puts with strike-to-spot ratios of between 0.98 and 1.02), and deeply out-of-the-money (DOTM) options (calls with strike-to-spot ratios above 1.07 and puts with strike-to-spot ratios below 0.93). In panel D, the time to expiration for the options is categorized as short term (0–30 days), medium term (30–90 days), and long term (more than 90 days).

Table II: Identifying Option Informed Traders During the Stock Market Nontrading Period

	Foreign Institutions	Domestic Institutions	Individual Investors	Market Makers
Panel A: Dependent variable is overnight return				
Intercept	20.39 ***	19.12 ***	18.83 ***	25.52 ***
	(3.39)	(3.18)	(3.18)	(4.06)
$\beta_{up}^{pre\text{-}open}$	**-35.6 ** **	**-28.2 * **	46.87	**-83.71 *** **
	(-2.51)	**(-1.69)**	(1.23)	**(-3.77)**
$\beta_{down}^{pre\text{-}open}$	**-88.62 *** **	**-94.65 *** **	80.35	**-223.16 *** **
	(-4.02)	**(-3.36)**	(1.43)	**(-7.05)**
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	-5.83	0.84	-40.39	41.36
	(-0.38)	(0.04)	(-0.96)	(1.24)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	**-48.43 ** **	-22.43	-92.46	45.12
	(-2.14)	(-0.67)	(-1.45)	(1.02)
Adj. R^2	0.0705	0.0421	0.014	0.1609
Panel B: Dependent variable is stock index return in the first minute of opening				
Intercept	1.74 ***	1.74 **	1.95 ***	1.84 ***
	(3.28)	(3.31)	(3.76)	(3.53)
$\beta_{up}^{pre\text{-}open}$	-1.23	0.67	-1.61	-1.05
	(-0.90)	(0.44)	(-0.47)	(-0.48)
$\beta_{down}^{pre\text{-}open}$	**-3.56 ** **	-0.78	17.48 ***	**-7.91 *** **
	(-2.05)	(-0.33)	(3.76)	**(-2.92)**
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	0.03	-6.04	-0.08	3.59
	(0.03)	(-0.55)	(-0.04)	(1.12)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	-0.12	-9.91	-2.25	1.89
	(-0.06)	(-0.64)	(-0.12)	(0.45)
Adj. R^2	0.0141	0.0089	0.0426	0.0283

This table lists the results from Equation (3) by different classes of investors:

$$R_t = \alpha + \beta_{i,t,up}^{pre-open}\Delta NR_{i,t}^{pre-open} \times D_t + \beta_{i,t-1,up}^{post-close}\Delta NR_{i,t-1}^{post-close} \times D_t + \beta_{i,t,down}^{pre-open}\Delta NR_{i,t}^{pre-open} \times (1-D_t) + \beta_{i,t-1,down}^{post-close}\Delta NR_{i,t-1}^{post-close} \times (1-D_t) + \varepsilon_t \quad (3)$$

$D_t = 1$ if $R_{\tau,t} > 0$, $= 0$, otherwise

where R_t is the overnight index returns ($R_t^{overnight} = ln\, S_t^{open} - ln\, S_{t-1}^{close}$) in Panel A and the first-minute index returns ($R_t^{1\ min} = ln\, S_t^{1\ minute\ of\ opening} - ln\, S_t^{open}$) on day t in Panel B; ΔNR is the option volume information variable, constructed by the difference of the daily negative-to-total volume ratio (*NR)* and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

Table III: Predictive Ability of Foreign Institutions' Preopen and Postclose Option Volume by Trade Size Group

	Small	Medium	Large
	below 5 contracts	5-10 contracts	above 10 contracts
Panel A: Dependent variable is overnight return			
Intercept	17.02 ***	15.30 *	13.59 **
	(2.77)	(1.78)	(1.98)
$\beta_{up}^{pre\text{-}open}$	**-47.09 *** **	**-41.28 ** **	**-28.01 * **
	(-2.85)	**(-2.27)**	**(-1.73)**
$\beta_{down}^{pre\text{-}open}$	**-60.58 ** **	**-61.63 ** **	**-75.95 *** **
	(-2.43)	**(-2.26)**	**(-3.30)**
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	-9.88	-12.09	-24.81
	(-0.47)	(-0.72)	(-1.51)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	1.35	-21.58	-59.93
	(0.04)	(-0.90)	(-0.82)
Adj. R^2	0.0667	0.0379	0.0539
Panel B: Dependent variable is spot index return in the first minute of opening			
Intercept	1.69 ***	1.64 ***	1.36
	(3.13)	(2.86)	(2.24)
$\beta_{up}^{pre\text{-}open}$	-0.51	-0.99	-0.63
	(-0.27)	(-0.61)	(-0.40)
$\beta_{down}^{pre\text{-}open}$	**-3.52 * **	**-4.60 ** **	-2.38
	(-1.67)	**(-2.19)**	(-1.36)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	-0.19	-0.42	-0.12
	(-0.10)	(-0.26)	(0.08)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	3.12	-0.37	0.48
	(1.20)	(-0.16)	(0.24)
Adj. R^2	0.0129	0.0170	0.0072

