The information content of net buying pressure: evidence from the Shanghai 50 ETF option market

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Abstract

This paper investigates the information trading in the Chinese index options market. Based on the theory of net buying pressure, we use the high frequency data of the Shanghai 50 ETF option to establish empirical model and test the market efficiency. We improve the method of previous studies (e.g. Bollen and Whaley, 2004, Kang and Park, 2008, zhen-long zheng, 2014) with the high frequency setting, and we find that there is information trading in the SSE 50 ETF option market, and to be more specific, among which the volatility information trading is dominant while the directional information trading is ancillary. More importantly, our subsample evidence suggests that the volatility information trading became more active during the 2015 stock crash.

Keywords: SSE 50 ETF options; Net Buying Pressure; Information Trading; Implied volatility

1. Introduction

Information plays an important role in the asset pricing, and information trading drives the formation of real asset prices. Traditional finance theory assumes that market participants have homogeneous information, but in reality, there is a widespread phenomenon of information asymmetry. Different traders have different information. Investors can be divided into three categories based on the information they hold and their trading motivations: The first category is the informed trader who have information not yet reflected in the asset price and want to use this information to gain excess returns; The second is the liquidity trader, who only have public information in the market, and their involvement in trading is to gain liquidity; And the third category is the noise trader who use noise as information to participate in transactions. Because investors generally have information asymmetry in reality, they will have different value judgments in the transaction process and adopt different trading strategies. These transaction behaviors will affect the liquidity and volatility of assets and thus influence the asset pricing. Therefore, identifying and extracting valid information from traders has become a focus of attention in literature.

In early studies, scholars focus more on the information trading in the stock market. [1] However, with the rapid development of the global derivatives market, the derivatives market especially the option market has gradually become the main focus for its low cost of short selling and high leverage. For example, Easley and O'Hara (1998), Llorence et al. (2002), Chan, Chun, Fong (2002) etc. have shown that private information owners are more inclined to choose the derivatives market than the stock

[1]There is a large literature on this topic. An incomplete list is Bagehot (1971), Copeland and Galai (1983), Kyle(1985), Admati and Pfleiderer(1988), Viswanathan(1990), Easley et al. (1996) and Chung and Charoenwong (1998).

market. Black (1975) believes that because of the high leverage of the options, private information owners will choose the option market for information trading in order to maximize the private information they own. Back (1993) point out that since only the option market can trade volatility, for speculators and volatility risk managers who only have volatility information, they can only choose the option market for volatility information trading. Zheng Zhenlong's (2009, 2012) research shows that the information implied by derivatives is the investors' expectations for the future market, so it is more accurate than the future expectations calculated from historical data. Therefore, the information contained in the derivatives market, especially the option market, is more timely and abundant than the information contained in the stock market. Therefore, it may be particularly important to identify and extract information on the option market.

In order to analyze the information trading in the option market, researches have developed different methods from different perspectives. One important branch is the theory of net buying pressure. The analysis of options market information based on net buying pressure was first conducted by Bollen and Whaley (2004). They put forward the limited arbitrage hypothesis and information learning hypothesis based on the impact of the net buying pressure on the implied volatility smile. They empirically test the net buying pressure hypothesis with the S&P 500 option daily data and find that the shape of the implied volatility smile is affected by the net buying pressure of the option. Based on Bollen and Whaley (2004), Kang and Park (2008) further improve the net buying pressure theory and provide three hypotheses regarding the information content of net buying pressure (limited arbitrage hypothesis, direction learning hypothesis, volatility learning hypothesis). Kang and Park (2008) used the method of Bollen and Whaley (2004) to conduct empirical tests on the KPOSI200 options market and different types of traders (individual investors, institutional investors, and foreign investors). They find that the KPOSI200' net buying pressure has information for future stock price changes, and the information trading violates the put call parity in the short term. They believe that the above results illustrate the direction learning hypothesis that traders who have information about future stock price movements will first trade in the options market. Zheng Zhenlong et al. (2014) conduct empirical research on the directional information and volatility information implied by the net buying pressure on the option index market based on Bollen and Whaley (2004) and Kang and Park (2008). They classify investors into three categories: individual investors, institutional investors in Taiwan, and institutional investors outside Taiwan. Their research shows that there are also some directional information traders in the Taiwan index options market. They profit from trading in the options market because they have the ups and downs of future stocks, but their research also shows that almost none of the three types of investors contain any volatility information. More recently, Chordia et al. (2017) find that both net buying and selling pressure in S&P 500 index put options are positively informative about future weekly index returns, indicating that index options play an important informational role as well.

