東海大學管理學院財務金融研究所

碩士論文

選擇權淨買壓對報酬及波動度之預測能力

Predictability of options' net buying pressure for returns and volatility

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摘要

選擇權之相關指標常被應用於股票報酬與波動度之預測。本文將過去預測能力方面文獻沒使用過的選擇權淨買壓用於台灣加權指數(TAIEX)報酬與波動度之預測。選擇權淨買壓之預測能力沒被過去文獻所探討之原因為：在作總淨買壓之計算時，方向交易效果與波動交易效果可能互相抵消掉，進而導致總淨買壓之資訊內涵的預測能力有限。因此，本文使用 Chang and Wang (2015)之方法將總淨買壓分成方向淨買壓(NBPD)和波動淨買壓(NBPV)，然後再將方向淨買壓用來預測台指報酬，並將波動淨買壓用於台指波動度之預測。本文實證結果發現，方向淨買壓不論 2011 年美債前後皆對台指報酬有顯著之預測能力，且其預測能力可長達對前八期報酬之預測。價內選擇權之波動淨買壓於美債後對台指有顯著之預測能力。因此，本文證實結果顯示，方向淨買壓與波動淨買壓對台指之報酬與波動度皆有預測能力。

關鍵字：選擇權淨買壓、資訊優勢者、報酬預測、波動度預測。

Abstract

Option-related indicators are often used to predict stock returns and volatility. In contrast to information variables adopted in the related literatures, we predict TAIEX returns and volatility with the information content of options' net buying pressure. Indeed, total net buying pressure used in the literatures has limited predictability, because the direction-trading effect and volatility-trading effect may cancel each other out in the calculation of total net buying pressure. We thus follow Chen and Wang (2015) to decompose total net buying pressure into the direction-trading-motivated net buying pressure (NBPD) and the volatility-trading-motivated net buying pressure (NBPV), and further examine their predictability in stock returns and volatility, respectively. Our empirical results show that NBPD of TAIEX options (TXO) has significant predictability in TAIEX returns, regardless of the happening of the 2011 U.S. Debt-Ceiling Crisis. The predicative power even persists up to the leading eight periods. We also find that NBPV of ITM options has predictability in TAIEX volatility after the U.S. Debt-Ceiling Crisis. It indicates that the decomposed net buying pressure contain information in both the future price movement and volatility of TAIEX prices.

Keywords: Net buying pressure, Informed trading, Volatility prediction, Return prediction.

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1. Introduction

It is generally acknowledged that whether in the academic field or in financial markets, people attempt to predict stock returns and volatility with manifold proxies. The rapid development of option markets offers relevant implications for the return prediction and the volatility prediction on the underlying assets, because the trading activities of derivative markets and the trading in spot markets are mutually dependent. Due to market inefficiency, there are chances that informed traders exist in the markets and react to the arrivals of directional shocks or volatility shocks on the underlying assets with the buying and selling of options. Therefore, information contents of option-related indicators imply some unreached shocks on stock prices that would be reflected in the future. This paper focuses on the predictability of option net buying pressure in stock returns and volatility.

Literatures on return and volatility prediction overlook the predictability of net buying pressure because total net buying pressure contains both the effect from volatility trading and the effect from direction trading. The two kinds of effects cancel each other out, making net buying pressure a limited predictors for stock returns and volatility. Literatures on net buying pressure mainly focus on the net buying pressure hypotheses, rather than the application of net buying pressure. To our knowledge, there hasn't been a literature centering on whether the information content of net buying pressure helps in predicting stock returns and volatilities.

Information pertinent to future prices and volatility of stocks is implied in option trading. This is by reason of the perspective that informed traders tend to trade in option markets before they trade in the underlying stock markets. Informed traders trade first in options markets due to the distinctions of higher leverage and lower transaction costs in option markets. Noticeably, volatility trading is feasible in option markets, rather than in stock markets. Fahlenbrach and Sandas (2010) confirm that traders with non-public information about the future volatility of stock prices trade in option markets precedent to trading in the underlying stock markets. They find order flows in volatility–sensitive option strategies to be predicative for the realized volatility of stock prices. Easley, O'hara, and Srinivas (1998) consider that as long as informed traders deem option trading to be more profitable than stock trading, they would choose to trade in option markets first, causing the information about future stock returns to be disseminated from option markets to stock markets. On condition that informed traders trade in option markets first, information would be revealed from option trading, enabling option trading to be have predictability for stock returns and volatility.

Several literatures document the application of option-related proxies on the stock-return prediction. Atilgan (2010) uses deviations form put-call parity, i.e. volatility spreads, to predict stock returns and finds that the predictability of volatility spreads is stronger around firms' earning announcements, suggesting that there is information related to expect stock returns contains in the option markets. Cremers and Weinbaum (2010) also come down to the conclusion that volatility spreads enable the forecast on stock returns. They suggest that buying stocks with expensive call options gains positive abnormal returns, while buying stocks with expensive put options results in negative abnormal returns. Additionally, the predictability of volatility spreads is even stronger in liquid option markets and illiquid stock markets, suggesting that market vitality affects the effectiveness of forecasting. Chang, Hsieh and Lai (2009), under the explicit assumption that foreign investors are informed traders, propose that option trade volume from foreign investors has significant predictability for stock returns, while total option trade volume does not. Cao, Chen, and Griffin (2005) state that option volume is informative for the next-day stock return during normal periods. Specifically, call-volume imbalance significantly predicts the next-day stock return prior to take-over announcement. Bhuyan and Chaudhury (2001) document that trading based on option open interest as the predictor for stock return earns significant returns. Pan and Poteshman (2006) confirm that option trade volume contains nonpublic information for future stock returns. They find that stocks with low put-call ratios outperform those with high put-call ratios in the future and options with greater leverage have stronger predictability. The forecasted period can be extend to the next day or the next week, with next-week predictions stronger than next-day predictions.