This table shows the results of the following predictive regression for foreign institutions' option volume by different trade sizes: small (1– 4 contracts), medium (5–10 contracts), and large (>10 contracts):

$$R_t = \alpha + \beta_{i,t,up}^{pre-open}\Delta NR_{i,t}^{pre-open} \times D_t + \beta_{i,t-1,up}^{post-close}\Delta NR_{i,t-1}^{post-close} \times D_t + \beta_{i,t,down}^{pre-open}\Delta NR_{i,t}^{pre-open} \times (1-D_t) + \beta_{i,t-1,down}^{post-close}\Delta NR_{i,t-1}^{post-close} \times (1-D_t) + \varepsilon_t \quad (3)$$

D_t=1 if $R_{\tau,t}$>0, =0, otherwise

where R_t is the overnight index returns ($R_t^{overnight} = \ln S_t^{open} - \ln S_{t-1}^{close}$) in Panel A and the first-minute index returns ($R_t^{1\ min} = \ln S_t^{1\ minute\ of\ opening} - \ln S_t^{open}$) on day t in Panel B; ΔNR is the option volume information variable, constructed by the difference of the daily negative-to-total volume ratio (*NR)* and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

Table IV: Predictive Ability of Foreign Institutions' Preopen Trading by Option Moneyness

	Deeply out-of-the-money (DOTM)	Out-of-the-money (OTM)	In- or near-the-money (INTM)
Panel A: Dependent variable is overnight return			
Intercept	7.04	14.59 **	19.05 ***
	(0.76)	(2.16)	(2.93)
$\beta_{up}^{pre\text{-}open}$	**-43.01 ****	-18.37	-14.53
	(-2.05)	(-1.38)	(-0.93)
$\beta_{down}^{pre\text{-}open}$	**-47.69 ****	**-50.47 ****	23.02
	(-1.97)	**(-2.40)**	(0.98)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	-23.25	-5.80	-4.83
	(-1.18)	(-0.36)	(-0.31)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	-1.98	**-38.62 ***	-17.21
	(-0.08)	**(-1.73)**	(-0.74)
Adj. R^2	0.0458	0.0391	0.0080
Panel B: Dependent variable is spot index return in the first minute of opening			
Intercept	1.54 **	1.72 ***	1.81 ***
	(2.11)	(2.97)	(3.13)
$\beta_{up}^{pre\text{-}open}$	-0.97	-1.47	0.07
	(-0.63)	(-1.21)	(0.05)
$\beta_{down}^{pre\text{-}open}$	-2.22	**-3.20 ****	-1.15
	(-1.07)	**(-1.96)**	(-0.60)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	1.19	-0.22	0.13
	(0.76)	(-0.16)	(0.09)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	4.86 **	-2.33	1.31
	(2.56)	(-1.22)	(0.65)
Adj. R^2	0.0414	0.0238	0.0026

This table illustrates the results of the following predictive regression for foreign institutions' option volume categorized by option moneyness:

$$R_t = \alpha + \beta_{i,t,up}^{pre-open} \Delta NR_{i,t}^{pre-open} \times D_t + \beta_{i,t-1,up}^{post-close} \Delta NR_{i,t-1}^{post-close} \times D_t + \beta_{i,t,down}^{pre-open} \Delta NR_{i,t}^{pre-open} \times (1 - D_t) + \beta_{i,t-1,down}^{post-close} \Delta NR_{i,t-1}^{post-close} \times (1 - D_t) + \varepsilon_t \quad (3)$$

$D_t = 1$ if $R_{\tau,t} > 0$, $= 0$, otherwise

where R_t is the overnight index returns ($R_t^{overnight} = \ln S_t^{open} - \ln S_{t-1}^{close}$) in Panel A and the first-minute index returns ($R_t^{1\ min} = \ln S_t^{1\ minute\ of\ opening} - \ln S_t^{open}$) on day t in Panel B; ΔNR is the option volume information variable, constructed by the difference of the daily negative-to-total volume ratio (*NR*) and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. We define in- or near-the-money (INTM) options as options with strike-to-spot ratios of between 0.98 and 1.02, out-of-the-money (OTM) calls as calls with strike-to-spot ratios of between 1.02 and 1.07, OTM puts as puts with strike-to-spot ratios of between 0.93 and 0.98. Other options are classified as deeply out-of-the-money (DOTM) options. Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

Table V: Predictive Ability of Foreign Institutions' Preopen Trading by Option Maturity

	Short-term	Medium-term	Long-term
	30 days ↓	30-90 days	90 days ↑
Panel A: Dependent variable is overnight return			
Intercept	18.44 ***	14.66 **	-16.71
	(2.75)	(2.05)	(-0.78)
$\beta_{up}^{pre\text{-}open}$	-19.58	**-42.39** ***	-110.43
	(-1.16)	**(-2.72)**	(-1.14)
$\beta_{down}^{pre\text{-}open}$	-32.84	**-117.46** ***	-32.34
	(-1.24)	**(-4.65)**	(-0.44)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	-4.51	-0.12	13.84
	(-0.24)	(-0.01)	(0.20)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	-39.47	32.84	62.79
	(-1.60)	(1.46)	(1.05)
Adj. R^2	0.0191	0.1125	0.0687
Panel B: Dependent variable is spot index return in the first minute of opening			
Intercept	2.04 ***	1.76 ***	1.95
	(3.40)	(2.79)	(1.19)
$\beta_{up}^{pre\text{-}open}$	-1.62	-1.08	1.28
	(-0.97)	(-0.75)	(0.26)
$\beta_{down}^{pre\text{-}open}$	-1.74	**-4.14** **	18.16
	(-0.88)	**(-2.01)**	(1.52)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	0.34	0.55	-4.57
	(0.21)	(0.36)	(-0.93)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	-0.04	2.95	6.29
	(-0.02)	(1.60)	(1.13)
Adj. R^2	0.0062	0.0266	0.1310