In this paper, we explore the newly launched Chinese index options market. As a matter of fact, there is a fast growth in trading volume of Chinese index option since its inception on Feb 9, 2015. The monthly trading volume increases from 2.86 million in July 2015 to 19.26 million in July 2017. To our best knowledge, we are among the first to study the information trading in this market. In particular, we address the following questions: Is there information trading in Chinese index options market? What kind of information trading dominates in the market, directional or volatility? Dose the 2015 stock crash restrain or strengthen the information trading? We answer these questions by taking advantage of high frequency data on the SSE 50 index option market and constructing the 5-min net buy pressure. We find evidence that Chinese index options market does have informed trading and it is the volatility rather than the directional information trading that dominates. Furthermore, during the 2015 Chinese stock crash, the information trading was even more active than normal, further doing harm to the market efficiency.

The rest of the paper is structured as follows. Section 2 introduces the data and methodology. Section 3 presents the empirical test. Section 4 is the robustness chech, and section 5 concludes.

2.Data and Methodology

2.1 Net buying pressure hypothesis

Based on the existing literature and the above theoretical analysis, we use the sample data of Shanghai 50ETF in the Chinese option market to test the following hypotheses established by the work of Bollen and Whaley (2004) and Kang and Park (2008):

Hypothesis 1: Limited arbitrage hypothesis

The limit of arbitrage hypothesis assumes that the supply curve of an option has a positive slope due to the limits of arbitrage. According to that hypothesis, the implied volatility of an option will be positively affected by the net buying pressure of the corresponding option not the other options. On the other hand, it will reverse as market makers adjust their risk positions and reduce their demand for risk compensation.

Hypothesis 2 Direction learning hypothesis

According to the direction learning hypothesis, the implied volatility is affected by the net buying pressure of the corresponding and the other options. The implied volatility of the call (put) option is positively correlated with the net buying pressure of directional information trading for call (put) options, and negatively correlated with that for put (call) options. And since the market maker has adjusted the option quote before the price changes of the underlying according to the trading of directional information traders, the implied volatility of all kinds of options will reverse.

Hypothesis 3 Volatility Learning Hypothesis

According to the volatility information trading hypothesis, the implied volatility will be affected by transactions of its own and other options. The implied volatility of call and put options is positive correlated with the net buying pressure of both call and put options. And the market maker has adjusted the implied volatility by adjusting the option price based on the transaction information, so the implied volatility will not reverse.

2.2 Data

The sample data selected in this paper is the trading data of the Shanghai 50 ETF options and its underlying Shanghai 50 ETF listed on the Shanghai Stock Exchange.

The SSE 50 ETF option refers to an investor's right to buy or sell a certain number of SSE 50 Index ETF at a certain price within a certain time in the future. This article employs the high frequency 50 ETF option transaction data and the SSE 50 ETF's real-time transaction data. The sample period is from February 2015 to July 2016.

The data comes from CSMAR and Wind database. Specifically, the detailed transaction data of the SSE 50 ETF option and its underlying comes from CSMAR. In order to facilitate the empirical part of the test, we transfer the raw data into five-minute high frequency data and remove the outliers based on the delta value, and the trading volume of different option contracts in the same period is weighted and aggregated.

The details of the option, the yield of government bond, the price of the underlying, and the trading volume used to calculate the implied volatility and control variables are from the WIND database. And the yield of 6-month Treasury bond is used as the risk-free interest rate.

2.3 Classification of options

We divide the options into the following ten categories according to the value of Delta in terms of moneyness: deep In-the-money call (DITMC), In-the-money call (ITMC), At-the-money call (ATMC), Out-of-the-money call (OTMC)), deep Out-of-the-money call (DOTMC), deep out-of-the-money put (DOTMP), Out-of-the-money put (OTMP), At-the-money put (ATMP), In-the-money put (ITMP) and deep In-the-money put (DITMP).

Table 1
The classification of options according to moneyness.

Call		Delta range	Put		Delta range
1	DITM	$0.875 < \Delta c \leq 0.98$	1	DOTM	$-0.125 < \Delta p \leq -0.02$
2	ITM	$0.625 < \Delta c \leq 0.875$	2	OTM	$-0.375 < \Delta p \leq -0.125$
3	ATM	$0.375 < \Delta c \leq 0.625$	3	ATM	$-0.625 < \Delta p \leq -0.375$
4	OTM	$0.125 < \Delta c \leq 0.375$	4	ITM	$-0.875 < \Delta p \leq -0.625$
5	DOTM	$0.02 < \Delta c \leq 0.125$	5	DITM	$-0.98 < \Delta p \leq -0.875$

2.4 Net buying pressure

Bollen and Whaley (2004) first put forward a method of constructing the net buying pressure index. They defined the net buying pressure as the non-market maker's active purchase of a certain type of option on a certain trading day minus the active sales, and Delta is used for weighting. We think that their indicator construction can be improved in two aspects: First, regarding the data frequency, they use daily data, but considering the degree of high frequency trading in option markets, we believe that options market is better to be tested with higher frequency intraday data; The second is about the selection of trading volume. According to the study of Pan and Poteshman (2006), there is a big difference in the volume of open positions and the volume of close positions, and closing transactions are easily affected by many other factors. Therefore, the selection of all trading volumes as a net trading volume may not effectively reflect the information.

