Does options trading convey information on futures prices?

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Abstract

This paper studies the presence of informed trading in Taiwan stock index options (TXO) and analyzes the informational role of foreign institutions in incorporating information into Taiwan stock index futures (TX). Using new open-buy trade data defined by Ni et al. (2008), we have found that only the option-induced part of the total TX order imbalance can predict future TX prices, and that option transactions from foreign institutions provide the most significant predictability. This finding shows that the price predictability stems from the information flow resulting from option transactions rather than from liquidity pressure. Option transactions conducted by foreign institutions, and out-of-the-money option transactions in particular, have played the primary role in conveying the information inherent in the TXO market to the TX market. Retail investors, the major players in both the TXO and TX markets, have done almost nothing of significance with regard to TXO information transmission into the TX market, with the exception of some near-the-money and out-of-the-money options.

Keywords: Delta hedging; Emerging futures market; Foreign institutions; Market-wide information; Option volume

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I Introduction

Options are attractive to informed investors because of their high inherent leverage, as well as the ease of concealing themselves that options afford (Holowczak et al., 2014). In this paper, we study the role of foreign institutions in incorporating the information from stock index options with their counterpart futures in the Taiwan futures market, which is the 18th-largest futures market in the world. When an informed investor places an order in the Taiwan stock index option (TXO) market, the TXO market makers have to make a counterpart offer. The market makers have cut the delta risk by trading Taiwan stock index futures (TX)[2]. This is how market makers transfer the information in the TXO to the TX market[3], and we can conceive of TX order imbalance as being comprised of two parts: the option-induced order imbalance and the option-independent future order imbalance.

One important feature of the Taiwan futures market, which is a major emerging market, is that it is heavily influenced by international political and economic fluctuations, and foreign institutions are more likely to possess such international market information. In addition, compared with developed futures markets such as the Chicago Mercantile Exchange (CME), information asymmetry is more prevalent among market investors, even in the index options market (Chang et al., 2009; Lin, Tsai, and Chiu, 2016). Since foreign institutions are generally considered to have greater access to global transaction information, it is interesting to explore whether the option-induced order imbalance calculated from their option trades would predict future TX prices, thus shedding light on the role of foreign institutions in the information transmission process.

[2] The underlying assumption is that market makers perform full delta hedging. When analyzing the hedging cost of market makers in TXO, Wu et al. (2014) have also made this assumption, and thus it is reasonable for us to do so as well.

[3] Chan et al. (2002) and Hu (2014) document the interaction between options and the underlying stocks in a developed options market.

The question of whether foreign institutions are better informed in emerging markets has been studied for years. Richards (2005) shows that foreign capital flow has a significant impact on the index levels of six emerging markets in eastern Asia. Bae et al. (2012) find that highly investible stocks in emerging stock markets with a greater degree of accessibility for foreign investors incorporate global information more quickly than do non-investible stocks. In addition, Dvorak (2005) and Agarwal et al. (2009) both provide evidence that foreign investors underperform domestic investors in Indonesia, although stock trading by foreign investors accounts for a meaningful percentage. Moreover, Lee et al. (2004) state that large domestic institutions, rather than foreign institutions, conduct the most informed trades in the Taiwan stock market. On the surface, we have mixed results; however, these findings reach a concurrence that foreign investors have an advantage in processing market-wide information, while domestic investors have an advantage with regard to firm-specific information.

In addition to the abundant evidence in the stock market, Chang et al. (2009) construct put-call ratios using TXO transaction data and find that only the options trading from foreign institutions can predict future prices of the underlying index, although they engage in a small proportion of total volume. This finding contrasts with the finding in Pan and Poteshman (2006) that there is little informed trading in an index options market. Subsequently, Lin, Tsai, and Chiu (2016) show that limit orders placed by foreign institutions exhibit superior predictability of future option price changes in the TXO. The implication of the two studies is twofold. First, they challenge the general view, at least in emerging markets, that the information content of index options markets is very low. Second, these findings support the claim that foreign institutions have better market-wide information than do domestic institutions in an emerging options market.

The TXO and TX markets provide a good venue for investigating whether foreign institutions have better market-wide information in the Taiwan futures market, because both of them are written on the Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX), representing the overall performance of the Taiwan stock market. Our sample covers the period from July 1, 2009 through November 30, 2012. During this period, the daily average trading volume of the TXO and TX amounted to approximately 325,000 contracts and 106,000 contracts, respectively, accounting for roughly 85 percent of the total trading volume in the Taiwan futures market. By participant, retail investors accounted for roughly 56.17%, domestic institutions for 32.03% and foreign institutions for approximately 11.80% of total TXO trading volume[4]. Compared with domestic investors, foreign institutions allocate more trades to out-of-the-money option contracts and tend to initiate a larger proportion of transactions, which potentially indicates heterogeneity among the trading patterns of the three classes of investors.

We construct the daily total order imbalance, future order imbalance and option order imbalance as information variables, as proposed by Hu (2014). To ensure that these variables are applicable to the TXO and TX, we make some amendments. First, we use nearby TX contracts to represent the overall TX market, because its trading volume amounted to roughly 85% of total TX trading volume during our sample period[5]. Second, we standardize three order imbalance variables using the sum of the daily trading volume for nearby TX and the quadrupled daily trading volume for TXO; the quadrupling derives from the fact that a per-index point of the TXO stands for

[4] As do Lin, Tsai, Zheng and Qiao (2016), we exclude the trading volume by market makers in the TXO market.

[5] When analyzing the relationship between DAX futures and DAX options, Schlag and Stoll (2005) also use nearby DAX futures to represent price movements in the index.

NTD50, while for the TX it is NTD200. If foreign institutions have market-wide information and they prefer to trade options to realize their information advantage, we would expect that the option order imbalance calculated from the trading volume of foreign institutions could predict future TX prices.

In contrast to prior studies that gauge the relative performance among three classes of investors in the Taiwan futures market, we focus on the interaction between the TXO and TX rather than that between the TXO and the underlying TAIEX (Chang et al., 2009), because market makers use the TX rather than the underlying index to hedge direction risk. Moreover, referring to Holowczak et al. (2014), we use delta exposure-based option order imbalance. This provides the benefit of retrieving higher-quality aggregate information from option volume as compared with the equal weighting method (Chang et al., 2009; Chiu et al., 2014) and the one pair method, choosing only one pair of call and put option contracts, (Lin, Tsai, and Chiu, 2016) according to the line of reasoning in Holowczak et al. (2014). Finally, unlike Chang et al. (2009) and Chiu et al. (2014), who use new open-buy option trades, and Lin, Tsai, and Chiu (2016), who use order book data, we employ more publicly observable option trades data as suggested by Pan and Poteshman (2006).