This table lists the results of the following predictive regression for foreign institutions' option volume categorized by option time to maturity:

$$R_t = \alpha + \beta_{i,t,up}^{pre-open} \Delta NR_{i,t}^{pre-open} \times D_t + \beta_{i,t-1,up}^{post-close} \Delta NR_{i,t-1}^{post-close} \times D_t + \beta_{i,t,down}^{pre-open} \Delta NR_{i,t}^{pre-open} \times (1 - D_t) + \beta_{i,t-1,down}^{post-close} \Delta NR_{i,t-1}^{post-close} \times (1 - D_t) + \varepsilon_t \quad (3)$$

$D_t = 1$ if $R_{\tau,t} > 0$, $= 0$, otherwise

where R_t is the overnight index returns ($R_t^{overnight} = \ln S_t^{open} - \ln S_{t-1}^{close}$) in Panel A and the first-minute index returns ($R_t^{1\ min} = \ln S_t^{1\ minute\ of\ opening} - \ln S_t^{open}$) on day t in Panel B; ΔNR is the option volume information variable, constructed by the difference of the daily negative-to-total volume ratio (*NR)* and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. We classify options that expire within 30 days as short maturity, between 30 and 90 days as medium maturity, and the rest as long maturity. Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

Table VI: Predictive Ability of Foreign Institutions' Preopen Option Trading Conditional on the Direction of the NASDAQ Index During the Overnight Period

	Spot index return in τ minutes of opening						
	τ=1	τ=5	τ=10	τ=15	τ=25	τ=40	τ=60
Panel A: the NASDAQ index moves up during the overnight period (188 trading days)							
Intercept	2.77 ***	-4.83 ***	-5.93 ***	-7.24 ***	-7.75 ***	-9.89 ***	-10.21 ***
	(4.10)	(-3.14)	(-3.09)	(-3.41)	(-2.75)	(-3.01)	(-2.64)
$\beta_{up}^{pre\text{-}open}$	-2.24	0.00	1.96	-5.50	-6.85	-2.19	-6.95
	(-1.33)	(0.00)	(0.33)	(-0.81)	(-0.77)	(-0.22)	(-0.56)
$\beta_{down}^{pre\text{-}open}$	-0.31	6.21 *	0.93	-2.20	2.96	8.76	0.25
	(-0.15)	(1.65)	(0.19)	(-0.42)	(0.42)	(1.05)	(0.03)
$\beta_{t-1,up}^{Post\text{-}close}$	-1.33	1.72	-4.26	-4.04	-18.10 *	-14.11	-21.23
	(-0.74)	(0.33)	(-0.69)	(-0.59)	(-1.92)	(-1.31)	(-1.55)
$\beta_{t-1,down}^{Post\text{-}close}$	4.31	8.26 *	9.72	8.70	3.91	-0.35	3.04
	(1.45)	(1.75)	(1.57)	(1.27)	(0.45)	(-0.03)	(0.26)
Adj. R^2	0.0270	0.0343	0.0169	0.0167	0.0276	0.0166	0.0189
Panel B: the NASDAQ index moves down during the overnight period (179 trading days)							
Intercept	0.80	3.02	-6.36 **	-3.90	-1.35	2.35	-3.14
	(0.96)	(1.60)	(-2.40)	(-1.46)	(-0.48)	(0.69)	(-0.74)
$\beta_{up}^{pre\text{-}open}$	0.76	2.32	8.84	8.10	3.71	10.47	11.30
	(0.35)	(0.47)	(1.09)	(1.01)	(0.47)	(1.03)	(0.92)
$\beta_{down}^{pre\text{-}open}$	**-6.93 ****	**-13.05 ****	**-14.46 ****	**-16.45 ****	**-22.24 ****	-12.14	-16.01
	(-2.51)	**(-2.05)**	**(-1.96)**	**(-2.17)**	**(-2.54)**	(-1.24)	(-1.27)

$\beta_{t-1,up}^{Post-close}$	1.86	5.39	1.54	0.96	3.81	8.31	14.04
	(0.83)	(1.02)	(0.17)	(0.11)	(0.45)	(0.79)	(1.05)
$\beta_{t-1,down}^{Post-close}$	-2.44	-6.42	-3.49	-8.17	-7.53	-5.56	-6.12
	(-0.90)	(-1.07)	(-0.49)	(-1.13)	(-0.91)	(-0.57)	(-0.51)
Adj. R^2	0.0445	0.0371	0.0312	0.0429	0.0453	0.0215	0.0232