Therefore, the net buying pressure in this paper is constructed as follows: First, we remove all the non-opened trading volume data, and select only the opening trading volume as the basis for the construction of net buying pressure index. Then we divide each trading day into 48 5-minute bulks. For each type of option contract in each 5-minute bar, we calculate the open buy and open sell volume and aggregate them with delta value. Finally, the net buying pressure is defined as the difference of open buy and open sell volume. To be conservative, we also calculate the net pressure using 30-minute and one-hour frequency bars in addition to the five-minute bulk in the empirical test.

Table 2 shows the mean value of the net buying pressure for the SSE 50 ETF options. It can be seen that, in general, Chinese option investors have negative net demand for the SSE 50 ETF options, indicating that the Chinese option market is dominated by short-selling. Horizontal comparison of calls and puts suggests that option investors' net buying pressure on puts is greater than that on call options. This means that Chinese option investors are basically bearish on China's stock market. This paper believes this is mainly related with the sample period of this article which covers 2015 stocks crash.

Table 2
The mean of net buying pressure for the SSE 50 ETF option.

Moneyness	Call	Put
Deep In-the-money	-2.15992	-1.0405
In-the-money	-6.19346	-2.02844
At-the-money	-8.80054	0.21340
Out-of-the-money	-1.92498	-0.33259
Deep Out-of-the-money	0.100292	-0.07735

2.5 Implied volatility

Implied volatility is an important indicator of this article. It is implied from the Black-Scholes option pricing formula, reflecting the investors' expectation of future volatility. Poteshman (2000) and Chernov (2001) pointed out that since the option price can contain much open information in the market, the implied volatility calculated from the current price can theoretically provide a better forecast for future volatility than the historical volatility. Based on the B-S formula, this paper calculates the implied volatility by collecting the real-time changes of option trading price, the yield of government bond and the contract information of each option. The specific calculation formula is as follows:

$$c = (\mathrm{S} - \mathrm{PVD})N(d_1) - Xe^{-rT}N(d_2) \quad (1)$$

$$p = Xe^{-rT}N(d_2) - (\mathrm{S} - \mathrm{PVD})N(-d_1) \quad (2)$$

$$d_1 = \frac{\ln\left(\frac{(S-PVD)e^{rT}}{X}\right) + 0.5\sigma^2 T}{\sigma\sqrt{T}} \quad (3)$$

$$d_2 = d_1 - \sigma\sqrt{T} \quad (4)$$

Where c (p) represents the price of the call (put) option, S represents the stock price at the corresponding time, X is the strike price, T is the expiration time, and r is the risk-free rate. PVD takes 0, N is a normal distribution function. There are six variables in the BS formula. When the other five variables are known, the sixth variable can be obtained by taking the values of the other five variables.

According to the method of classification of options mentioned above, call options and put options can be further divided into five categories. Table 3 lists the average value of the implied volatility of various options. It shows that basically there are smiley volatility curves for call options and put options in the Chinese options market. The implied volatility of the At-the-money option is the smallest, and the implied volatility of the in-the-money option and Out-of-the-money option is relatively larger. In addition, the implied volatility of the Deep In-the-money option is much greater than that of the other options in the value range. This is particularly evident from the performance of the put options in the table below.

Table 3
The mean of implied volatility for the SSE 50 ETF option.

Moneyness	Call	Put
Deep In-the-money	0.30719	0.505192
In-the-money	0.275691	0.413552
At-the-money	0.299906	0.374596
Out-of-the-money	0.325289	0.360604
Deep Out-of-the-money	0.348492	0.355381

2.6 The testing model

Considering that in-the-money options are not active traded and are easily affected by market noises, making their test results not reliable enough, this paper only examines out-of-the-money options and at-the-money options. Following Bollen and Whaley (2004), we use the following model to test the ATMC, ATMP, OTMC and OTMP:

$$\Delta\sigma_t = c + \alpha_1 R_t + \alpha_2 Volume_t + \alpha_3 NBP_{t,1} + \alpha_4 NBP_{t,2} + \alpha_5 \Delta\sigma_{t-1} + \varepsilon_t \qquad (5)$$

Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index as control variables. $NBP_{t,1}$ indicates the net buying pressure of the tested option, while $NBP_{t,2}$ is the net buying pressure of other types of options. Since the at-the-money option is the most liquid type of option in the market, we use the net buying pressure of at-the-money options as the benchmark for $NBP_{t,2}$ here. $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes, which is used to test whether the implied volatility has a reversal phenomenon.