Literatures also put emphases on the prediction on stock return volatility. Day and Lewis (1992) add in the implied volatility from S&P 100 index call options to GARCH and EGARCH models. Their out-of-sample test indicates that weekly volatility are hard to predict. Ni, Pan, and Poteshman (2008) predict realized volatility of the underlying stocks with non-market makers' net demand for volatility, which is constructed from option trade volume. They empirically show that non-market makers' net demand for volatility implies positive changes in future volatility of stock prices. Furthermore, the predictability of non-market makers' net demand for volatility from new option open positions is stronger than that of the existing closing option positions. This is consistent with the observation that informed traders are more likely to trade their information with open positions. Closing positions acquire traders to have position at the time they are informed, while open positions do not. Following Ni, Pan, and Poteshman (2008), Chang, Hsieh and Lai (2009) document that in the Taiwan option market, the net demand for volatility from foreign institutional investors is the most informative, and thus has strongest predictability, of all trader types. Wilmott and Schönbucher (2000) find that stock holdings in the hedging positions of option buyers to have higher volatility, suggesting a link between option buyers and return volatility of stocks. Pearson, Poteshman, and White (2006) confirm the negative relationship between net purchased option positions of investors who are likely to hedge and stock return volatility. In all, past literature support the information role of option trading in the prediction for stock return volatility.

Informed traders with information concerning the future volatility of stock returns are often referred to as volatility traders, while informed traders trading on information about the rises or falls of future stock prices are known as directional traders. Volatility traders can only trade in option markets. Therefore, Bollen and Whaley (2004) assume option traders to be volatility traders. However, because of other attractive characteristics, such as higher leverage and lower transaction costs, in option markets, directional traders may also trade in option markets.

Kang and Park (2008) revisit the relationship between net buying pressure and implied volatility with the consideration of the possibility that directional traders also trade in option markets. They conclude that in KOSPI 200 index option market, directional traders dominate. In fact, related to the discussion on the relationship between demand pressure and changes in implied volatility, there are three demand-pressure hypotheses, which are the limit of arbitrage hypothesis, the volatility-learning hypothesis, and the direction-learning hypothesis. The limit of arbitrage hypothesis states that the supply curve of an option is positively sloped due to the risks and losses market makers face and implied volatility are determined by the demand for option contracts, without the consideration of information shocks. Both the volatility-learning hypothesis and the direction-learning hypothesis assume the option supply curve to be flat and implied volatility change when new information shocks enter. The information shocks could be either volatility shocks or direction shocks. Under the volatility-learning hypothesis, volatility traders trade when volatility shocks arrive, leading to a positive relationship between net buying pressure and implied-volatility changes. The volatility-learning hypothesis infers that when a positive (negative) volatility shock arrives at time t, informed traders trade in the option market through the buying (selling) of both put and call options, since they know nothing about directional information. The increased (decreased) net buying pressure for both put and call options increases (decreases) the implied volatility for both put and call options. At time $t+1$, the positive (negative) volatility shock is spread around the stock market, the stock price would change and cause the expensiveness, hence implied volatility, of call and put options to change accordingly. When the direction-learning hypothesis holds, direction traders trade when direction shocks are perceived. Under the direction-learning hypothesis, when informed traders learn new positive (negative) shock on the stock price at time t, they would exploit the information, i.e. the new shock, in the option market first and at time t. As they do so, the net buying pressure of call (put) options is positive and the net buying pressure of put (call) options is negative. Therefore, at time t, the implied volatility and expensiveness of call (put) options increases and the implied volatility and expensiveness of put (call) options decreases. At the time the information is disseminated from the option market to the stock market, i.e. at time $t+1$, the stock price goes up (down), resulting the implied volatility of call (put) options to rise and the implied volatility of put (call) options to fall. Accordingly, under the directional-learning hypothesis, informed traders take advantage of their information in option markets first and changes in implied volatility have a negative serial correlation.

As reviewed, applications of net buying pressure have been presently less discussed. Accordingly, this paper is motivated to work on the application of net buying pressure on the forecast of stock returns. Under the direction-learning hypothesis, informed traders respond to a new direction shock in option trading first and the direction shock is passed on to the underlying asset market subsequently. Therefore, demand pressure from directional traders may make predictions for stock returns possible. Under volatility-learning hypothesis, when a new volatility shock hits the market, both the implied volatility and the option price immediately reflect the shock due to demand pressure from volatility traders. Afterward, the volatility shock is diffused from the option market to the underlying asset market, resulting in the change in the volatility of the underlying asset returns. Consequently, demand pressure from volatility traders should be capable of forecasting stock return volatility. The difference between this paper and that of Kang and Park (2008) is that this paper involves the possibility that option markets support "both" the direction-learning hypothesis and the volatility-learning hypothesis. That is, this paper examines the predicative ability of net buying pressure for stock return not only by looking at the net buying pressure from directional traders, but also at the net buying pressure form volatility traders.