This table illustrates the results of the following predictive regression for foreign institutions' option volume conditional on upward or downward movement of the NASDAQ index overnight:

$$R_t^{\tau\ \min} = \alpha + \beta_{i,\,t,\,up}^{pre-open}\Delta NR_{i,\,t}^{pre-open} \times D_t + \beta_{i,\,t-1,\,up}^{post-close}\Delta NR_{i,\,t-1}^{post-close} \times D_t + \beta_{i,\,t,\,down}^{pre-open}\Delta NR_{i,\,t}^{pre-open} \times (1-D_t) + \beta_{i,\,t-1,\,down}^{post-close}\Delta NR_{i,\,t-1}^{post-close} \times (1-D_t) + \varepsilon_t \quad (3)$$
$$D_t = 1 \text{ if } R_{\tau,t} > 0, \quad = 0, \text{ otherwise}$$

where $R_t^{\tau\ min}$ is the index returns in τ minutes of opening on day t ($R_t^{\tau\ min} = \ln S_t^{\tau \text{ minute of opening}} - \ln S_t^{open}$); ΔNR is the option volume information variable, constructed by the difference of the daily negative-to-total volume ratio (*NR)* and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. Panel A lists regression results for the subsample for days on which the NASDAQ index moves upward (188 trading days) overnight, and Panel B lists the results for the subsample for days when the NASDAQ index moves downward (179 trading days). Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

Table VII: Predictive Ability of Foreign Institutions' Preopen Option Trading by Tertiles of NASDAQ Downward Returns

	Spot index return in τ minutes of opening						
	τ=1	τ=5	τ=10	τ=15	τ=25	τ=40	τ=60
Panel A: Low tertile of downward Nasdaq index returns (62 trading days)							
Intercept	2.39 ***	-5.58 ***	-8.81 ***	-9.26 ***	-8.72 ***	-9.11 ***	-9.03 ***
	(4.20)	(-3.89)	(-5.10)	(-5.08)	(-3.73)	(-3.35)	(-2.73)
$\beta_{up}^{pre\text{-}open}$	-1.58	0.69	2.95	-4.12	-5.49	-5.64	-8.32
	(-1.10)	(0.16)	(0.53)	(-0.72)	(-0.77)	(-0.68)	(-0.81)
$\beta_{down}^{pre\text{-}open}$	-0.89	3.37	-0.74	-4.76	0.54	5.44	-3.32
	(-0.48)	(0.92)	(-0.17)	(-1.03)	(0.09)	(0.77)	(-0.39)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	-0.24	6.38	-3.41	-4.37	-11.12	-3.87	-3.90
	(-0.16)	(1.31)	(-0.60)	(-0.72)	(-1.39)	(-0.43)	(-0.34)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	4.23	5.40	2.79	2.55	1.17	-0.43	0.19
	(1.80)	(1.26)	(0.53)	(0.46)	(0.17)	(-0.05)	(0.02)
Adj. R^2	0.0204	0.0191	0.0036	0.0100	0.0115	0.0055	0.0045
Panel B: Medium tertile of downward Nasdaq index returns (59 trading days)							
Intercept	-1.80	0.62	2.17	-0.49	3.28	1.97	-2.49
	(-1.27)	(0.25)	(0.60)	(-0.14)	(0.84)	(0.40)	(-0.39)
$\beta_{up}^{pre\text{-}open}$	0.79	1.21	2.33	8.30	0.78	16.48	14.50
	(0.18)	(0.17)	(0.25)	(0.85)	(0.08)	(1.19)	(0.82)
$\beta_{down}^{pre\text{-}open}$	-4.48	-10.31	-5.62	-9.23	-19.10	-4.65	-11.88
	(-1.06)	(-1.27)	(-0.42)	(-0.81)	(-1.38)	(-0.29)	(-0.56)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	3.47	2.51	-3.97	-16.08	-14.31	-17.61	-8.40
	(0.79)	(0.38)	(-0.38)	(-1.47)	(-1.19)	(-1.14)	(-0.44)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	-3.62	-13.28	-15.95	-13.32	-17.33	-13.26	-15.78
	(-0.87)	(-1.62)	(-1.44)	(-1.32)	(-1.53)	(-0.96)	(-0.84)
Adj. R^2	0.0465	0.0846	0.0478	0.1018	0.1075	0.0705	0.0338

Continued on next page

Table VII continued

Table VII: Predictive Ability of Foreign Institutions' Preopen Option Trading by Tertiles of NASDAQ Downward Returns