We construct the following models to test the information trading in the Chinese option market:

$$\Delta\sigma_t^{ATMC} = c + \alpha_1 R_t + \alpha_2 Volume_t + \alpha_3 NBP_t^{ATMC} + \alpha_4 NBP_t^{ATMP} + \alpha_5 \Delta\sigma_{t-1}^{ATMC} + \varepsilon_t \quad (6)$$

$$\Delta\sigma_t^{ATMP} = c + \alpha_1 R_t + \alpha_2 Volume_t + \alpha_3 NBP_t^{ATMP} + \alpha_4 NBP_t^{ATMC} + \alpha_5 \Delta\sigma_{t-1}^{ATMP} + \varepsilon_t \quad (7)$$

$$\Delta\sigma_t^{OTMC} = c + \alpha_1 R_t + \alpha_2 Volume_t + \alpha_3 NBP_t^{OTMC} + \alpha_4 NBP_t^{ATMC} + \alpha_5 \Delta\sigma_{t-1}^{OTMC} + \varepsilon_t \quad (8)$$

$$\Delta\sigma_t^{OTMC} = c + \alpha_1 R_t + \alpha_2 Volume_t + \alpha_3 NBP_t^{OTMC} + \alpha_4 NBP_t^{ATMP} + \alpha_5 \Delta\sigma_{t-1}^{OTMC} + \varepsilon_t \quad (9)$$

$$\Delta\sigma_t^{OTMP} = c + \alpha_1 R_t + \alpha_2 Volume_t + \alpha_3 NBP_t^{OTMP} + \alpha_4 NBP_t^{ATMC} + \alpha_5 \Delta\sigma_{t-1}^{OTMP} + \varepsilon_t \quad (10)$$

$$\Delta\sigma_t^{OTMP} = c + \alpha_1 R_t + \alpha_2 Volume_t + \alpha_3 NBP_t^{OTMP} + \alpha_4 NBP_t^{ATMP} + \alpha_5 \Delta\sigma_{t-1}^{OTMP} + \varepsilon_t \quad (11)$$

According to the three net buying pressure assumptions in section 2.1, α_3, α_4, and α_5 will show different signs and significance under different hypotheses. According to the limited arbitrage hypothesis, the implied volatility of an option is only affected by the net buying pressure of its own option, so α_3 is significantly different from zero and the sign is positive but α_3 is insignificant. Due to the existence of reversal phenomenon, α_5 is significantly different from zero and the sign is negative. According to the direction learning Hypothesis, since the implied volatility of an option is affected by the net buying pressure of the tested option and other options, α_3 is significantly different from zero and the sign is positive. Because the implied volatility of the option under the direction information hypothesis is also affected by other options, so α_4 is also significant. As for its sign, the influence of the same type (call or bear) option is positive, and that of the opposite type option is negative. Also, under the hypothesis of directional information, the implied volatility has a reversal effect, resulting in a significant and negative α_5. Under the volatility learning hypothesis, there is no significant difference in the effects of call and put options, so both α_3 and α_4 are significant with the same sign, and as there is no reversal effect under the volatility information learning hypothesis, α_5 does not significantly differ from zero.

3.Empirical results

In this part, we test the above hypotheses through the volatility forecasting model. And the situation of the 2015 Chinese stock crash is analyzed.

3.1 At-the-money option

Table 4 and 5 report the testing result of the at-the-money call (ATMC) and at-the-money put (ATMP) respectively (equation 6 and 7).

The result of 5-minute frequency is presented in column 1 of table 4. It can be seen that $\Delta\sigma_{t-1}^{ATMC}$ is negative and significant at the level of 1%, which indicates that there is a clear reversal in the implied volatility of ATMC, consistent with the limited arbitrage and directional information hypothesis. However, the net buying pressures of ATMC and ATMP are both positive and significant at the 1% level. According to the theoretical analysis in the previous section, it can be known that some traders have strong volatility information. However, from the absolute value of the parameter estimation, the estimated value of ATMP is obviously smaller than that of ATMC, especially when the test results of the frequency of 30min and 1h are taken into account. According to the three hypotheses proposed in the theoretical analysis section of the previous article, some traders also contain certain direction information.

Table 4
The impact of net buying pressure on the implied volatility of at-the-money call options.