Chen and Wang (2015) allow volatility traders and directional traders to exist in option markets simultaneously. Unlike literatures on the testing of net-buying-pressure hypotheses prior to them, they test the hypotheses independently, rather than treating the hypotheses as the mutually exclusive explanations, which only one hypothesis can explain the relationship between net buying pressure and changes in implied volatility. That is, Chen and Wang (2015) do not test the net-buying-pressure hypotheses jointly. To test the direction-learning hypothesis and the volatility-learning hypothesis independently, they offer a new methodology to decompose total net buying pressure into the volatility-trading-motivated net buying pressure (NBPV) and the direction-trading-motivated net buying pressure (NBPD). By taking the volatility-trading-motivated net buying pressure as a function of option prices and the volatility of the underlying asset prices and the direction-trading-motivated net buying pressure as a function of option prices and the underlying asset prices, they come up with general representations for volatility-trading-motivated net buying pressure and direction-trading-motivated net buying pressure. This paper adopts the methodology of Chen and Wang (2015) to examine whether the volatility-trading-motivated net buying pressure enables the prediction for stock return volatility and whether the direction-trading-motivated net buying pressure is capable of forecasting the rises or falls of stock returns. Note that when this paper chooses the methodology of Chen and Wang (2015) to allow for both the volatility-learning hypothesis and the direction-learning hypothesis to exist, the limit of arbitrage hypothesis is out of our concerns. Because this paper simply focuses on the role informed traders play in stock return prediction, leaving out the consideration for the limit of arbitrage hypothesis may be sensible.

This paper expects the direction-trading-motivated net buying pressure for call options to be positively related to future stock returns. Moreover, the predictability the direction-trading motivated net buying pressure from OTM options has on future stock returns is expected to be at greater magnitude than that from ATM options. This is based on the perspective that directional traders trade in option markets before they trade in stock markets because of the higher leverage in option markets. OTM options offer greater leverage than ATM options do. The volatility-trading-motivated net buying pressure is expected to have a positive relationship with future stock return volatility. The impact of the volatility-trading-motivated net buying pressure from ATM options is expected to have stronger influence on the future stock return volatility, comparing to that from OTM options. ATM options have higher vega and therefore, carry more volatility information than OTM options.

Investigating into TAIEX option market, this paper provides supporting evidences for the predictability of net buying pressure. Specifically, the direction-trading-motivated net buying pressure across all moneyness has significant predictability for TAIEX prices regardless of the happening of the U.S. Debt-Ceiling Crisis and the predictability can persist for several periods ahead. The volatility-trading-motivated from ITM options predicts TAIEX volatility after the U.S. Debt-Ceiling Crisis. The predictability persists for six periods ahead.

This paper is organized as follows. Section 2 briefly reviews the decomposition of net buying pressure in Chen and Wang (2015). Section 3 lays out the methodology and model specifications. Section 4 shows and interprets the empirical results. Section 5 concludes.

2. The decomposition of net buying pressure in Chen and Wang (2015)

This paper follows Chen and Wang (2015) to decompose the entire option demand pressure into the direction-trading-motivated component and the volatility-trading-motivated component. They assume that all option traders are rational and are either directional traders or volatility traders. Under the assumption, the entire option demand pressure can be decompose into direction-trading-motivated component and volatility-trading-motivated component:

$$NBP_{i,t}^{k} = NBPD_{i,t}^{k} + NBPV_{i,t}^{k},$$

where $k \in \{ITM, ATM, OTM\}$ and $i \in \{C, P\}$. $NBP_{i,t}^{k}$ is the entire net buying pressure, $NBPD_{i,t}^{k}$ is the direction-trading-motivated net buying pressure, and $NBPV_{i,t}^{k}$ is the volatility-trading-motivated net buying pressure of the call or put in category k summed across the time interval t.

Because volatility traders react to the arrival of volatility shock and expect volatility to change by $\Delta\sigma^E$:

$$NBPV_{i,t}^k = \frac{\partial NBP_{i.t}^k}{\partial \sigma} \Delta\sigma^E ,$$

where $\partial NBP_{i,t}^k \big/ \partial\sigma$ is sensitivity of entire net buying pressure to changes in underlying stock price volatility.

Whereas, directional traders react to the arrival of direction shock and expect underlying stock price to change by ΔS^E :

$$NBPD_{i,t}^k = \frac{\partial NBP_{i,t}^k}{\partial S} \Delta S^E ,$$

where $\partial NBP_{i,t}^k \big/ \partial S$ is sensitivity of entire net buying pressure to changes in underlying stock price.

Accordingly, using Chain rule and the fact that $NBPD_{C,t}^k$ ($NBPD_{P,t}^k$) is a function of call (put) option prices and stock prices, while an option price is a function of the stock price volatility and the stock price:

$$NBP_{i,t}^k = \frac{\partial NBP_{i,t}^k}{\partial i_t^k} \frac{\partial i_t^k}{\partial S} \Delta S^E + \frac{\partial NBP_{i,t}^k}{\partial i_t^k} \frac{\partial i_t^k}{\partial \sigma} \Delta\sigma^E$$

$$= \frac{\partial NBP_{i,t}^k}{\partial i_t^k} delta_{i,t}^k \Delta S^E + \frac{\partial NBP_{i,t}^k}{\partial i_t^k} vega_{i,t}^k \Delta\sigma^E .$$

Under Black-Scholes constant volatility assumption, $vega_{i,t}^{k}$ is the same when $i = P$ and $i = C$ for the same k and t. Under the same moneyness, k, $delta_{C,t}^{k} = -delta_{P,t}^{k}$ because $\partial i_{t}^{k} / \partial S$ is negative when $i = P$.

Together,

$$NBPD_{C,t}^{k} = \frac{NBP_{C,t}^{k} - NBP_{P,t}^{k}}{2},$$

$$NBPD_{P,t}^{k} = \frac{NBP_{P,t}^{k} - NBP_{C,t}^{k}}{2},$$

$$NBPV_{C,t}^{k} = NBPV_{P,t}^{k} = \frac{NBP_{C,t}^{k} + NBP_{P,t}^{k}}{2}.$$

This paper uses the NBPD for call options to predict the rises or falls of stock returns and the NBPV to forecast the volatility of stock returns.