Panel C: High tertile of downward Nasdaq index returns (58 trading days)							
Intercept	4.17 **	13.75 ***	-0.15	3.36	3.88	10.52	-0.67
	(2.36)	(3.44)	(-0.03)	(0.55)	(0.61)	(1.27)	(-0.07)
$\beta_{up}^{pre\text{-}open}$	-0.20	1.79	5.33	1.76	12.77	16.76	30.75
	(-0.05)	(0.18)	(0.27)	(0.10)	(0.58)	(0.63)	(0.93)
$\beta_{down}^{pre\text{-}open}$	**-16.59 ** **	**-35.48 ** **	**-30.49 * **	**-41.85 ** **	**-35.61 ** **	-19.16	-15.10
	(-2.53)	**(-2.26)**	**(-1.80)**	**(-2.15)**	**(-1.99)**	(-0.80)	(-0.59)
$\beta_{t\text{-}1,up}^{Post\text{-}close}$	-0.16	3.75	11.42	26.79	17.71	17.28	19.63
	(-0.04)	(0.37)	(0.60)	(1.43)	(0.92)	(0.75)	(0.61)
$\beta_{t\text{-}1,down}^{Post\text{-}close}$	-8.69	-32.32 **	2.20	-11.38	-11.26	-8.85	0.82
	(-1.38)	(-2.12)	(0.13)	(-0.64)	(-0.56)	(-0.32)	(0.61)
Adj. R^2	0.1384	0.1174	0.0726	0.1187	0.0999	0.0355	0.0302

This table shows the results of the following predictive regression for foreign institutions' option volume categorized by three tertiles of downward movement in the NASDAQ index overnight:

$$R_t^{\tau\ \min} = \alpha + \beta_{i,\,t,\,up}^{pre-open}\Delta NR_{i,\,t}^{pre-open} \times D_t + \beta_{i,\,t-1,\,up}^{post-close}\Delta NR_{i,\,t-1}^{post-close} \times D_t + \beta_{i,\,t,\,down}^{pre-open}\Delta NR_{i,\,t}^{pre-open} \times (1 - D_t) + \beta_{i,\,t-1,\,down}^{post-close}\Delta NR_{i,\,t-1}^{post-close} \times (1 - D_t) + \varepsilon_t \quad (3)$$

$$D_t = 1 \text{ if } R_{\tau,t} > 0, \quad = 0, \text{ otherwise}$$

where $R_t^{\tau\ min}$ is the index returns in τ minutes of opening on day t ($R_t^{\tau\ min} = \ln S_t^{\tau\ minute\ of\ opening} - \ln S_t^{open}$); ΔNR is the option volume information variable, constructed by the difference of the daily negative-to-total volume ratio (*NR)* and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. We divide the subsample for which the NASDAQ index moves downward into three groups according to the tertiles of the negative index returns. The low tertile group contains 62 trading days for which the previous-day NASDAQ index drops less than 58.72 basis points, the medium tertile group contains 59 trading days for which the previous-day NASDAQ index drops between 58.22 and 166.73 basis points, and the high tertile group has 58 trading days for which the previous-day NASDAQ index drops more than 166.73 basis points. Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

Table VIII: Predictive Ability of Foreign Institutions' Preopen Option Trading Conditional on Days of Extreme NASDAQ Decline

	Spot index return in τ minutes of opening						
	τ=1	τ=5	τ=10	τ=15	τ=25	τ=40	τ=60
Panel A: Medium-sized trades only							
Intercept	2.79	15.70 ***	11.01 *	11.11	12.72 *	20.02 **	9.29
	(1.35)	(3.93)	(1.74)	(1.57)	(1.80)	(2.42)	(0.88)
$\beta_{up}^{pre\text{-}open}$	4.27	8.54	-8.04	5.82	11.54	27.52	31.41
	(0.72)	(0.82)	(-0.36)	(0.29)	(0.54)	(1.13)	(0.92)
$\beta_{down}^{pre\text{-}open}$	**-11.17 ***	**-33.32 ****	**-30.40 ***	**-45.77 ***	**-55.02 ****	-42.31	-31.45
	(-1.68)	**(-1.97)**	**(-1.72)**	**(-1.93)**	**(-2.38)**	(-1.52)	(-1.00)
Adj. R^2	0.1360	0.1709	0.1430	0.1304	0.1911	0.1134	0.0930
Panel B: Out-of-the-money options only							
Intercept	2.93	14.67 ***	7.06	13.45 **	14.60 **	24.43 ***	13.54
	(1.41)	(3.66)	(1.13)	(2.02)	(2.07)	(2.84)	(1.22)
$\beta_{up}^{pre\text{-}open}$	3.76	5.53	2.19	1.68	5.81	10.72	1.69
	(0.90)	(0.69)	(0.17)	(0.12)	(0.36)	(0.58)	(0.07)
$\beta_{down}^{pre\text{-}open}$	**-11.80 ***	**-18.39 ***	**-30.22 ***	**-42.01 ****	**-29.59 ***	-22.10	-15.07
	(-1.86)	**(-1.72)**	**(-1.70)**	**(-2.22)**	**(-1.73)**	(-0.96)	(-0.46)
Adj. R^2	0.1519	0.1043	0.0876	0.1363	0.0901	0.0432	0.0326

Continued on next page

Table VIII continued

Table VIII: Predictive Ability of Foreign Institutions' Preopen Option Trading Conditional on Days of Extreme NASDAQ Decline