Our three main findings provide insight into the respective roles of three classes of investors in transmitting information from the TXO to the TX market. Our first empirical investigation is to examine the presence of informed trading in the overall TXO market. We find that the total order imbalance in the TX can predict future TX prices. However, when decomposing the total order imbalance in the TX into two parts – future order imbalance and option order imbalance – we find that only the coefficient of the option order imbalance remains significantly positive, which indicates that the predictability of the total order imbalance comes from the option-induced portion. A natural explanation is that informed investors primarily trade on private information in options markets (e.g., Chang et al., 2009; Pan and Poteshman, 2006). This interpretation is corroborated by two additional results. First, we find incremental predictability from option order imbalances calculated by "open-buy" option trades, in which non-market makers buy options to open new positions. Second, there is little evidence of price reversal when adding more lagged option order imbalance variables.

Our second main finding is that daily option order imbalances from options trading by both domestic institutions and foreign institutions exhibit a predictability of three days ahead. Comparing their corresponding coefficients, those for foreign institutions present greater predictability in terms of both magnitude and statistical significance. Moreover, the superior performance of foreign institutions persists during downward trending periods. We also find that the predictability of lagged option order imbalances for both domestic institutions and foreign institutions primarily arises from their superiority in possessing negative information regarding the TX market.

Our third main finding is that, among the best-performance option order imbalances across varying moneyness for foreign institutions, those calculated by out-of-the-money options trading significantly predict the returns on the next day. In addition, the past option order imbalances at lag 3 calculated by near-the-money, out-of-the-money, and deep out-of-the-money trades are also informative, and their corresponding predictability becomes stronger in both magnitude and statistical significance, indicating that the information content is the greatest for deep out-of-the-money options transactions. This finding is consistent with the leverage hypothesis that informed investors prefer to trade options because of the inherent leverage of option contracts. Interestingly, contrary to the traditional view that retail investors are noise traders, we find that some near-the-money and out-of-the-money option trades from retail investors also seem to convey information about future TX prices[6].

An outline of this paper is as follows. Section II describes our data and its corresponding descriptive statistics. Section III introduces our empirical specifications and primary information variables. We present empirical analysis in section IV. Section V concludes the paper.

II Data

We obtained the trade data of the TXO and TX used to calculate total future order imbalance, future order imbalance, and option order imbalance from the Taiwan Futures Exchange. The sample period ranges from July 1, 2009 through November 30, 2012. During this period, the daily average trading volume of the TXO and TX amounted to approximately 431,000 contracts, accounting for roughly 85 percent of the total trading volume in the Taiwan futures market. Globally, the TXO now ranks 6th among all index options.

Each trade record includes the product type, expirations, strikes (only for the TXO), quantity and price. Following Lin, Tsai, Zheng and Qiao (2016) and Ni et al. (2008), our paper excludes option trades by market makers. In addition, referring to Hu (2014), we discard the options and futures with expirations of less than five calendar days, as well as trades at the market open (8:45-9:00) and the market close (13:40-13:45).

One feature of our data set is that it further classifies the trading volume of options by trade type and investor class. The trade type indicator provides information about

[6] This finding is consistent with Chang et al. (2010), who also find that some retail trades contain useful information about the future volatility of the underlying TAIEX.

investors' motivations for trading, namely opening a new position or closing an existing position. This information is useful because Pan and Poteshman (2006) and Ni et al. (2008) show that the information content of open-buy option trades is greater, thus serving as a conditional test of whether the predictability from option volume arises from information asymmetry.

During the same sample period, we also collected the last best bid and ask prices of the TX from the Taiwan Futures Exchange to calculate the daily logarithmic return and closing spread, one of our control variables, of the nearby TX contract. We obtained daily closing prices of the TAIEX during the period from April 6, 2009 through November 30, 2012 from the Taiwan Stock Exchange to calculate the delta of option contract and turnover ratio, another of our control variables. Also, daily VIX data during the entire sample period was also obtained from the Taiwan Futures Exchange.

There are four types of participants (retail traders, foreign institutions, domestic institutions and market makers) in the Taiwan futures market, and they exhibit great heterogeneity with regard to their ability to acquire information, their trading experience, etc. This classification could assist in determining who has better information in the TXO market.

Table 2.1 presents a summary of options trading volume by investor class and option moneyness. Panel A shows that the trading volume of call options is, on average, a little larger than that for put options. This contrasts with the findings of Holowczak et al. (2014) and Pan and Poteshman (2006), in which index put options prevail in developed options markets. Analyzing each investor class individually, we find that retail investors account for more than half of options trading and that they show a stronger preference for call options. However, both foreign and domestic institutions tend to trade more put options, similar to what is seen in developed index options markets.

We further partition both call and put options into five categories of moneyness, including deep in-the-money (DITM), in-the-money (ITM), near-the-money (ATM), out-of-the-money (OTM) and deep out-of-the-money (DOTM) options, using 3% and 10% as cutoffs. Panel B presents the trading behavior of three classes of investors. Overall, unlike in developed options markets such as the CME, investors in the TXO allocate option trades less evenly across moneyness: ATM options are most actively traded, accounting for 49.17% of total option volume; DITM and ITM options share the smallest proportion, only 1.42%; and OTM and DOTM options account for 40.46% and 8.95%, respectively. This pattern exists across retail investors, foreign institutions and domestic institutions. Interestingly, we find that the trading volume distribution for put options across option moneyness is more even than is that for call options. Further, although all types of investors tend to trade more ATM options, foreign institutions distribute a larger proportion of option trades to OTM and DOTM options.

Table 2.1
Options trading behavior by investor class

Panel A: Daily average trading volume by investor class		
	Call	Put
Overall	120,582	117,497
Domestic institutions	36,874	39,385
Foreign institutions	13,626	14,464
Retail investors	70,082	63,648

Panel B: Trading volume by investor class and moneyness								
	Overall		Domestic institutions		Foreign institutions		Retail investors	
	Call	Put	Call	Put	Call	Put	Call	Put
DITM	0.08%	0.07%	0.08%	0.10%	0.32%	0.13%	0.03%	0.04%
ITM	1.39%	1.30%	1.65%	1.42%	1.53%	1.20%	1.23%	1.24%
ATM	54.24%	43.97%	57.20%	46.10%	45.81%	38.22%	54.32%	43.97%
OTM	39.55%	41.39%	37.77%	42.86%	44.89%	37.77%	39.45%	41.30%
DOTM	4.74%	13.27%	3.30%	9.52%	7.46%	22.68%	4.97%	13.45%

This table describes the options market activities during the period from July 1, 2009-November 30, 2012. We exclude option trades by market makers, those with an expiration of less than five days, and those at the market open (8:45-9:00) and the market close (13:40-13:45). Panel A provides the daily average trading volume calculated by the time-series average of the aggregated option volume with different strikes and the time to expiration by option type and investor class for each day. Panel B presents the option volume breakdown as percentages of the total volume by the option type, moneyness, and investor class. DITM denotes deep in-the-money options, ITM denotes in-the-money options, ATM denotes near-the-money options, OTM denotes out-of-the-money options, and DOTM denotes deep out-of-the-money options.