	$\Delta\sigma_t^{ATMC}$		
	5min	30min	1h
c	-.0000741*	-.0000583	.0003694
	(.0000403)	(.0001978)	(.000374)
R_t	-1.542394***	-.8832202***	-.7441743***
	(.0137148)	(.0263213)	(.0319237)
$Volume_t$	9.81e-12***	3.07e-12***	1.06e-12
	(1.08e-12)	(9.30e-13)	(9.03e-13)
NBP_t^{ATMC}	.0000125***	6.28e-06***	6.90e-06***
	(6.71e-07)	(9.44e-07)	(1.06e-06)
NBP_t^{ATMP}	.0000107***	3.18e-06**	-3.20e-07
	(9.04e-07)	(1.27e-06)	(1.40e-06)
$\Delta\sigma_{t-1}^{ATMC}$	-.2204651***	-.2045368***	-.2929047***
	(.0055596)	(.0153606)	(.02121)
Adjusted R-squared	0.4699	0.3239	0.3568

Note: This table reports the impact of the net buying pressure on the implied volatility of the at-the-money call option (ATMC). Column 1 to 3 present the results of the equation (6) at different frequencies (5 min, 30 min, 1 h). Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index , NBP_t^{ATMC} indicates the net buying pressure of the tested option, while NBP_t^{ATMP} is the net buying pressure of other types of options, and $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes. *, ** and *** indicate a significant level of 1%, 5% and 10%, respectively. And the *Adjusted R-squared* is the adjusted R-squared value of the model.

Table 5 shows the result of at-the-money put option (ATMP). We can see that the impact of the net buying pressure of the tested option (ATMC) and the other options (ATMP) are both negative and significant, consistent with the volatility information hypothesis. At the same time, it can be observed that the absolute value of the parameter of the ATMC is significantly smaller than that of the ATMP, so it is the net buying pressure of the tested option itself that dominates. In addition, we can see that the coefficient of $\Delta\sigma_{t-1}^{ATMC}$ is negatively significant, contradicting the volatility information hypothesis. Therefore, the result of ATMP also shows that there is strong volatility information among the SSE 50ETF parity put traders, and there are also a small number of traders with certain direction information.

Table 5
The impact of net buying pressure on the implied volatility of at-the-money call options.

	$\Delta\sigma_t^{ATMP}$		
	5min	30min	1h
c	-.0001716*** (.0000562)	-.0008931*** (.000277)	-.0017049*** (.000537)
R_t	1.917058*** (.019127)	.9199191*** (.0368621)	.6603075*** (.0459499)
$Volume_t$	2.93e-12* (1.50e-12)	5.64e-12*** (1.30e-12)	5.91e-12*** (1.30e-12)
NBP_t^{ATMP}	-.0000223*** (1.26e-06)	-.0000104*** (1.78e-06)	-9.38e-06*** (2.01e-06)
NBP_t^{ATMC}	-9.11e-06*** (9.37e-07)	-2.16e-06 (1.32e-06)	-1.16e-06 (1.52e-06)
$\Delta\sigma_{t-1}^{ATMP}$	-.2147004*** (.0058428)	-.2244941*** (.0164597)	-.3309455*** (.022942)
Adjusted R-squared	0.4145	0.2260	0.2506

Note: This table reports the impact of the net buying pressure on the implied volatility of the at-the-money put option (ATMP). Column 1 to 3 present the results of the equation (7) at different frequencies (5 min, 30 min, 1 h). Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index , NBP_t^{ATMP} indicates the net buying pressure of the tested option, whileNBP_t^{ATMC} is the net buying pressure of other types of options, and $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes. *, ** and *** indicate a significant level of 1%, 5% and 10%, respectively. And the *Adjusted R-squared* is the adjusted R-squared value of the model.

3.2 Out-of-the-money option

The following Table 6 to 9 are the test results of the influence of the net buying pressure on the volatility of out-of-the-money options, corresponding to equation (8) to (11).

Looking at the results of OTMC tests in Table 6 and Table 7 and OTMP tests in Table 8 and 9, we find that the coefficient of $\Delta\sigma_{t-1}$ are all negative and significantly different from zero, indicating the existence of a reversal phenomenon thus the directional information trading. OTMC and OTMP's net buying pressure both have a significant impact on its implied volatility. At the same time, the net buying pressure of ATMC and ATMP also have a significant impact on the implied volatility of OTMC and OTMP and are all in the same direction with their own impact. Thus, just similar with what we can infer from the results of at-the-money options, traders in the SSE

ETF50 out-of-the-money options also have strong volatility information, with a small number of traders who have direction information.

Table 6
The impact of net buying pressure on the implied volatility of out-of-the-money call options.