The NBPD this paper adopts is $NBPD_{C,t}^{k}$. Therefore, we can expect NBPD to be positively related to future stock index returns. The NBPV in this paper can be $NBPV_{C,t}^{k}$ or $NBPV_{P,t}^{k}$, because $NBPV_{C,t}^{k}$ and $NBPV_{P,t}^{k}$ are the same.

3. Methodology

3.1 Data

This study demonstrates the predictability of net buying pressure by researching into TAIEX Option (TXO) market. The underlying asset of TXO is Taiwan-stock-exchange-capitalization-weighted-stock index (TAIEX). Index options account for more than 98% of options traded in Taiwan. Among index options, TXO occupies the proportion of more than 95%. TXO are European-style options. Options are traded during 8:45 to 13:45 (Taiwan time) of each trading day in Taiwan. Intraday data of TAIEX options and the underlying TAIEX are from Cmoney database. Data of risk-free interest rate are from Taiwan Economic Journal (TEJ) database.

Table I

Moneyness category definitions

Following the bounds of moneyness category proposed by Bollen and Whaley (2004), this table defines categories and their corresponding delta ranges for call and put options. To avoid distortion caused by price discreteness, options with absolute deltas above 0.98 and below 0.02 are deleted.

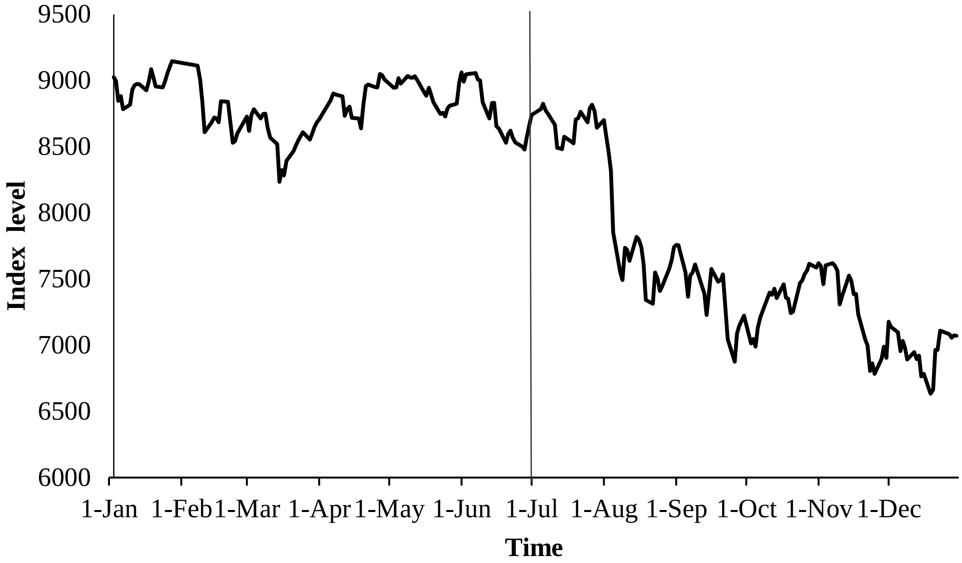
Calls			
	Moneyness for calls	**Category**	**Delta range**
	DITM	1	$0.875<\Delta_C\leq 0.980$
	ITM	2	$0.625<\Delta_C\leq 0.875$
	ATM	3	$0.375<\Delta_C\leq 0.625$
	OTM	4	$0.125<\Delta_C\leq 0.375$
	DOTM	5	$0.020<\Delta_C\leq 0.125$
Puts			
	Moneyness for puts	**Category**	**Delta range**
	DOTM	1	$-0.125<\Delta_P\leq -0.020$
	OTM	2	$-0.375<\Delta_P\leq -0.125$
	ATM	3	$-0.625<\Delta_P\leq -0.375$
	ITM	4	$-0.875<\Delta_P\leq -0.625$
	DITM	5	$-0.980<\Delta_P\leq -0.875$

As Table 1 shows, this paper follows Bollen and Whaley (2004) to classify options into five moneyness categories: DITM call and DCTM put (the category 1), ITM call and OTM put (the category 2), ATM call and put (the category 3), OTM call and ITM put (the category 4), and DOTM call and DITM put (the category 5). There are some data-filtering criteria. Options that have time-to-maturity days less than two or greater than ninety are omitted from the data set. Options out of the five moneyness categories are eliminated from our sample. Data of the first and the last five minutes of a day are deleted to prevent misleading tests on predictability.

One of the most serious events happened in the year 2011 is the U.S. Debt-Ceiling Crisis. The close relationship between the U.S. stock markets and the Taiwan stock markets motivates this paper to examine prices of TAIEX before and after the crisis. Figure 1 illustrates the possible structural change of TAIEX after July, 2011, which is the time the U.S. Debt-Ceiling Crisis occurred. The price levels are lower and the volatility is larger for TAIEX prices after the crisis. Therefore, it is suggested that the whole sample period of the year 2011 be divided into two subperiods: January, 1, 2011-June, 30, 2011 and July, 1, 2011-December, 31, 2011.