We use the procedure developed by Lee and Ready (1991) to determine whether an option trade is buyer-initiated or seller-initiated. If the trade price is above (below) the last effectively different trade price, it is classified as buyer-initiated (seller-initiated) and its corresponding direction dummy variable is set to positive (negative) one[7]. Panel A of Table 2.2 shows that this works well in the TXO market, with only 0.3% of total option trades unclassified, which is even smaller than that in Holowczak et al. (2014). On average, 53.29% of option transactions are initiated by sellers and 46.40% by buyers. However, this pattern does not apply to foreign institutions: seller-initiated transactions account for 46.25% and buyer-initiated transactions account for 52.69%. This implies that foreign institutions are relatively more active in option transactions.

[7] The same procedure applies to TX transactions to determine whether a future trade is buyer-initiated or seller-initiated.

In our analysis, the dependent variable is the daily logarithmic return of the nearby TX contract, and the main independent variables are total future order imbalance, future order imbalance, and option order imbalance. In addition, we add several control variables that may influence TX prices; in section 3.1, we detail the mathematical formulas for these variables. Panel B of Table 2.2 provides the correlation matrix of the above-mentioned variables. The results show that the return series of the TX is positively related with TOI (correlation coefficient=0.617), FOI (correlation coefficient=0.39), and OOI (correlation coefficient=0.332), indicating that the three order imbalance variables display strong contemporaneous impacts on TX prices, although it is unclear whether the price impacts are permanent. Also, the positive correlation coefficient between TOI and OOI reveals that market makers transmit volume in the TXO to the TX market through their hedging activities, as per Schlag and Stoll (2005). Further, the correlation coefficient, 0.547, is larger than that in Hu (2014), suggesting that a larger portion of TOI stems from the hedging activities in the TXO. This can also be confirmed by the fact that the correlation coefficient between TOI and FOI is smaller than that in Hu (2014). The negative relationship between FOI and OOI, though not that large, indicates that order flows in the TX and TXO markets provide inconsistent information about future price changes of the TX. Furthermore, the trading activities in the TX and TXO markets are closely related, as the correlation coefficient between Vol_{Option} and Vol_{Future} is 0.825.

Table 2.2
Summary statistics of the main variables

Panel A：Trade indicator statistics in TXO			
	Buyer-initiated	Seller-initiated	Unclassified
Overall	46.40%	53.29%	0.30%
Foreign	52.69%	46.25%	1.07%
Domestic	38.24%	61.59%	0.17%
Individual	48.34%	51.40%	0.26%

Table 2.2 Continued

Panel B: Correlations								
	R	TOI	FOI	OOI	Spread	Turnover	Vol_{Option}	$Vol_{Futture}$
R	1							
TOI	0.617	1						
FOI	0.390	0.625	1					
OOI	0.332	0.547	-0.312	1				
Spread	-0.058	-0.044	-0.018	-0.034	1			
Turnover	-0.232	-0.095	-0.202	0.102	0.180	1		
Vol_{Option}	-0.005	-0.029	-0.058	0.027	0.001	0.524	1	
$Vol_{Futture}$	0.020	-0.076	-0.103	0.018	0.044	0.480	0.825	1

Daily data ranges from July 1, 2009 through November 30, 2012. Panel A describes the trade indicator statistics in the TXO market. In this paper, we use the algorithm of Lee and Ready (1991) to determine whether an option transaction is buyer-initiated or seller-initiated. Panel B reports the pairwise correlations of our main variables. *R* is the daily logarithmic return of the nearby TX contract, calculated by using the midpoint of last best bid and ask prices. *TOI* is the total future order imbalance of the nearby TX contract. *FOI* represents the future order imbalance independent of TXO trading. OOI denotes the option order imbalance, in which options with different strikes and the time to expiration are aggregated via the delta aggregation method. *Spread* is the daily closing spread of the nearby TX contract. Turnover stands for the turnover ratio of the nearby TX contract, defined as the trading value of the nearby TX contract scaled by the closing price of its underlying index. Vol_{Option} and Vol_{Future} are the log trading volume of TXO and the log trading volume of the nearby TX contract, respectively.

III Methodology

3.1 Examining the predictability of options trading

Our first empirical investigation attempts to examine whether the trading volume of TXO contains information about the future TX prices. Easley et al. (1998) suggest that informed traders choose to trade options to realize their private information when the leverage inherent in options is high and an options market can provide ample liquidity. While futures also offer high leverage to informed investors, two additional characteristics make options more appealing in the Taiwan futures market. First, liquidity in the TXO is higher than that in the TX. The daily average trading volume of the TXO is more than 300,000, while that of the TX is about 100,000. Second, the TXO market provides hundreds of contracts available for trading, while the TX market provides only five contracts. This makes options more attractive for informed investors, who can therefore better conceal themselves among the hundreds of option contracts (Holowczak et al., 2014).

The information transmission between the TXO and TX markets is channeled through the hedging activities of market makers in the TXO market. When an investor longs an option position, the market makers, acting as their trading counterparts, have to hold the corresponding short position. To maintain delta neutral, market makers always take an opposite position in the TX market. As a result, the order imbalance in the TXO is transferred to the TX market. According to information-based models, information is incorporated into security prices through the trading behavior of informed investors (Pan and Poteshman, 2006). Therefore, if the aforementioned investor is informed, we would expect that the trading volume of the TXO could predict future TX prices.

Because the trading volume of the nearby TX contract accounts for roughly 86% of the total trading volume in the TX market, we use the nearby TX contract to represent the price movements of the overall TX market, following Schlag and Stoll (2005). Referring to Holowczak et al. (2014) and Hu (2014), we adopt order imbalances as our information variables; specifically, order imbalances in the options and futures markets are defined in equations (3.1) to (3.4).

We first define total order imbalance (TOI) in the TX market as:

$$TOI_t = \frac{\sum_{j=1}^{N} Dir_{j,t} \cdot size_{j,t}}{VolTX_t + 4 \cdot VolTXO_t} \tag{3.1}$$

where $VolTX_t$ and $VolTXO_t$ represent the trading volume of the nearby TX contract and the trading volume of the total TXO market on day *t*, respectively; $Dir_{j,t}$ and $size_{j,t}$ are the direction dummy variable and the size of the *j*th trade of the nearby TX contract on day *t*. Here, the dummy variable is equal to positive (negative) one if the *j*th trade for nearby TX is buyer-initiated (seller-initiated).

To account for differential exposures of option contracts to price movements of the TX, we aggregate order flows from the options market with a delta exposure-based weighting scheme, as do Holowczak et al. (2014) and Hu (2014). Thus, option order imbalance (OOI) is defined as

$$OOI_t = \frac{\sum_{j=1}^{N} Dir_{i,j,t} \cdot delta_{i,j,t} \cdot size_{i,j,t}}{VolTX_t + 4 \cdot VolTXO_t} \tag{3.2}$$

where, on day t for the ith option contract, $Dir_{i,j,t}$ and $size_{i,j,t}$ are the direction dummy variable and the trade size of the jth trade; $delta_{i,j,t}$ represents the delta of the an option contract calculated using the Black-Scholes model. When calculating the delta of each option contract, we choose the first trade price of the nearby TX for every minute on day t and denote it as F; we then apply the following formula in Holowczak et al. (2014) to calculate d_1.

$$d_1 = \frac{\ln(F/K) + \frac{1}{2}\sigma^2 T}{\sigma\sqrt{T}} \tag{3.3}$$

where σ is the average volatility of the underlying index over the past 60 days.