	$\Delta\sigma_t^{OTMC}$		
	5min	30min	1h
c	-.0002312***	-.0003995	-.0000762
	(.0000653)	(.0003013)	(.0005859)
R_t	-1.166615***	-.7459568***	-.6353528***
	(.0227229)	(.0419572)	(.0535142)
$Volume_t$	1.97e-11***	7.09e-12***	2.57e-12*
	(1.78e-12)	(1.44e-12)	(1.45e-12)
NBP_t^{OTMC}	.0000251***	.0000113***	5.34e-06
	(2.45e-06)	(3.45e-06)	(4.03e-06)
NBP_t^{ATMC}	8.08e-06***	4.74e-06***	4.09e-06***
	(1.03e-06)	(1.37e-06)	(1.60e-06)
$\Delta\sigma_{t-1}^{OTMP}$	-.2578599***	-.1732203***	-.3186092***
	(.0071672)	(.0178628)	(.024465)
Adjusted R-squared	0.2053	0.1457	0.2037

Note: This table reports the impact of the net buying pressure on the implied volatility of the at-the-money call option (OTMC). Column 1 to 3 present the results of the equation (8) at different frequencies (5 min, 30 min, 1 h). Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index , NBP_t^{OTMC} indicates the net buying pressure of the tested option, whileNBP_t^{ATMC} is the net buying pressure of other types of options, and $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes. *, ** and *** indicate a significant level of 1%, 5% and 10%, respectively. And the *Adjusted R-squared* is the adjusted R-squared value of the model.

Table 7
The impact of net buying pressure on the implied volatility of out-of-the-money call options.

	$\Delta\sigma_t^{OTMC}$		
	5min	30min	1h
c	-.0002312***	-.0003995	-.0000762
	(.0000653)	(.0003013)	(.0005859)
R_t	-1.166615***	-.7459568***	-.6353528***
	(.0227229)	(.0419572)	(.0535142)
$Volume_t$	1.97e-11***	7.09e-12***	2.57e-12*
	(1.78e-12)	(1.44e-12)	(1.45e-12)
NBP_t^{OTMC}	.0000251***	.0000113***	5.34e-06
	(2.45e-06)	(3.45e-06)	(4.03e-06)
NBP_t^{ATMP}	8.08e-06***	4.74e-06***	4.09e-06***
	(1.03e-06)	(1.37e-06)	(1.60e-06)
$\Delta\sigma_{t-1}^{OTMP}$	-.2578599***	-.1732203***	-.3186092***
	(.0071672)	(.0178628)	(.024465)
Adjusted R-squared	0.2053	0.1457	0.2037

Note: This table reports the impact of the net buying pressure on the implied volatility of the at-the-money call option (OTMC). Column 1 to 3 present the results of the equation (9) at different frequencies (5 min, 30 min, 1 h). Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index , NBP_t^{OTMC} indicates the net buying pressure of the tested option, whileNBP_t^{ATMP} is the net buying pressure of other types of options, and $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes. *, ** and *** indicate a significant level of 1%, 5% and 10%, respectively. And the *Adjusted R-squared* is the adjusted R-squared value of the model.

Table 8
The impact of net buying pressure on the implied volatility of out-of-the-money put options.

	$\Delta\sigma_t^{OTMP}$		
	5min	30min	1h
c	-.0002312***	-.0003995	-.0000762
	(.0000653)	(.0003013)	(.0005859)
R_t	-1.166615***	-.7459568***	-.6353528***
	(.0227229)	(.0419572)	(.0535142)
$Volume_t$	1.97e-11***	7.09e-12***	2.57e-12*
	(1.78e-12)	(1.44e-12)	(1.45e-12)
NBP_t^{OTMP}	.0000251***	.0000113***	5.34e-06
	(2.45e-06)	(3.45e-06)	(4.03e-06)
NBP_t^{ATMC}	8.08e-06***	4.74e-06***	4.09e-06***
	(1.03e-06)	(1.37e-06)	(1.60e-06)
$\Delta\sigma_{t-1}^{OTMP}$	-.2578599***	-.1732203***	-.3186092***
	(.0071672)	(.0178628)	(.024465)
Adjusted R-squared	0.2053	0.1457	0.2037

Note: This table reports the impact of the net buying pressure on the implied volatility of the at-the-money put option (OTMP). Column 1 to 3 present the results of the equation (10) at different frequencies (5 min, 30 min, 1 h). Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index , NBP_t^{OTMP} indicates the net buying pressure of the tested option, whileNBP_t^{ATMC} is the net buying pressure of other types of options, and $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes. *, ** and *** indicate a significant level of 1%, 5% and 10%, respectively. And the *Adjusted R-squared* is the adjusted R-squared value of the model.

Table 7
The impact of net buying pressure on the implied volatility of out-of-the-money put options.