Panel C: Medium-term options (expiration between 30 and 90 days) only							
Intercept	6.08 ***	12.53 ***	-4.74	-4.90	13.41 *	11.33	-5.76
	(3.46)	(2.69)	(-0.62)	(-0.69)	(1.80)	(1.13)	(-0.48)
$\beta_{up}^{pre\text{-}open}$	-0.14	12.14	51.90 **	61.25	26.50	46.72	89.03 **
	(-0.03)	(0.96)	(2.07)	(2.40)	(1.40)	(1.56)	(2.23)
$\beta_{down}^{pre\text{-}open}$	**-26.75 *** **	**-27.76 ***	**-49.37 ***	**-38.12 ***	**-76.27 *** **	-28.86	-24.61
	(-4.08)	**(-1.80)**	**(-2.42)**	**(-2.15)**	**(-2.86)**	(-0.98)	(-0.76)
Adj. R^2	0.3742	0.1359	0.3062	0.2981	0.3030	0.1118	0.1701

This table lists the results of the following predictive regression for foreign institutions' option volume in medium-sized trades, out-of-the-money (OTM) options, and medium-term contracts under the condition of extreme decline of the NASDAQ index overnight:

$$R_t^{\tau\ \min} = \alpha + \beta_{i,t,up}^{pre-open} \Delta NR_{i,t}^{pre-open} \times D_t + \beta_{i,t-1,up}^{post-close} \Delta NR_{i,t-1}^{post-close} \times D_t + \beta_{i,t,down}^{pre-open} \Delta NR_{i,t}^{pre-open} \times (1 - D_t) + \beta_{i,t-1,down}^{post-close} \Delta NR_{i,t-1}^{post-close} \times (1 - D_t) + \varepsilon_t \quad (3)$$

$$D_t = 1,\ if\ R_{\tau,t} > 0;\ = 0,\ otherwise$$

where $R_t^{\tau\ min}$ is the index returns in τ minutes of opening on day t ($R_t^{\tau\ min} = ln\, S_t^{\tau\ minute\ of\ opening} - ln\, S_t^{open}$); ΔNR is the option volume information variable, constructed by the difference of the daily negative-to-total volume ratio (*NR)* and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. Medium-sized trades are those with between 5 and 10 option contracts; OTM options are calls with strike-to-spot ratios of between 1.02 and 1.07, and puts with strike-to-spot ratios of between 0.93 and 0.98; and medium-term contracts are options with a time to maturity between 30 and 60 days. Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

Table IX: Predictability of Foreign Institutions' Options Volume during The Regular Trading Session

j interval	1	2	3	4	5	6	7	8	9
Time	9:00a.m. -9:15a.m.	9:15a.m -9:30a.m.	9:30a.m. -9:45a.m.	9:45a.m. -10:00a.m.	10:00a.m. -10:15a.m.	10:15a.m. -10:30a.m.	10:30 -10:45a.m.	10:45a.m. -11:00a.m.	11:00a.m. -11:15a.m.
Intercept	0.47 *	0.22	-0.25	-0.09	-0.14	0.37 **	0.07	-0.11	-0.27
	-1.67	-0.85	(-1.09)	(-0.46)	(-0.78)	-2.29	-0.41	(-0.65)	(-1.52)
β_{up}	0.39	0.34	-0.15	0.15	-0.46	0.26	0.03	0.23	-0.25
	-0.54	-0.45	(-0.23)	-0.24	(-0.79)	-0.5	-0.07	-0.42	(-0.44)
β_{down}	0.01	-0.03	0.26	-0.81	0.12	0.22	-0.19	0.72	0.12
	-0.03	(-0.05)	-0.38	(-1.35)	-0.20	-0.44	(-0.34)	-1.37	-0.22
Adj. R^2	0.0008	0.0006	0.0006	0.0052	0.0018	0.0013	0.0003	0.0058	0.0007
j interval	10	11	12	13	14	15	16	17	
Time	11:15a.m. -11:30a.m.	11:30a.m. -11:45a.m.	11:45a.m. -12:00p.m.	12:00p.m. -12:15p.m.	12:15p.m. 12:30p.m.	12:30p.m. -12:45p.m.	12:45p.m. -13:00p.m.	13:00p.m. -13:15p.m.	
Intercept	-0.07	0.07	-0.37 **	-0.47 ***	-0.17	0.10	0.25	-0.14	
	(-0.42)	-0.45	(-2.22)	(-2.67)	(-0.94)	-0.56	-1.41	(-0.76)	
β_{up}	-0.67	0.06	1.00 *	1.22 **	-0.30	0.80	-0.40	0.33	
	(-1.24)	-0.12	-1.79	-1.96	(-0.52)	-1.44	(-0.72)	-0.55	
β_{down}	-0.42	0.34	0.87 *	0.24	0.77	-0.18	-0.25	-0.56	
	(-0.73)	-0.64	-1.69	-0.45	-1.23	(-0.31)	(-0.42)	(-0.86)	
Adj. R^2	0.0057	0.0012	0.0168	0.0112	0.0049	0.0060	0.0019	0.0029	