Hu (2014) suggests that order imbalance tends to be more imbalanced when trading is less active, and thus it is necessary to standardize order imbalance variables by a stock's number of common shares outstanding. To standardize TOI and OOI, we use the sum of the daily trading volume for the nearby TX and the quadrupled daily trading volume for the TXO. Here we multiply $VolTXO_t$ by 4 because a per-index point of the TXO stands for NTD50, while for the TX it is NTD200.

TOI is comprised of two parts: option-induced order imbalance (OOI) and future order imbalance (FOI) independent of options trading. Therefore, to obtain FOI in the TX market we should subtract OOI from TOI, following Hu (2014).

$$FOI_t = TOI_t - OOI_t \tag{3.4}$$

The assumption behind this formula is that market makers conduct full delta hedging. Considering that Wu et al. (2014) have also utilized this assumption in analyzing market makers' hedging activities in the TXO market, it is reasonable for us to make the same assumption.

We test whether the order flows in the TXO market predict future TX prices by estimating the following equation:

$$R_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k} + Control_{t-1} + \varepsilon_t \tag{3.5}$$

where R_t is the logarithmic return of the nearby TX contract, calculated by the midpoint of last best bid and ask prices on day *t-1* and *t*; $Control_{t-1}$ is a set of control variables influencing R_t, including the daily closing spread of the nearby TX contract, the turnover ratio of the nearby TX contract defined as the trading value of the nearby TX contract scaled by the closing price of its underlying index, the log trading volume of the nearby TX contract, the log trading volume of all TXO contracts, the lagged return of the nearby TX contract and the lagged equally weighted options returns over the past five days.

According to the implications of the information-based model, if informed investors choose to trade options (futures) for direction information, we would expect at least some of the coefficients of OOIs (FOIs) to be significantly positive. Given that informed investors are more likely to open new positions than to close existing positions when they trade on their private information in an options market (Ni et al., 2008; Pan and Poteshman, 2006), we would therefore expect an incremental predictability if the predictive power derives from information asymmetry rather than liquidity pressure. To determine whether the potential predictive ability of option order imbalance arises from information asymmetry, we further utilize equation (3.5) with OOIs calculated by open-buy option trades.

3.2 Predictability of the option trades of different classes of investors

Despite considerable research in the literature (Albuquerque et al., 2009; Bae et al., 2012; Lee et al., 2004; Richards, 2005), there has been no consensus as to whether foreign institutions (investors) outperform in emerging markets. One possible explanation is that prior researchers have studied two different types of information advantage of foreign institutions, namely firm-specific and market-wide information.

Lin, Tsai, and Chiu (2016) summarize these papers and document that, while domestic institutions and foreign institutions are both informed investors, they have an advantage in acquiring different types of information. In particular, foreign institutions seem to perform better in trading market-wide information (Chang et al., 2009; Lin, Tsai, and Chiu, 2016; Richards, 2005).

The TXO and TX markets provide a good venue for examining whether foreign institutions have better market-wide information in emerging markets because their underlying index is the TAIEX, which represents the overall performance of the Taiwan market. To examine the issue, we design three empirical specifications. According to the information transmission analysis in the previous section, among the three classes of investors (domestic institutions, foreign institutions, and retail investors), the one whose option trades provide the strongest predictability plays the leading role in transmitting information from the TXO to the TX.

3.2.1 Predictability of different classes of investors using all TXO trade data

To determine which class of investors may acquire a superior information advantage, we divide all option transactions into three groups based on investor class and construct their respective option order imbalance series. The regression follows the below equation[8]:

$$R_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k}^{Investor\_Category} + \varepsilon_t \tag{3.6}$$

where $OOI_{t-k}^{Investor\_Category}$ denotes the option order imbalance calculated by option trades from domestic institutions, foreign institutions, and retail investors. If foreign institutions have better market-wide information in Taiwan, we would expect that the option order imbalance calculated from their trades could provide the strongest predictability.

3.2.2 Predictability of different classes of investors when market volatility surges

Another contributing factor affecting the information content of option volume is volatility. Chan et al. (2009) find that informed trading in an options market is more prevalent when the market is in a downward trending period. The authors attribute this to the incremental difficulty of short sales in the underlying market, which makes options more appealing to informed investors. Lin, Tsai, Zheng and Qiao (2016) also provide evidence to support the idea that the informational role of options is related to the fear index VIX.

Motivated by this consideration, we choose the post-crisis period from July 1, 2009 to November 13, 2009 as a subsample during which the VIX continually exceeds 25. Subsequently, we run equation (3.6) separately to examine whether the superior performance by foreign institutions persists during this period. If informed investors allocate a larger proportion of trades to the options market when market volatility

[8] In equations (3.6), (3.7), (3.8), and (3.9) below, we drop the control variables from the previous section, because our empirical results in section (4.1) show that it provides stronger predictability by omitting these control variables.

surges, we would expect greater predictive power from option order imbalance. This analysis also serves as a conditional test, helping to reveal whose performance is more robust across different market conditions.

3.2.3 Predictability of different classes of investors for asymmetric price movements

It is useful to divide all return series into two segments based on their signs. In examining whether retail investors are informed, Kelly and Tetlock (2013) use order imbalance variables to predict future negative news, as fluctuations in negative words are associated with stronger reactions than those in positive words. Further, one of the most important rules in trading is that survival must always come first in a recession. Of special interest for our paper is an investigation of whether informed investors in the TXO show asymmetrical responses to positive and negative information in TX market prices.

To provide further empirical information about this issue, we divide all return series into two segments and estimate the following two equations:

$$MAXR_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k}^{Investor\_Category} + \varepsilon_t \tag{3.7}$$

$$MINR_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k}^{Investor\_Category} + \varepsilon_t \tag{3.8}$$

where $MAXR_t = \max(R_t, 0)$ and $MINR_t = \min(0, R_t)$, and R_t is the daily logarithmic return of the nearby TX contract. The two regressions are estimated separately for domestic institutions, foreign institutions, and retail investors. If foreign institutions are sensitive to both positive and negative news, we would expect at least some of $OOI_{t-k}^{Foreign}$ (k=1, 2, 3, 4, and 5) to show k-day-ahead predictability of $MAXR_t$ and $MINR_t$; a similar analysis applies to domestic institutions and retail investors.

3.3 Predictability of the option trades of different categories of moneyness

Information-based models such as that of Easley et al. (1998) suggest that informed traders prefer trading options due to their high inherent leverage. Therefore, information variables calculated from OTM options exhibit incremental predictability (Pan and Poteshman, 2006). However, leverage is not the only consideration. Informed investors also want to choose option contracts with ample liquidity with the aim of reducing trading cost (Holowczak et al., 2014). Collectively, leverage and liquidity together determine which categories of options are appealing to informed investors.