	$\Delta\sigma_t^{OTMP}$		
	5min	30min	1h
c	-.0002312***	-.0003995	-.0000762
	(.0000653)	(.0003013)	(.0005859)
R_t	-1.166615***	-.7459568***	-.6353528***
	(.0227229)	(.0419572)	(.0535142)
$Volume_t$	1.97e-11***	7.09e-12***	2.57e-12*
	(1.78e-12)	(1.44e-12)	(1.45e-12)
NBP_t^{OTMP}	.0000251***	.0000113***	5.34e-06
	(2.45e-06)	(3.45e-06)	(4.03e-06)
NBP_t^{ATMP}	8.08e-06***	4.74e-06***	4.09e-06***
	(1.03e-06)	(1.37e-06)	(1.60e-06)
$\Delta\sigma_{t-1}^{OTMP}$	-.2578599***	-.1732203***	-.3186092***
	(.0071672)	(.0178628)	(.024465)
Adjusted R-squared	0.2053	0.1457	0.2037

Note: This table reports the impact of the net buying pressure on the implied volatility of the at-the-money put option (OTMP). Column 1 to 3 present the results of the equation (11) at different frequencies (5 min, 30 min, 1 h). Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index , NBP_t^{OTMP} indicates the net buying pressure of the tested option, whileNBP_t^{ATMP} is the net buying pressure of other types of options, and $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes. *, ** and *** indicate a significant level of 1%, 5% and 10%, respectively. And the *Adjusted R-squared* is the adjusted R-squared value of the model.

3.3 The 2015 Chinese stock crash

After the empirical analysis of the whole sample, we look particularly at the period of 2015 Chinese stock crash (from June 15, 2015 to August 26, 2015) to see the market efficiency during the crisis period. Table 8 below shows the test results of option information transactions during the Chinese stock market (take the call option as an example). It can be seen that $\Delta\sigma_{t-1}^{ATMC}$ is negative and significant, indicating the existence of directional information trading. And the effect of NBP_t^{ATMC} and NBP_t^{ATMP} still holds, both positive and significant. Notably, comparing the estimation results ofNBP_t^{ATMP} between the entire sample period (February 2015 to July 2016) and the stock crisis period (June 15, 2015 to August 26, 2015), it can be found that the estimated coefficient of NBP_t^{ATMP} during the stock crash period is approximately twice the value of the entire sample period, which indicates that investors may have more volatility information during the crash. Also, the significance of the coefficient drops more quickly with time (see column 2 and 3) during the crash, indicating that the information was transmitted more rapidly during the disaster period.

Table 8
The impact of net buying pressure on the implied volatility of at-the-money call options during the 2015 Chinese stock crash.

	$\Delta\sigma_t^{ATMC}$		
	5min	30min	1h
c	-.0005884*** (.0002109)	-.0008895 (.0010197)	-.0004469 (.00188)
R_t	-1.589678*** (.0357145)	-.8525935*** (.0673795)	-.7306583*** (.0786102)
$Volume_t$	1.45e-11*** (2.63e-12)	3.10e-12 (2.23e-12)	7.39e-13 (2.12e-12)
NBP_t^{ATMC}	.0000111*** (3.28e-06)	6.50e-06 (4.10e-06)	.0000111** (4.34e-06)
NBP_t^{ATMP}	.0000251*** (4.59e-06)	6.89e-06 (6.06e-06)	-2.75e-06 (6.56e-06)
$\Delta\sigma_{t-1}^{ATMC}$	-.2042897*** (.0143641)	-.2022879*** (.0407642)	-.3586961*** (.0543079)
Adjusted R-squared	0.4901	0.3151	0.3900

Note: This table reports the impact of the net buying pressure on the implied volatility of the at-the-money call option (ATMC). Column 1 to 3 present the results of the equation (6) at different frequencies (5 min, 30 min, 1 h). Where $\Delta\sigma_t$ represents the change of the implied volatility, R_t and $Volume_t$ represent the current return and the trading volume of the stock index , NBP_t^{ATMC} indicates the net buying pressure of the tested option, while NBP_t^{ATMP} is the net buying pressure of other types of options, and $\Delta\sigma_{t-1}$ is the lagged value of the implied volatility changes. *, ** and *** indicate a significant level of 1%, 5% and 10%, respectively. And the *Adjusted R-squared* is the adjusted R-squared value of the model.

4.Robustness test

In order to examine the information content of China's option market more comprehensively and steadily, we carry out a series of other tests based on the basic model, including analyzing the relationship between the net buying pressure of different types of options and analyzing the impact of net buying pressure on the direction of the stock returns. And different frequency analysis has already been done in the former part.