This table shows the results of the following predictive regression for foreign institutions' option volume in 17 nonoverlapping 15-min intervals during the regular spot session:

$$R_t^{1\,\min} = \alpha + \beta_{i,\,t,\,up}^{j\text{interval}} \Delta NR_{i,\,t}^{j\text{interval}} \times D_t + \beta_{i,\,t,\,down}^{j\text{interval}} \Delta NR_{i,\,t}^{j\text{interval}} \times (1 - D_t) + \varepsilon_t$$

$$D_t = 1,\ if\ R_t^{1\,\min} > 0;\ 0,\ otherwise$$

where $R_t^{1\,miin}$ is the first-minute index returns after the jth 15-minute interval on day t ($R_t^{1\,min} = \ln S_t^{\delta+1\,min} - \ln S_t^{\delta\,min}$); ΔNR is the option volume information variable, constructed by the difference of the 15-min negative-to-total volume ratio (*NR)* and the rolling monthly average over the previous-month average *NR*. The *NR* ratio is calculated by dividing the negative option volume in new open positions (open-buy puts + open-sell calls) over the sum of the total volume of new open positions. Bold numbers indicate statistically significant coefficients with a sign consistent with the predictive ability of option volume. Figures in parentheses are t statistics, with *, **, and *** respectively representing statistical significance at the 10%, 5%, and 1% levels.

References

Admati, A.R. and P. Pfeiderer,1988, 'A Theory of Intraday Patterns: Volume and Price Variability', *Review of Financial Studies* 1, 3-40.

Alexander, G.J. and M.A. Peterson,2007, 'An Analysis of Trade-size Clustering and its Relation to Stealth Trading', *Journal of Financial Economics* 84, 435-71.

Anand, A. and S. Chakravarty,2007, 'Stealth Trading in Options Markets', *Journal of Financial and Quantitative Analysis* 42, 167-87.

Bae, K.H., G. A. Karolyi and R. M. Stulz,2003, ' A New Approach to Measuring Financial Contagion', *Review of Financial Studies* 16, 717-763.

Bakshi, G., C. Cao and Z. Chen,2000, 'Do Call Prices and the Underlying Stocks Always Move in the Same Direction?' *Review of Financial Studies* 13, 549-584.

Barclay, M.J., C.G. Dunbar and J.B. Warner,1993, 'Stealth and Volatility: Which Trades Move Prices?', *Journal of Financial Economics* 34, 281-306.

Black, F.,1975, 'Fact and Fantasy in the Use of Options', *Financial Analysts Journal* 31, 36-41.

Blau, B.M., B.F. Van Ness and R.A. Van Ness,2009, 'Intraday Stealth Trading: Which Traders Move Prices during Periods of High Volume?', *Journal of Financial Research* 32, 1-21.

Brock, W.A. and Kleidon, A.W.,1992, 'Periodic Market Closure and Trading Volume: A model of Intraday Bids and Asks', *Journal of Economic Dynamics and Control* 16, 45-489.

Brockman, P. and D.Y. Chung, 2008, 'Commonality under Market Stress: Evidence from an Order-Driven Market', *International Review of Economics and Finance* 17, 179-196.

Cao, C., Z. Chen and J.M. Griffin,2005, 'The Information Content of Options Volume Prior to Takeovers', *Journal of Business* 78, 1073-1109.

Chakravarty, S.,2001, 'Stealth-trading: Which Traders' Trades Move Stock Prices?', *Journal of Financial Economics* 61, 289-307.

Chan, Leo, Johnny Chan, and Louis Cheng,2002, The Effect of Extended Trading Hours on the Information Flow Between Cash and Futures Markets, Available at SSRN 314246.

Chan, Y.C.,2005, 'Who Trades in the Stock Index Futures Market when the Underlying Cash Market is not Trading?', *Pacific-Basin Finance Journal* 13, 547-561.

Chan, K.C., Y. Chang and P.P. Lung,2009, 'Informed Trading under Different Market Conditions and Moneyness: Evidence from TXO Options', *Pacific- Basin Finance Journal* 17, 189-208.

Chang, E.C., J.W. Cheng and A. Khorana,2000, 'An Examination of Herd Behavior in Equity Markets: An International Perspective', *Journal of Banking and Finance* 24, 1651-1679,

Chang, C.C., P.F. Hsieh and H.N. Lai,2009, 'Do Informed Options Investors Predict Stock Returns? Evidence from the Taiwan Stock Exchange', *Journal of Banking and Finance* 33, 757-64.

Chang, C.C., P.F. Hsieh, and H.N. Lai,2013, 'The Price Impact of Options and Futures Volume in After-Hours Stock Market Trading', *Pacific-Basin Finance Journal* 21, 984-1007.

Chaput, J.S. and L.H. Ederington,2005, 'Volatility Trade Design', *Journal of Futures Markets* 25, 243-79.

Chakravarty,2001, 'Stealth Trading: Which Traders' Trades Move Stock Prices?' *Journal of Financial Economics* 61, 289-307.

Cheng, K., and L.T.W. Cheng,2000, 'Trading hour extension in futures markets reduces cash market volatility', Hong Kong Futures Exchange Ltd. Education Article Issue No. 8.