Prior studies such as those conducted by Blasco et al. (2010) and Pan and Poteshman (2006) indicate that information variables calculated by out-of-the-money options show stronger predictability, because out-of-the-money options transactions comprise the majority of transactions in developed options markets, as well as providing higher leverage to investors. However, conditions in the TXO are different from those in the aforementioned two markets; instead of out-of-the-money options, most option transactions are concentrated at near-the-money options, as detailed in section II above. The inconsistency between the category of options with the highest leverage and that with the highest liquidity suggests a question: which categories of options do informed investors most prefer to realize their information in the TXO market? To answer the question, we break OOI down into five portions of varying leverage and run the following empirical specification for each:

$$R_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k}^{Moneyness\_Category} + \varepsilon_t \tag{3.9}$$

where $OOI^{Moneyness\_Category}$ is the option order imbalance variables calculated for DITM options, ITM options, ATM options, OTM options, and DOTM options, respectively.

Another difference between the TXO and major developed options markets is that investors show greater heterogeneity in the TXO. Although retail investors and domestic institutions allocate roughly half of their trades to ATM options, foreign institutions distribute their trades more evenly across option moneyness. To determine the categories of options preferred by informed investors in the TXO, we divide the daily option trades into 15 categories, defined by five categories of options in terms of moneyness and three investor classes, and then run equation (3.9) separately.

IV Empirical Analysis

4.1 Return predictability from the FOIs and the OOIs

In this section, we examine the presence of informed trading in futures and options markets; the results are contained in Table 4.1. Specifically, we first investigate the predictability of TOI, the total order imbalance in the TX market, by running the following equation:

$$R_t = \alpha + TOI_{t-1} + \varepsilon_t \tag{4.1}$$

The first column in Table 4.1 reports the results, which show that the coefficient (coefficient=0.166, t-statistic=2.15) on TOI_{t-1} is significant and positive, implying that the trading volume in the TX market contains information about future TX prices.

However, as detailed in section 3.1, the TOI is comprised of two components: the option-induced portion (OOI) and the future order imbalance (FOI) independent of option trades. To determine what contributes to the predictability of the TOI, we divide the TOI into the FOI and OOI and run equation (4.1) again. The corresponding results are presented in column 2. We find that the FOI coefficient of 0.122 is positive but insignificant (t-statistic=1.32), while, the OOI has a coefficient of 0.221 and t-statistic of 2.23. The results suggest that the predictive ability of the OOI is stronger than that of the TOI in terms of both magnitude and statistical significance. The only significant coefficient of the OOI also reveals that the return predictability of the TOI mainly arises from the OOI, which supports the idea that informed investors with private information primarily trade in an options market rather than a futures market.

Column 3 gives the empirical results of testing the predictability of the FOIs and the OOIs over longer horizons, which show that the FOI coefficient of day *t-2* of -0.169 is significant at the 10% level. This negative coefficient indicates that part of the contemporaneous price impacts documented in Panel B of Table 2.2 is reversed on day *t+2*. Turning to the results for OOIs, we find that the coefficient of OOI_{t-1} remains significant at the 10% level. Moreover, there is no evidence of a reversal effect for OOIs, according to the reasoning line of Schlag and Stoll (2005), because the other four OOIs have no significant and negative coefficients. These results suggest that the option volume in TXO can predict the returns on the next day.

For the sake of robustness, we run a similar regression using the OOIs constructed by open-buy option trades, following Ni et al. (2008) and Pan and Poteshman (2006); the results are reported in column 4. Consistent with the results in Ni et al. (2008) and Pan and Poteshman (2006), the OOIs using open-buy option volume provide incremental predictability. The coefficient of OOI_{t-1} increases to 0.267 (t-statistic=1.84) and the corresponding R^2 to 0.0181. Moreover, the positive coefficient of OOI_{t-3} becomes significant, which extends the predictive horizon to three days. Again, we find little evidence of price reversal for the OOIs. The economic implication of this finding is twofold. First, it further confirms our conclusion that the return predictability from OOIs arises from information asymmetry rather than liquidity pressure. Second, this finding implies that informed investors in the TXO, like those in developed markets, are more likely to use open-buy options.

Considering that liquidity in futures and options markets as well as the lagged return series may have an impact on predictability, we add a number of factors to our regression: turnover, spread, log futures volume, log options volume, futures returns for the previous days, and equally weighted options returns across strikes and the time to expiration for the previous days; column 5 reports the results. Similar to what is found in Hu (2014) and Pan and Poteshman (2006), the predictive ability of the OOIs weakens because the coefficient of the OOI on day *t-3* decreases in both magnitude and statistical significance. While the coefficient of OOI_{t-1} remains positive, it becomes insignificant. Moreover, all of the control variables seem to have little relationship with future TX price movements, with the exception of the log futures volume. Although adding these control variables works well in a stock options market (Hu, 2014), we choose to drop these for the remainder of our analysis because it weakens the return predictability from option order imbalances.

Collectively, our results suggest that options trading in the TXO conveys information about future TX prices, although Chang et al. (2009) and Chiu et al. (2014) find no predictability of future returns of the TAIEX within one week even when they use the non-public newly open-buy option trades. In our view, it is the option-information aggregation method that results to the inconsistent results. They both adopt the equal weighting method, which relies on the unreasonable assumption that informed investors randomly choose an option contract, thus distorting the estimated relationship (Holowczak et al., 2014). Our findings further support the idea of Holowczak et al. (2014) that the means of aggregating options is crucial to retrieving information from option volume.

Table 4.1
Return predictability from the FOIs and the OOIs

Variables	(1)	(2)	(3)	(4)	(5)
Intercept	1.037E-04	1.355E-04	2.192E-04	1.619E-04	-3.054E-02
t	(0.24)	(0.31)	(0.48)	(0.37)	(-1.02)
TOI_{t-1}	0.166**				
t	(2.15)				
FOI_{t-1}		0.122	0.132	0.106	0.143
t		(1.32)	(1.42)	(1.17)	(1.25)
FOI_{t-2}			-0.169*	-0.178*	-0.140
t			(-1.79)	(-1.96)	(-1.23)
FOI_{t-3}			0.080	0.066	0.082
t			(0.84)	(0.72)	(0.72)
FOI_{t-4}			-0.359	-0.046	-0.045
t			(-0.37)	(-0.50)	(-0.4)
FOI_{t-5}			-0.076	-0.103	-0.120
t			(-0.79)	(-1.13)	(-1.06)
OOI_{t-1}		0.221**	0.180*	0.267*	0.171
t		(2.23)	(1.75)	(1.84)	(1.36)
OOI_{t-2}			-0.773	-0.031	-0.016
t			(-0.75)	(-0.22)	(-0.13)
OOI_{t-3}			0.167	0.299**	0.209*
t			(1.63)	(2.06)	(1.70)
OOI_{t-4}			0.019	0.049	0.041
t			(0.18)	(0.34)	(0.34)
OOI_{t-5}			0.073	0.015	0.009
t			(0.73)	(0.10)	(0.08)
R_{t-1}					0.013
t					(0.27)
R_{t-2}					-0.029
t					(-0.63)
R_{t-3}					0.009
t					(0.21)
R_{t-4}					0.008
t					(0.18)
R_{t-5}					0.066
t					(1.46)
$OptR_{t-1}$					-0.003
t					(-1.51)
$OptR_{t-2}$					-0.002
t					(-0.88)
$OptR_{t-3}$					-0.003
t					(-1.14)