4.1 Correlation analysis of the net buying pressure of different options

The correlation of the net buying pressure of ATMC and ATMP is 0.5480, which shows that the ATM call option and put option have an appreciable positive correlation. This is in accordance with the hypothesis of volatility information mentioned in the theoretical analysis section and our empirical results that traders have volatility information in advance, so the net purchase pressure of call options and put options is positively related in the number of open positions. Buying (selling) a call option makes no difference with buying (selling) a put option for those volatility information traders.

4.2 Net buying pressure and the index return

In this subsection we calculate the difference of the net buying pressure of the ATMC and ATMP as the measure of the net longing pressure of the index option. By analyzing the effect of the net buying pressure of the index option on the index return (yield is positive or negative), we can test whether there is directional information trading. Table 9 below shows the results of the logit regression test on this issue, where DIRECTION indicates the direction of the yield (1 for positive and 0 for negative); DIFFERENCE indicates the net buying pressure for the index. As can be seen from Table 9, for each unit of increase in the net buying pressure for the index, the possibility of a positive stock return will increase by 6.6% at the 1% level of significance. Therefore, it confirms the finding above that some traders have directional information in advance.

Table 9
The logit regression of the impact of net buying pressure for the index option on the index return direction.

	DIRECTION			
	Coef.	Std. Err.	P>|z|	Pseudo R2
C	-.2044403	.0156817	0.000	0.0204
DIFFERENCE	.0065999	.0003158	0.000	0.0204

5. Conclusion

Information plays an important role in the asset pricing. Traditional finance theory assumes that market participants have homogenous information, but in reality, different investors may have different information and that will be reflected in the formation of asset price and volatility through their trading behaviors. In this study, we use high frequency data and improve the method proposed by Bollen and Whaley (2004) to investigate the information trading in the SSE 50 ETF options market in China.

Through the testing of the theoretical model of net buying pressure on the Shanghai 50 ETF options, we find that during the selected sample period, there is indeed information trading in the SSE 50 ETF options market. And the volatility information trading is the dominant one, but there is also a small amount of directional information trading. More important, evidence shows that during the 2015 financial crisis in China, the information trading in the index option market became even more active.

Our results have implications for both investors and policy makers. On the one hand, there is information trading especially volatility information trading in the newly developed Chinese index options market and the net buying pressure is a good proxy to capture it, so it will be better for investors to pay more attention to the order flow of the market. On the other hand, the net buying pressure is also a useful tool for regulators to better supervise the market and improve the market efficiency.

References

Admati A. R., Pfleiderer P. A Theory of Intraday Patterns: Volume and Price Variability. Review of Financial Studies, 1988, 1(1):3-40.

Bagehot W. The Only Game in Town. Financial Analysts Journal, 1971, 27(2): 12-22.

Black F. Fact and Fantasy in the Use of Options[J]. Financial Analysts Journal, 1975, 31(4):36-41.

Bollen N. P. B., Whaley R. E. Does Net Buying Pressure Affect the Shape of Implied Volatility Functions? The Journal of Finance, 2004, 59(2):711-753.

Chan K., Chung Y. P., Fong W. M. The Informational Role of Stock and Option Volume. Review of Financial Studies, 2002, 15(4):1049-1075.

Chan K., Chung Y. P., Johnson H. Why Option Prices Lag Stock Prices: A Trading-Based Explanation. The Journal of Finance, 1993, 48(5):1957-1967.

Chan K., Chung Y. P. Intraday relationships among index arbitrage, spot and futures price volatility, and spot market volume: A transactions data test. Journal of Banking & Finance, 1993, 17(4):663–687.

Chernov M. Implied Volatilities as Forecasts of Future Volatility, Time-Varying Risk Premia, and Returns Variability. Ssrn Electronic Journal, 2001.

Chung K. H., Charlie C. Insider Trading and the Bid-Ask Spread. Financial Review, 1998, 33(3):1-20.

Copeland T. E., Dan G. Information Effects on the Bid-Ask Spread. The Journal of Finance, 1983, 38(5):1457-1469.

Easley D., O'Hara M., Srinivas P. S. Option Volume and Stock Prices: Evidence on Where Informed Traders Trade. The Journal of Finance, 1998, 53(2):431-465.

Easley D.，Kiefer，O’Hara. Cream-Skimming or Profit-Sharing? The curious role of purchased order flow.Journal of Finance, 1996, 51(3)：811~833.

Kang J., Park H. J. The information content of net buying pressure: Evidence from the KOSPI 200 index option market. Journal of Financial Markets, 2008, 11(1):36-56.

Kyle A. Continuous auctions and insider trading. Econometrica, 1985, 53:1315–1335.

Pan J., Poteshman A. M. The Information in Option Volume for Future Stock Prices. Review of Financial Studies, 2004, 19(3):871-908.