Figure I

Level and volatility of TAIEX in year 2011



3.2 Information variables

Bollen and Whaley (2004) define option net buying pressure as "the difference between the number of buyer-motivated contracts and the number of seller-motivated contracts traded each day". Specifically, they calculate the difference between the number of buyer-motivated contracts and the number of seller-motivated contracts traded on series-by-series basis. To express option net buying pressure as the underlying-stock-equivalent unit, the difference is multiplied by the absolute value of the option's delta, which is the dollar change in the option price with respect to a dollar change in the underlying asset price. A contract traded is classified as a buyer-motivated contract traded if its executed price is above the midpoint of prevailing bid-ask spread. Whereas, a contract traded is categorized as a seller-motivated contract traded if its executed price is below the midpoint of prevailing bid-ask spread.

This paper follows the definition and the calculation method of Bollen and Whaley (2004) for option net buying pressure:

$$NBP_{i,t}^{k} = \left(NBC_{i,t}^{k} - NSC_{i,t}^{k}\right) \times \left|delta_{i,t}^{k}\right|,$$

where the interval for t is a day, $i \in \{C, P\}$, $k \in \{ITM, ATM, OTM\}$, $NBC_{i,t}^{k}$ is the number of buyer-motivated contracts, $NSC_{i,t}^{k}$ is the number of seller-motivated contracts, $delta_{i,t}^{k}$ is the delta of option contract at strike k and type i, and is summed across the time interval of t.

3.3 Descriptive statistics

Table 2 illustrates the descriptive statistics of our data set. Data are examined for different sample periods: the whole period of year 2011, the subperiod before the U.S. Debt-Ceiling Crisis (from January, 01, 2011 to June, 30, 2011), and the subperiod after the U.S. Debt-Ceiling Crisis (from July, 01, 2011 to December, 31, 2011).Because it is already observed in Figure 1 that the levels and volatility of TAIEX prices have changed dramatically after the U.S. Debt-Ceiling Crisis, separating samples according to the crisis event while inspecting descriptive statistics is important. The mean value of direction-trading-motivated net buying pressure (NBPD) has increased since the crisis. This indicates that the information hold by directional traders suggest less downward values in future TAIEX.

The less standard deviations in NBPD and NBPV in Subperiod 2, comparing to Subperiod 1, stand for less discrepancy in both directional and volatility information after the crisis. Additionally, both the net buying pressures from calls and from puts have increased after the crisis, implying that option traders either long more options or short less options, or both after the crisis. The decreased in option trade volume after June, 30, 2011 supports less liquidity in TAIEX options after the crisis.

Table II

Descriptive statistics

This table shows the summary statistics of variables for the whole sample period, Subperiod 1, and Subperiod 2. Our sample period ranges from January, 1, 2011 to December, 31, 2011. We use the U.S. Debt-Ceiling Crisis to separate into two subperiods, which are Subperiod 1 and Subperiod 2. NBPD is the direction-trading-motivated demand pressure, whose denominator is the net buying pressure from calls subtracts the net buying pressure from puts. NBPV is the direction-trading-motivated demand pressure.

		Whole Period (Year 2011)	Subperiod 1 (1/1 to 6/30)	Subperiod 2 (7/1 to 12/31)
NBP from calls				
	Mean	-14.13	-12.38	-15.73
	Median	-10.21	-8.56	-10.97
	Std. Dev.	293.52	339.10	244.96
	Min	-2,002.03	-2,002.03	-1,914.09
	Max	2,760.99	2,760.99	2,376.25
NBP from puts				
	Mean	-11.52	-8.19	-14.54
	Median	-7.93	-7.65	-8.37
	Std. Dev.	221.10	254.36	185.83
	Min	-2,174.70	-2,174.70	-1,510.59
	Max	2,828.51	2,828.51	2,461.36
NBPD				
	Mean	-1.31	-2.09	-0.59
	Median	-1.46	0.59	-2.58
	Std. Dev.	234.69	273.83	192.45
	Min	-2,336.83	-2,336.83	-1,880.26
	Max	2,053.62	2,053.62	1,603.85
NBPV				
	Mean	-12.83	-10.28	-15.13
	Medium	-9.91	-8.38	-11.34
	Std. Dev.	111.53	121.91	101.14
	Min	-1,032.65	-1,032.65	-993.17
	Max	994.07	970.95	994.07
Option volume ($\times 10^2$)				
	Mean	54.98	60.35	50.12
	Medium	40.70	43.29	38.60
	Std. Dev.	49.39	55.27	42.79
	Min	1.35	2.02	1.35
	Max	751.55	751.55	609.81

3.4 Models specification

3.4.1 Return-prediction model

The regression models are specified for the prediction in stock returns with the volatility-trading-motivated net buying pressure and the direction-trading-motivated net buying pressure. The time step of the regression models is five minutes. The methodology for dividing the total net buying pressure into the volatility-trading-motivated net buying pressure and the direction-trading-motivated net buying pressure follows the methodology of Chen and Wang (2015). There are return-prediction model and volatility-prediction model in our empirical tests. Following Chang, Hsieh, and Lai (2009), who investigate the predictability of put-call ratios for TAIEX returns, in the determination of control variables for stock returns, we use the logarithm of the trade volume of TAIEX (VOL) and past five-minute TAIEX cumulative return (CR) as control variables for our return-prediction model. Under the assumption of Chen and Wang (2015), option traders are either volatility traders or directional traders. This paper uses the direction-trading-motivated net buying pressure from option contracts to forecast stock returns as follow:

$$R_{t+\tau} = \alpha_0 + \alpha_1 NBPD_t^k + \alpha_2 VOL_t + \alpha_3 CR_{t,-5} + \varepsilon_{t+\tau}, \quad (1)$$

where $\tau = 1, 2, ..., 5$, and $k \in \{ITM, ATM, OTM\}$, $R_{t+\tau}$ is the time $t+\tau$ index return, $NBPD_t^k$ is the time t direction-trading-motivated net buying pressure of k-moneyness options. VOL_t is the logarithm of the index trade volume on time t, and $CR_{t,-5}$ is the accumulative return of the underlying index for the past twenty-five minutes.