Table 4.1 Continued

$OptR_{t-4}$					0.001
t					(0.46)
$OptR_{t-5}$					-1.162E-04
t					(-0.06)
Spread					2.030E-05
t					(0.05)
Turnover					0.003
t					(1.24)
$Vol_{options}$					0.002
t					(1.27)
$Vol_{futures}$					-0.003**
t					(-2.08)
R^2	0.0054	0.0063	0.0173	0.0181	0.0329

This table reports estimates from time series regressions during the period from July 1, 2009 through November 30, 2012. The dependent variable, R_t, is the daily logarithmic return of the nearby TX contract, using the midpoint of last best bid and ask prices on day *t-1* and *t*; TOI_{t-1} is the total future order imbalance in the TX market on day *t-1*. FOI_{t-k} is the future order imbalance independent of TXO trading on day *t-k*. OOI_{t-k} is the option order imbalance calculated using the delta aggregation method on day *t-k*. $Control_{t-1}$ consists of a set of control variables which may influence R_t, including R_{t-k}, the lagged returns for the previous five days; $OptR_{t-k}$, the equally weighted options returns over the past five days; Spread, the daily closing spread of the nearby TX contract; Turnover, the ratio of the trading value of the nearby TX contract to the closing price of its underlying index; $Vol_{options}$, the log options volume; $Vol_{futures}$, the log trading volume of the nearby TX contract. Column (4) reports the regression results that use option order imbalance calculated by open-buy option trades. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

4.2 Predictive performance by different investor classes

Our analysis thus far suggests that option volume is informative in predicting future price changes of the TX. This section turns to an evaluation of which class of investors – domestic institutions, foreign institutions, and retail investors – possesses superior information.

4.2.1 Predictability of the option trades of different classes of investors

Table 4.2 reports the main results of the regressions specified in equation (3.6). For the sake of brevity, we only report the coefficients and t-statistics on the OOIs. For all values of *k*=1, 2, 3, 4, 5, we would expect at least some of OOI_{t-k} for each group of investors to display *k*-day-ahead predictive power if they conduct informed trading in an options market (Ni et al., 2008). When focusing on the results in the final column, we find no significant coefficients of OOIs calculated by option volume from retail investors. Consistent with Chang et al. (2009), this lack of predictability indicates that options trading by retail investors conveys little useful information regarding futures prices, although it accounts for roughly half of all options trading.

For both domestic institutions and foreign institutions, the OOIs on day t-3 have a significant and positive coefficient, one of 0.37 (t-statistic=1.93) and the other of 0.62 (t-statistic=1.98), indicating that their options trading provides 3-day-ahead predictability of future TX prices. Moreover, there is no price reversal in longer horizons. The two findings together signal that domestic institutions and foreign institutions are highly likely to be informed investors in the TXO market.

Comparing the coefficients of OOI_{t-3} for domestic institutions and foreign institutions, we find that the coefficient for foreign institutions shows stronger predictability in terms of both magnitude and statistical significance. Moreover, we have a larger R^2, 0.0163, when using the OOIs calculated by option volume from foreign institutions. This finding is consistent with prior studies such as those conducted by Chang et al. (2009), Lin, Tsai, and Chiu (2016), and Richards (2005) in the sense that foreign institutions have better market-wide information in an emerging options market.

Table 4.2
Predictability by different investor classes

Variables	Domestic institutions	Foreign institutions	Retail investors
OOI_{t-1}	0.20	-0.08	0.13
t	(1.01)	(-0.25)	(1.15)
OOI_{t-2}	-0.13	-0.21	-0.10
t	(-0.69)	(-0.66)	(-0.85)
OOI_{t-3}	0.37*	0.62**	0.20
t	(1.93)	(1.98)	(1.63)
OOI_{t-4}	0.04	-0.11	0.08
t	(0.21)	(-0.35)	(0.74)
OOI_{t-5}	0.07	0.42	-0.03
t	(0.38)	(1.35)	(-0.29)
R^2	0.0156	0.0163	0.0156

This table reports estimates from time series regressions during the period from July 1, 2009 through November 30, 2012. The empirical specification is:

$$R_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k}^{Investor\_Category} + \varepsilon_t$$

The dependent variable, R_t, is the logarithmic return of the nearby TX contract, calculated using the midpoint of last best bid and ask prices on day *t-1* and *t*; FOI_{t-k} is the future order imbalance independent of TXO trading on day *t-k*. $OOI_{t-k}^{Investor\_Category}$ is the option order imbalance calculated using option volume from various classes of investors, including domestic institutions, foreign institutions, and retail investors. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

4.2.2 Predictability of different classes of investors when market volatility surges

Given that foreign institutions may have an advantage in possessing market-wide information, in this section we investigate whether their superior performance persists during a downward trending period. Table 4.3 displays the estimated coefficients of the OOIs for each class of investors for equation (3.6), with the post-crisis sample period from July 1, 2009 to November 13, 2009, during which time the VIX continually exceeds 25.

Again, we find that the options trading of retail investors is not informative in predicting future TX prices. For foreign institutions, the OOI_{t-3} now has a larger coefficient of 2.51 (t-statistic=1.96), and the R^2 also increases to 0.09. This finding indicates that the return predictability from options trading by foreign institutions is stronger when the market is more volatile. Conversely, the return predictability from the OOIs calculated by option volume from domestic institutions vanishes, as none of the coefficients remains significant. The surviving predictability from the options trading of foreign institutions suggests that foreign institutions play the primary role in transmitting information from the options market to the futures market, and this conclusion is robust under different market conditions.

Table 4.3
Predictability by different investor classes during a downward trending period

Variables	Domestic institutions	Foreign institutions	Retail investors
OOI_{t-1}	0.25	0.16	-0.55
t	(0.28)	(0.12)	(-1.09)
OOI_{t-2}	0.50	1.23	0.22
t	(0.57)	(0.94)	(0.44)
OOI_{t-3}	0.07	2.51*	0.50
t	(0.08)	(1.96)	(0.98)
OOI_{t-4}	0.07	-1.20	0.24
t	(0.09)	(-0.94)	(0.48)
OOI_{t-5}	-0.04	0.24	-0.28
t	(-0.05)	(0.19)	(-0.54)
R^2	0.03	0.09	0.06

This table reports estimates from time series regressions during the time period from July 1, 2009 to November 13, 2009, during which time the VIX continually exceeds 25. The empirical specification is:

$$R_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k}^{Investor\_Category} + \varepsilon_t$$

The dependent variable, R_t, is the logarithmic return of the nearby TX contract, using the midpoint of last best bid and ask prices on day *t-1* and *t*; FOI_{t-k} is the future order imbalance independent of TXO trading on day *t-k*. $OOI_{t-k}^{Investor\_Category}$ represents the option order imbalances calculated using the option volume from various classes of investors, including domestic institutions, foreign institutions, and retail investors. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

4.2.3 Predictability of different classes of investors for asymmetric price movements

Table 4.4 contains the regression results using the OOIs for each class of investors to predict both upward and downward movements of TX prices, respectively. Regressions (1), (3), and (5), which investigate the predictability of future upward price movements, show that the OOIs calculated using the option volume from both institutions and retail investors are unable to predict future positive news in the TX market.