Chen, L.W., S.A. Johnson, J.C. Lin and Y. J. Liu,2009, 'Information, Sophistication, and

Foreign versus Domestic Investors' Performance', *Journal of Banking and Finance* 33, 1636-51.
Chen C.X. and S.G. Rhee,2010, 'Short Sales and the Speed of Price Adjustment: Evidence from the Hong Kong Stock Market', *Journal of Banking and Finance* 34, 471-483.
Cheng, Louis T. W., Li Jiang, and Renne W. Y. Ng, 2004, 'Information Content of Extended Trading for Index Futures', *Journal of Futures Markets* 24, 861-886.
Chou, R.K. and Y.Y. Wang,2009, 'Strategic Order Splitting, Order Choice and Aggressiveness: Evidence from the Taiwan Futures Exchange', *Journal of Futures Markets* 29, 1102-29.
Chordia, T., R. Roll and A. Subrahmanyam,2002,'Order Imbalance, Liquidity and Market Returns', *Journal of Financial Economics* 65, 111-130.
Danielsen, B.R. and S.M. Sorescu,2001, 'Why do Options Introductions Depress Stock Prices? A Study of Diminishing Short Sale Constraints', *Journal of Financial and Quantitative Analysis* 36, 451-84.
Easley, D., M. O'Hara and P.S. Srinivas,1998,'Option Volume and Stock Prices: Evidence on Where Informed Traders Trade', *Journal of Finance* 53, 431-65.
Figlewski, S. and G.P. Webb,1993, 'Options, Short Sales and Market Completeness', *Journal of Finance* 48, 761-77.
Fleming, J., B. Ostdiek and R.E. Whaley,1996, 'Trading Costs and the Relative Rate of Price Discovery in Stock, Futures and Options Markets', *Journal of Futures Markets* 16, 353-87.
Gerety, M. and H., Mulherin,1992, 'Trading Halts and Market Activity: An Analysis of Volume at the Open and the Close', *Journal of Finance* 47, 1765-1784.
Grinblatt, M. and M. Keloharju,2000, 'The Investment Behavior and Performance of Various Investor Types: A Study of Finland's Unique dataset', *Journal of Financial Economics* 55, 43-67.
Hameed, A., W. Kang and S. Viswanathan,2010,'Stock Market Declines and Liquidity', *Journal of Finance* 65, 257-293.
Han, B., Y.T. Lee and Y.J. Liu,2009, 'Investor Trading Behavior and Performance: Evidence from Taiwan Stock Index Options', *McCombs Research Paper Series*, No. Fin-06-09.
Hiraki, Takato, Edwin D. Maberly, and N. Takezawa,1995, 'The Information Content of End-of-the-Day Index Futures Returns: International Evidence from the Osaka Nikkei 225 Futures Contract', *Journal of Banking and Finance* 19, 921-936.
Hsieh W.L. and H.R. He,2014, 'Informed Trading, Trading Strategies and the Information Content of Trading Volume: Evidence from the Taiwan Index Options Market', *Journal of International Financial Markets*, Institutions and Money 31, 187-215.
Johnson, T. L. and E.C. So,2012, 'The Option to Stock Volume Ratio and Future Returns', *Journal of Financial Economics* 106, 262-286.
Kaul, G., M. Nimalendran and D. Zhang,2004, 'Informed Trading and Options Spreads', Working Paper, University of Michigan.
Kang, J. and H.J. Park,2008, 'The Information Content of Net Buying Pressure: Evidence from the KOSPI 200 Index Option Market', *Journal of Financial Markets* 11, 36-56.
King, M.A. and Sushil Wadhwani,1990, 'Transmission of Volatility between Stock Markets', *Review of Financial Studies* 3, 5-33.
Kyle, A.S.,1985, 'Continuous Auctions and Insider Trading', *Econometrica*, 53, 1315-35.
Lakonishok, J., I. Lee and A.M. Poteshman,2004, 'Behavioral finance and the option market', Working paper. Department of Finance, University of Illinois at Urbana Champaign.
Lee, Charles M. C., and Mark J. Ready,1991, ' Inferring trade direction from intraday data', *Journal of Finance* 46, 733-746.
Lee, H.C., C.Y. Chien, H.L. Chen, and Y.S. Huang,2009,'The Extended Opening Session of

the Futures Market and Stock Price Behavior: Evidence from the Taiwan Stock Exchange', *Review of Pacific Basin Financial Markets and Policies* 12, 403-416.
Lee, K.H. and S.F. Wang,2012, 'Are Foreign Short-sellers to Blame? Evidence from Daily Short-selling in Korean Stock Exchange', *Working Paper*, SSRN.
Ni, S.X., J. Pan and A.M. Poteshman,2008, 'Volatility Information Trading in the Options Market', *Journal of Finance* 63, 1059-91.
Pan, J. and A. Poteshman,2006, 'The Information in Option Volume for Future Stock Prices', *Review of Financial Studies* 19, 871-908.
Schlag, C. and H. Stoll,2005, 'Price Impacts of Option Volume', *Journal of Financial Markets* 8, 69-87.

Authors

Wen-liang G. Hsieh
Graduate Institute of Finance, National Chiao Tung University, 1001 University Road, Hsinchu City 300, Taiwan, ROC wlh@faculty.nctu.edu.tw

Huimin Chung
Graduate Institute of Finance, National Chiao Tung University, 1001 University Road, Hsinchu City 300, Taiwan, ROC, chunghui@mail.nctu.edu.tw

Huei-Ru He*
Graduate Institute of Finance, National Chiao Tung University, 1001 University Road, Hsinchu City 300, Taiwan, ROC tina65762003@yahoo.com.tw

* Corresponding Author