There may be a possibility that the volatility-trading-motivated demand pressure also affects future underlying index return. This is because if the volatility-trading-motivated net buying pressure can forecast stock return volatility and the stock return volatility and stock returns are correlated, the volatility-trading-motivated demand pressure may have influence on future stock returns. Several past literatures have documented the positive correlation between equity returns and equity volatility, as mentioned by Duffee (1995). However, Bekaert and Wu (2000) find that conditional volatility negatively correlates with stock returns. No matter stock return volatility and stock returns are positively or negatively correlated, that they are correlated with each other is suggested by many. Though the canceling effect on option expensiveness of direction trading and volatility trading has been disentangled in Chen and Wang (2015), the predictability of them has not. That is, though the net buying pressure from directional traders can predict stock returns directly, the net buying pressure from volatility traders may indirectly predict stock returns through the return-volatility correlation. Therefore, this paper proposes the second regression:

$$R_{t+\tau} = \alpha_0 + \alpha_1 NBPD_t^k + \alpha_2 NBPV_t^k + \alpha_3 Vol_t + \alpha_4 CR_{t,-5} + \varepsilon_{t+\tau}, \tag{2}$$

where $NBPV_t^k$ is the time t volatility-trading-motivated net buying pressure of k-moneyness options and other variable definitions are the same as Equation (1).

3.4.2 Volatility-prediction model

This paper follows Chang, Hsieh, and Wang (2009), who predict the volatility of TAIEX with vega-weighted net demand for volatility, for the control variables of the volatility-prediction model. Therefore, this paper selects the one-to-five-minute lagged realized volatility (RV), the average implied volatility of the nearest ATM call and put option contracts with the shortest (and at least five trading days) maturity (IV), the number of option contracts traded (OPV), the logarithm of TAIEX trade volume (INV), and the absolute value of NBPD

($\left|NBPD\right|$).

The volatility-trading-motivated net buying pressure from option contracts are applied to forecast the future volatility of stock return, as the follows:

$$RV_{t+\tau} = \alpha_0 + \alpha_1 NBPV_t^k + \sum_{i=1}^{5} \alpha_{i+1} RV_{t+\tau-i} + \alpha_7 IV_{t+\tau-1} + \alpha_8 OPV_t + \alpha_9 INV_t + \alpha_{10} \left|NBPD_t^k\right| + \varepsilon_{t+\tau}, \quad (3)$$

where $\tau = 1, 2, ..., 5$ and $k \in \{ITM, ATM, OTM\}$, $RV_{t+\tau}$ is the index realized volatility for the time $t+\tau$, $NBPV_t^k$ is option's volatility-trading-motivated demand pressure for call or put options on time t, $RV_{t+\tau-i}$ for $i = 1, 2, 3, 4,$ or 5 is the lagged underlying index realized volatility i period(s) before time $t+\tau$, $IV_{t+\tau-1}$ is the one-period lagged average implied volatility of the nearest ATM call and put option contracts with the shortest (and at least five trading days) maturity, OPV_t is the number of option contracts traded, INV_t is the logarithm of TAIEX trade volume, and $\left|NBPD_t^k\right|$ is the absolute value of the direction-trading-motivated demand pressure. The realized volatility is defined as the difference of the highest and lowest prices divided by the last price of the five-minute time interval.

4. Empirical results

This section analyzes the empirical results of our regression models. The predictability of the direction-trading-motivated net buying pressure (NBPD) for TAIEX return is shown in Table 3. As can be observed from Table 3, the coefficients of NBPD are positive and are significant at 1% level across all moneynesses in our whole sample period. Apparently, NBPD have extremely significant ability in predicting the next-period TAIEX return. The stronger predictability of NBPD from OTM options, comparing to that from ATM options, supports the expectation that directional traders choose to trade in option markets first due to higher leverage. Furthermore, the coefficients of NBPV are negative and are significant at 1% level for ITM and OTM options. Hence, the volatility-trading-motivated net buying pressure (NBPV) from ITM and OTM options are negatively related with the next-five-minute TAIEX return. This supports the proposal made by literatures that volatility and returns are negatively correlated.

One concern in this paper is that the price structure of TAIEX has changed after the U.S. Debt-Ceiling Crisis. Therefore, the empirical analyses done for each subperiod are presented in Table 5. The predictability of NBPD before the U.S. Debt-Ceiling Crisis (Subperiod 1) are shown in the Panel A, while the predictability of NBPD after the U.S. Debt-Ceiling Crisis (Subperiod 2) are shown in the Panel B. In both subperiods, NBPD has 1% significance in predicting TAIEX return. Still, the coefficients of NBPV are negative and are at 1% significance across ITM and OTM options for both subperiods. The predictability of NBPV for volatility is presented in Table 5. Table 5 tells us that the NBPV from ITM options starts to have predictability for stock volatility after the U.S. Debt-Ceiling Crisis. The coefficients of NBPV are significant at 5% level for ITM options.