However, the estimated results paint a different picture of the predictability of downward price movements from the OOIs for each class of investors. In column 2, we find that the OOIs calculated by using option trades from domestic institutions on day *t-1* and *t-3* both have a significant (albeit at the 10% level) and positive coefficient; one is 0.23 (t-statistic=1.79) and the other is 0.21 (t-statistic=1.66). Similar to the results for predicting entire returns, column 4 shows that the options trading from foreign institutions display significant 3-day-ahead predictability. Surprisingly, the OOI on day *t-1* for retail investors also has a significant and positive coefficient of 0.143, and the t-statistic is 1.96. This finding contrasts with the view that retail investors are noise traders, but accords with the results of Chang et al. (2010) that some retail trading in the TXO is also informative.

Consistent with Hu (2014) and Kelley and Tetlock (2013), informed investors exhibit a greater advantage in possessing negative information related to downward price movements of the TX. This interpretation is further supported by the fact that the respective R^2 for regressions (2), (4), and (6) is greater than the corresponding R^2 for regressions (1), (3), and (5). Comparing the estimated results for regressions (2) and (4), we find that although there is an additional more significant coefficient of the OOI for domestic institutions, its corresponding R^2 is smaller than that for foreign institutions. This indicates that options trading from foreign institutions provides stronger predictability of future downward price movements. In addition, the coefficient of the OOI on day *t-3* in column 4 is 0.52 (t-statistic=2.54), which is greater than that in column 2. As such, we conclude that foreign institutions are still better informed.

Table 4.4

Predictability of upward and downward price movements by different classes of investors

Dependent variable	$MAXR_t$ (1)	$MINR_t$ (2)	$MAXR_t$ (3)	$MINR_t$ (4)	$MAXR_t$ (5)	$MINR_t$ (6)
	Domestic institutions		Foreign institutions		Retail investors	
OOI_{t-1}	-0.03	0.23*	-0.25	0.17	-0.01	0.143*
t	(-0.28)	(1.79)	(-1.41)	(0.82)	(-0.22)	(1.96)
OOI_{t-2}	-0.07	-0.06	-0.05	-0.15	-0.04	-0.06
t	(-0.69)	(-0.47)	(-0.30)	(-0.76)	(-0.65)	(-0.75)
OOI_{t-3}	0.16	0.21*	0.10	0.52**	0.08	0.12
t	(1.52)	(1.66)	(0.58)	(2.54)	(1.35)	(1.56)
OOI_{t-4}	-0.03	0.07	-0.16	0.05	-0.02	0.11
t	(-0.31)	(0.60)	(-0.90)	(0.24)	(-0.36)	(1.46)
OOI_{t-5}	-0.01	0.09	0.15	0.27	0.00	-0.04
t	(-0.12)	(0.69)	(0.86)	(1.34)	(0.07)	(-0.50)
R^2	0.017	0.02	0.018	0.023	0.017	0.022

This table reports estimates from time series regressions during the period from July 1, 2009 through November 30, 2012. In this table, columns (1), (3), and (5) report the time series regression results of the following equation:

$$MAXR_t = \alpha + \sum_{k=1}^{5}\beta_{1,k}FOI_{t-k} + \sum_{k=1}^{5}\beta_{2,k}OOI_{t-k}^{Investor\_Category} + \varepsilon_t$$

Columns (2), (4), and (6) report the corresponding results of the following equation:

$$MINR_t = \alpha + \sum_{k=1}^{5}\beta_{1,k}FOI_{t-k} + \sum_{k=1}^{5}\beta_{2,k}OOI_{t-k}^{Investor\_Category} + \varepsilon_t$$

where $MAXR_t = \max(R_t, 0)$ and $MINR_t = \min(0, R_t)$, and R_t is the daily logarithmic return of the nearby TX contract. FOI_{t-k} is the future order imbalance independent of TXO trading on day *t-k*. $OOI_{t-k}^{Investor\_Category}$ represents the option order imbalances calculated using the option volume of various classes of investors, including domestic institutions, foreign institutions, and retail investors. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

4.3 Predictability of options trading with varying moneyness

In this section, we investigate which category of options in terms of moneyness is most informative about future TX prices. Panel A of Table 4.5 reports the respective regression results of the OOIs from each option moneyness category. Contrary to Hu (2014), neither OOIs constructed by DITM options nor by ITM options in the TXO exhibit much predictability. A possible explanation is that, considering the potential large price impacts, informed investors may not trade DITM and ITM options since their trading volume accounts for less than 2% of the total trading volume of the TXO.

The OOI on day *t-1* for ATM options has a significant coefficient of 0.23 (t-statistic=-1.99). This finding partially supports the liquidity hypothesis in Holowczak et al. (2014) that informed investors are prone to allocate their trades to option contracts with high liquidity. In the TXO market, this category of options is ATM options. Unlike what is found by Hu (2014), the information content of OTM options trading is higher because the coefficient of OOI_{t-3}^{OTM} increases to 2.79 and the regression generates a larger R^2. This result implies that leverage is also a critical consideration for informed investors. However, the predictability from DOTM options becomes weaker, although they provide the highest leverage.

Panel B reports the best-performance OOIs across option moneyness for domestic institutions. Consistent with the results for the analysis of the entire sample, domestic institutions tend to trade on private information in ATM and OTM options. The significant negative coefficient of the OOI on day *t-2* for DOTM options reveals that the possible purpose of domestic institutions' trading in DOTM options is to buy protection against market crash according to Holowczak et al. (2014). The results in Panel C reveal that the OOIs calculated by using ATM options, OTM options, and DOTM options from foreign institutions all provide a 3-day-ahead predictability of future TX prices, and the predictive ability of trading volume from options of increasing leverage is also increasing in both magnitude and statistical significance. In addition, the OOI calculated by OTM options from foreign institutions can predict the returns on the next day.

Comparing the coefficients of OOIs for ATM options, OTM options, and DOTM options at lag 3 between foreign and domestic institutions, we find that those from foreign institutions outperform those from domestic institutions in terms of both magnitude and statistical significance. In addition, OTM option volume from foreign institutions also provides predictability of the next day's TX return. Taken together, the two facts further support our conjecture that foreign institutions have better market-wide information.

Finally, we focus on retail investors; the results are presented in Panel D. Surprisingly, although overall options trading by retail investors offers little predictability, some ATM, OTM and DOTM options are informative. This indicates that there is a small subset of retail investors who possess direction information in addition to volatility information, as documented in Chang et al. (2010).

Table 4.5
Predictability with varying option moneyness by different investor classes

	DITM	ITM	ATM	OTM	DOTM
			Panel A: Overall Market		
OOI_{t-1}	-2.14	-0.09	0.23**	1.32	-20.23
t	(-1.13)	(-0.16)	(-1.99)	(1.33)	(-0.95)
OOI_{t-2}	0.12	-0.72	-0.06	-1.11	26.73
t	(0.06)	(-1.36)	(-0.5)	(-1.11)	(1.26)
OOI_{t-3}	-1.55	-0.14	0.19	2.79**	36.12*
t	(-0.81)	(-0.27)	(1.64)	(2.81)	(1.70)
OOI_{t-4}	0.25	-0.12	0.02	0.30	-13.65
t	(0.13)	(-0.23)	(0.17)	(0.30)	(-0.64)
OOI_{t-5}	-2.10	0.85	0.05	0.37	13.40
t	(-1.1)	(1.61)	(0.45)	(0.37)	(0.63)
R^2	0.0125	0.0142	0.0175	0.021	0.0161
			Panel B: Domestic institutions		
OOI_{t-1}	0.78	0.37	0.20	3.22	-60.30
t	(0.26)	(0.46)	(0.88)	(1.64)	(-0.8)
OOI_{t-2}	-2.95	-0.39	-0.12	0.32	-153.40**
t	(-0.94)	(-0.49)	(-0.54)	(0.16)	(-2.02)
OOI_{t-3}	1.38	0.49	0.39*	5.36**	74.92
t	(0.44)	(0.61)	(1.77)	(2.73)	(0.99)
OOI_{t-4}	-1.57	0.06	0.01	1.29	-61.98
t	(-0.50)	(0.08)	(0.06)	(0.65)	(-0.82)
OOI_{t-5}	-1.27	1.59**	-0.01	1.30	3.42
t	(-0.42)	(2.02)	(-0.06)	(0.66)	(-0.05)
R^2	0.0104	0.0146	0.014	0.021	0.0169

Table 4.5 Continued

Panel C: Foreign institutions					
OOI_{t-1}	-1.43	1.21	-0.35	5.21**	-26.62
t	(-0.43)	(1.11)	(-0.99)	(2.44)	(-0.53)
OOI_{t-2}	-1.16	-1.88*	-0.01	-2.26	1.44
t	(-0.34)	(-1.71)	(-0.02)	(-1.06)	(0.03)
OOI_{t-3}	-1.81	-0.34	0.74**	5.40**	128.80**
t	(-0.53)	(-0.30)	(2.09)	(2.53)	(2.54)
OOI_{t-4}	1.13	0.89	-0.29	-1.84	-42.98
t	(0.33)	(0.81)	(-0.83)	(-0.86)	(-0.88)
OOI_{t-5}	-2.21	1.96*	0.53	-2.78	18.65
t	(-0.67)	(1.78)	(1.51)	(-1.30)	(0.38)
R^2	0.0102	0.016	0.0166	0.0242	0.0151
Panel D: Retail investors					
OOI_{t-1}	4.11	-0.79	0.18	1.03	-43.50
t	(0.81)	(-1.08)	(1.43)	(0.63)	(-0.70)
OOI_{t-2}	-5.31	0.35	-0.11	-0.77	-57.09
t	(-1.04)	(0.47)	(-0.91)	(-0.47)	(-0.92)
OOI_{t-3}	5.12	-0.59	0.24*	2.90*	145.69**
t	(1.00)	(-0.80)	(1.91)	(1.77)	(2.41)
OOI_{t-4}	-5.76	-0.33	0.10	0.74	-28.51
t	(-1.13)	(-0.45)	(0.83)	(0.45)	(-0.46)
OOI_{t-5}	-5.76	0.45	-0.06	1.51	-31.43
t	(-1.13)	(0.61)	(-0.46)	(0.92)	(-0.51)
R^2	0.0134	0.0119	0.0174	0.0141	0.0191

In this table, Panel A reports estimates of the following time series regressions during the period from July 1, 2009 through November 30, 2012.

$$R_t = \alpha + \sum_{k=1}^{5} \beta_{1,k} FOI_{t-k} + \sum_{k=1}^{5} \beta_{2,k} OOI_{t-k}^{Moneyness\_Category} + \varepsilon_t$$

The dependent variable, R_t, is the logarithmic return of the nearby TX contract, using the midpoint of last best bid and ask prices on day *t-1* and *t*; FOI_{t-k} is the future order imbalance independent of TXO trading on day *t-k*. $OOI_{t-k}^{Moneyness\_Category}$ represents the option order imbalances calculated using the entire option volume from each option moneyness category, including DITM=deep in-the-money options, ITM=in-the-money options, ATM=near-the-money options, OTM=out-of-the-money options, DOTM=deep out-of-the-money options. Panels B, C, and D report the respective results for domestic institutions, foreign institutions, and retail investors. The resulting t-statistics are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

V Conclusion

This article investigates whether the trading volume of the TXO conveys information about future TX prices, and also whether there is an informational role of foreign institutions in the information transmission process. The rationale for the interaction between the TXO and the TX is that market makers, acting as trading counterparts of the other participants, use the TX to hedge the direction risk posed by transactions in the TXO. Thus, the total order imbalance in the TX consists of the option-induced order imbalance and the future order imbalance independent of option transactions. If informed investors prefer to trade in the TXO, we would expect the option-induced order imbalance to be informative about future TX prices.

We provide compelling evidence of the presence of informed trading in the TXO by demonstrating that the option order imbalance positively predicts the future prices of the TX. Additionally, the option order imbalance calculated using open-buy options trading, in which non-market makers buy options to open new positions, shows incremental predictability, indicating that the predictability arises from information asymmetry rather than liquidity pressure (Ni et al., 2008). Inconsistent with the conclusion of Pan and Poteshman (2006) that informed investors in a developed options market tend to possess firm-specific rather than market-wide information, our study yields the evidence of market-wide informed trading in the TXO market.

We also find that the option order imbalances calculated by options trading from both foreign institutions and domestic institutions are informative in predicting future TX prices, and the former generates stronger predictability in terms of both magnitude and statistical significance. Moreover, their superior predictability performance persists during more volatile periods. By dividing the entire return series of the TX into two portions – upward and downward price movements – we find that the option order imbalances only provide significant predictability for downward movements of TX prices and that those calculated by options trading from foreign institutions provide the most significant predictability.

Finally, we investigate which category of options is preferred by informed investors. Overall, near-the-money options and out-of-the-money options are both informative; however, the information content of out-of-the-money options is higher. The results hold for options trading by foreign institutions. Therefore, our findings are consistent with the leverage hypothesis that informed investors choose to trade on private information in an options market because of the high leverage inherent in options.

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