Table III

Predictability of direction-trading-motivated net buying pressure

This table presents the predictability of NBPD in TAIEX return. The regression specifications are

Model 1

$$R_{t+\tau} = \alpha_0 + \alpha_1 NBPD_t^k + \alpha_2 VOL_t + \alpha_3 CR_{t,-5} + \varepsilon_{t+\tau},$$

and

Model 2

$$R_{t+\tau} = \alpha_0 + \alpha_1 NBPD_t^k + \alpha_2 NBPV_t^k + \alpha_3 Vol_t + \alpha_4 CR_{t,-5} + \varepsilon_{t+\tau},$$

where $R_{t+\tau}$ is the TAIEX return over the five minute interval $t+\tau$, $NBPD_t^k$ and $NBPV_t^k$ are the direction-trading-motivated net buying pressure and volatility-trading-motivated net buying pressure over the five minute interval t, respectively. The control variables, which are Vol_t and $CR_{t,-5}$, indicate the trade volume and the five-minute accumulative return of TAIEX of time interval t. "*", "**", or "***" is attached correspondingly when the parameter estimate is statistically significant at the 0.1, 0.05, or 0.01 significance level.

Category		N	$Adj.R^2$	Parameter estimates				
				α_0 ($\times 10^{-2}$)	α_1 ($\times 10^{-4}$)	α_2 ($\times 10^{-5}$)	α_3 ($\times 10^{-4}$)	α_4 ($\times 10^{-2}$)
ITM								
	Model 1	59,887	0.07	0.01	0.05***	-	-0.11	0.41***
	Model 2	59,887	0.07	0.01	0.05***	-0.67***	-0.10	0.40***
ATM								
	Model 1	62,720	0.15	-0.01*	0.04***	-	0.11	-0.21**
	Model 2	62,720	0.15	-0.01*	0.04***	-0.00	0.11	-0.21**
OTM								
	Model 1	62,730	0.22	0.01	0.05***	-	-0.14**	-0.36***
	Model 2	62,730	0.22	0.01	0.05***	-0.02***	-0.12**	-0.34***

Table IV

Predictability of direction-trading-motivated net buying pressure before and after the U.S. Debt-Ceiling Crisis

This table demonstrates the predictability of direction-prediction models before and after the U.S. Debt-Ceiling Crisis in July, 2011. The regression models are

Model 1

$$R_{t+\tau} = \alpha_0 + \alpha_1 NBPD_t^k + \alpha_2 VOL_t + \alpha_3 CR_{t,-5} + \varepsilon_{t+\tau},$$

and

Model 2

$$R_{t+\tau} = \alpha_0 + \alpha_1 NBPD_t^k + \alpha_2 NBPV_t^k + \alpha_3 Vol_t + \alpha_4 CR_{t,-5} + \varepsilon_{t+\tau},$$

where $R_{t+\tau}$ is the TAIEX return for the five-minute time interval $t+\tau$ and the information variable on the time interval t is the direction-trading-motivated net buying pressure, which is denoted as $NBPD_t^k$. $NBPV_t^k$ represents the volatility-trading-motivated net buying pressure on the time interval t. Vol_t indicates TAIEX trade volume over the time interval t, while $CR_{t,-5}$ is the twenty-five-minutes accumulative TAIEX return for the time interval t. "*", "**", or "***" is marked on the parameter estimate when it is statistically significant at the 0.1, 0.05, or 0.01 significance level.

Category		N	Adj.R^2	Parameter estimates				
				α_0 ($\times 10^{-3}$)	α_1 ($\times 10^{-4}$)	α_2 ($\times 10^{-4}$)	α_3 ($\times 10^{-4}$)	α_4 ($\times 10^{-2}$)
Panel A: Subperiod 1 (January, 01, 2011 – June, 30, 2011)								
ITM								
	Model 1	29,055	0.10	0.3***	0.04***	-	-0.25***	0.21
	Model 2	29,055	0.10	0.2**	0.04***	-0.1***	-0.24***	23
ATM								
	Model 1	29,830	0.21	-0.06	0.04***	-	5	-0.91***
	Model 2	29,830	0.21	-0.1	0.04***	-0.01***	0.06	-0.90***
OTM								
	Model 1	29,835	0.25	0.2***	0.04***	-	-0.24***	-1***
	Model 2	29,835	0.25	0.2**	0.04***	-0.51***	-0.21***	-0.87***
Panel B:Subperiod 2 (July, 01, 2011 – December, 31, 2011)								
ITM								
	Model 1	30,832	0.06	-0.04	0.07***	-	-0.03	0.44***
	Model 2	30,832	0.06	-0.06	0.07***	-1***	-0.03	0.43***
ATM								
	Model 1	32,890	0.13	-0.93	0.06***	-	0.07	-0.07
	Model 2	32,890	0.13	-1	0.06***	0.09	0.07	-0.07
OTM								
	Model 1	32,895	0.22	0.30	0.07***	-	-0.05	-0.30***
	Model 2	32,895	0.22	0.43	0.07***	0.21	-0.06	-0.31***

Table V

Predictability of volatility-trading-motivated net buying pressure before and after the U.S. Debt-Ceiling Crisis

This table reports the predictability of NBPV for the whole period and the two subperiods, which are divided by the Debt-Ceiling Crisis. The model we apply is

$$RV_{t+\tau} = \alpha_0 + \alpha_1 NBPV_t^k + \sum_{i=1}^{5} \alpha_{i+1} RV_{t+\tau-i} + \alpha_7 IV_{t+\tau-1} + \alpha_8 OPV_t + \alpha_9 INV_t + \alpha_{10} \left| NBPD_t^k \right| + \varepsilon_{t+\tau},$$

where $RV_{t+\tau}$ is the TAIEX realized volatility over the five-minute interval $t+\tau$ and the information variable $NBPV_t^k$ is the volatility-trading-motivated net buying pressure for the time interval t. $RV_{t+\tau-i}$, $i = 1, 2, 3, 4, 5$, are the time $t+\tau-i$ realized volatility. $IV_{t+\tau-1}$ represents the implied volatility of TAIEX option for the time interval $t+\tau-1$. OPV_t is TAIEX option trade volume and INV_t is the TAIEX trade volume over the time interval t. $\left| NBPD_t^k \right|$ is the absolute value of direction-trading-motivated net buying pressure. "*", "**", or "***" is annotated when the parameter estimate is statistically significant at the 0.1, 0.05, or 0.01 significance level.

Category	N	$AdjR^2$	Parameter estimates										
			α_0 $(\times 10^{-2})$	α_1 $(\times 10^{-6})$	α_2	α_3 $(\times 10^{-3})$	α_4 $(\times 10^{-3})$	α_5 $(\times 10^{-3})$	α_6	α_7 $(\times 10^{-6})$	α_8 $(\times 10^{-6})$	α_9 $(\times 10^{-4})$	α_{10} $(\times 10^{-6})$
Panel A: Whole Period													
ITM	59,841	0.76	0.05***	0.04	0.89***	-0.05	-0.03	-0.00	-0.10***	0.06*	0.41***	-0.36***	-0.07**
ATM	62,674	0.76	0.05***	-0.03	0.89***	-0.1	-0.03	-0.01	-0.10***	0.04	0.01***	-0.36***	-0.36***
OTM	62,680	0.76	0.05***	0.01	0.89***	-0.06	-0.03	-0.01	-0.10***	0.04	0.01***	-0.36***	-0.35***
Panel B: Subperiod 1 (January, 01, 2011 – June, 30, 2011)													
ITM	29,030	0.76	0.04***	-0.01	0.88***	-0.08	-0.06	-0.04	-0.10***	0.15***	0.37***	-0.27***	-0.04
ATM	29,805	0.76	0.04***	0.01	0.89***	-0.1	-0.06	-0.03	-0.10***	0.14**	0.01***	-0.26***	-0.22***
OTM	29,810	0.76	0.04***	0.04	0.89***	-0.08	-0.06	-0.03	-0.10***	0.14***	0.01***	-0.26***	-0.20***
Panel C: Subperiod 2(July, 01, 2011 – December, 31, 2011)													
ITM	30,811	0.75	0.06**	0.13**	0.88***	-0.04	-0.00	0.01	-0.10***	0.02	0.01***	-0.41***	0.03
ATM	32,869	0.75	0.06***	-0.08**	0.88***	-0.04	-0.01	0.01	-0.10***	0.01	0.01***	-0.42***	-0.38***
OTM	32,870	0.75	0.06***	0.01	0.89***	-0.04	-0.01	0.01	-0.11***	0.22	0.01***	-0.42***	-0.51*

With very significant predictability of NBPD for TAIEX return, it is then to ask how many periods ahead can NBPD predicts. Table 6 answers this question with ATM options. As shown, even till eighteen periods ahead, NBPD predicts TAIEX significantly. Especially, for seventeen periods ahead, the significance level is still 1 %. Accordingly, Table 6 confirms the predictability of NBPD to last for several period.

Table 7 shows the predictability of NBPV from ITM options over time. The period selected is Subperiod 2, because NBPV starts to have predictability after the U.S. Debt-Ceiling Crisis. NBPV from ITM options is deemed to be able to correctly predict stock return volatility. Till five periods ahead, NBPV from ITM options has predictability. For more than five periods ahead, NBPV from ITM options are insignificant.

Table VI

Predictability of the NBPD overtime for ATM options

This table demonstrates the predictability of NBPD over time, with ATM options for instance. The sample period in this table is the whole sample period."*", "**", and "***" is attached respectively when the coefficient is statistically significant at the 0.1, 0.05, and 0.01 significance level.

Leading period (s)	Whole period (Year 2011)	Subperiod 1 (1/1 to 6/30)	Subperiod 2 (7/1 to 12/31)
1	0.0443***	0.0375***	0.0565***
2	0.0385***	0.0329***	0.0485***
3	0.0323***	0.0281***	0.0400***
4	0.0261***	0.0232***	0.0316***
5	0.0199***	0.0183***	0.0231***
6	0.0150***	0.0141***	0.0168***
7	0.0101***	0.0099***	0.0104***
8	0.0051***	0.0057***	0.0041***
9	0.0002	0.0015***	-0.0022**
10	-0.0046***	-0.0027***	-0.0085***

Table VII

Predictability of the NBPV overtime for ITM options

This table shows the predictability of ITM options' NBPV over time. The sample period is Subperiod 2 (after the Jul, 1, 2011). "*", "**", and "***" is attached respectively when the coefficient is statistically significant at the 0.1, 0.05, and 0.01 significance level.

Leading periods	Slope coefficient
1	0.13**
2	0.09
3	0.10*
4	0.11*
5	0.12**
6	-0.05

5. Conclusion

It is believed that the information content of option informed trading, including direction trading and volatility trading, is helpful to predict the future price movement and volatility of the underlying asset. Using the methodology of Chen and Wang (2015), we apply NBPD and NBPV on the predictions for returns and volatility, respectively. Based on empirical results, NBPD from TAIEX options has 1%-level significant predictability for TAIEX returns across all option moneynesses, regardless of the happening of the 2011 U.S. Debt-Ceiling Crisis. Additionally, NBPD even enables the prediction for the eighteen-periods-ahead TAIEX return. Furthermore, NBPV from ITM and OTM options is negatively related to future TAIEX returns.

NBPV from ITM options has predictability for the volatility of TAIEX after the U.S. Debt-Ceiling Crisis. The NBPV from ITM options can predict TAIEX volatility within twenty-five minutes ahead.

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