The Predictability of Option Intraday Information On Index Returns

I FAN CHIANG

27 April 2019

Abstract

The Intraday IVS contains certain imformation about intraday stock return.

1 Introduction

In recent year, the information of derivatives market plays an increasingly crucial role in financial markets. There are multiple reasons why option market are vital for investors. One, informed traders may choose to trade in derivative markets since they can camouflage with noise traders by trading different option contracts on one specific security (Easley, O'hara, and Srinivas 1998). Another, authors such as Black and Scholes (1973), Mayhew, Sarin, and Shastri (1995), Fleming, Ostdiek, and Whaley (1996), among others, argue that widened financial leverage and narrowed transaction costs may encourage informed traders to trade in the option market instead of the equity market, Third, unlike stock market, there are no short selling constraints in option market. Therefore, the characteristics of an option contract are informational and worthy to investigate. However, To what extent has it been supported by empirical works?

It has been a fierce debate that the trading information from derivative markets lead the underlying markets. Prior studies hold different arguments toward this topic. Relevant papers, like Manaster and Rendleman Jr (1982), Anthony (1988), Chakravarty, Gulen, and Mayhew (2004), Cremers and Weinbaum (2010), Xing, Zhang, and Zhao (2010) have found that the information from option market take the lead of the information from stock market. When informed traders recieved private information, they prefer to trade in option market since there are several advatanges we mentioned in the first paragraph. Furthermore, voluminious literatures address that the informed trading in option market elucidate the process of price discovery, and the information contained in option price and volume would eventually get incoperated into the underlying prices. While, other studies like Chan, Chung, and Johnson (1993), Stephan and Whaley (1990) find no evidence that option prices can lead stock prices.

In this paper, we provide a comprehensive analysis on the examination of the interrelation between option and index markets. In other words, this paper contributes to the literature in several ways. First, rather than investigating on stock market, we focus mainly on the index, S&P 500. Since we would like to research on which interval in a single trading day carries the trading information the most rather than study imbalance orders behind an option volume, index are harder for traders to acquire private information than others. Most prior literature discuss informational linkage between option and stock markets, few of them had mentioned about index market.

Based on the call and put implied volatilty spread(CPIV) propsed by Cremers and Weinbaum (2010), we refine this approach and derive an intraday version which tells the predictability power toward future index returns within a single trading day. Within a single day, we would like to see whether the predictability power is stronger in open period, middle period or close period. Therefore, we partition a single day to 14 intervals, and each interval we only include 5 minutes long in case the Put-Call parity would be unbalanced due to major difference between the underlying prices in call and put options. Apart from the above reason, there are several causes that are responsible for the deviation of put-call parity, short sell constraints, the early exercise value of American options, transaction costs, taxes, to name a few.

The remainder of paper is organized as follows. In Section 2 we describe our research hypothesis, In Section 3, we describe our methedology and data. Section 4 presents the main empirical results on quote data on predicting index returns. Section 5 provides the results are robust to trade data given the identical sample period. Section 6 concludes.

2 Hypothesis Development

Pan and Poteshman (2006) considers that there is no evidence to prove the informed trading in the index market via performing an regression of the next-day index returns on open-buy put-call ratios. It is a common believe that informed traders tend to hold private information in firm-specific level rather than market-wide level. Therefore, we first exclude the possibility that the predictability of index market may comes from informed-trading.

In our research, we articulate the intraday CPIV may comes from yesterday trading information and the news beyond market close. Hence, we would like to see in which interval may also contain information toward the contemporaneous index prices and next-day index prices. Apart from prior studies, which possess the best-bid and best-offer of call and put option price within 5 minutes before market close. On top of that, we apply prior approaches to establish CPIV of every interval in a single trading day. We assume that yesterday trading information and news would also reflect in other intervals. In fact, we discuss whether it is appropriate to use the last 5-minutes best bid and best offer to represent the option information in daily frequency. Would it be another chance that other intervals may also be crucial roles in price discovery?

Hypothesis 1: The open and mid intervals may also contain important information toward index returns

Bergsma et al. (2018) spans the results from Easley, O'hara, and Srinivas (1998) that intraday signed option to stock ratios (O/S) have strong stock return predictability especially in the first 30 minutes of market open. They make a statemtent that the first half hour of trading has predictive power for the remainder of the trading day. In line with this study, we believe CPIV also reflect the market sentiment like O/S. Consequently, we suggest S&P 500 index option carry information toward the index market, and the information would get incorporated into the index market as time flows.

Hypothesis 2: The first 5-minutes CPIV has predictability during the rest of the trading day

3 Data and Empirical Methodology

3.1 Deviation From Put-Call Parity

The put-call parity relations derived from Stoll (1969) is a classical options pricing concepts in finance. It characterized the relationship that must exist between European put and call options with the identical underlying asset, expiration and strike prices. The equation must hold for European options on no-dividends paying underlying in a perfect market.

$$C - P = S - PV(K) \tag{1}$$

Where C and P represent call prices and put prices, and S is Stock price. With same maturity and exercise price K, the arbitrage opportunity would exist if the equation is not hold. The Black and Scholes (1973) formula satisfies the put-call parity for any assumed value of the volatility parameter σ, therefore,

$$C^{BS}(\sigma) + PV(K) = P^{BS}(\sigma) + S \tag{2}$$

where $C^{BS}(\sigma)$ and $P^{BS}(\sigma)$ indicate Black-Scholes call and put prices, respectively. Combine the above equation, we can derive the equation

$$C^{BS}(\sigma) - C = P^{BS}(\sigma) - P \tag{3}$$

which implies that the implied volatility of call option and put option should be the same if all equation holds.

$$IV^{call} = IV^{put} \tag{4}$$

Of course the equation may not be hold once the option is American-style. However, our primary studies on SPX option is European style. Therefore, we do not need to consider the dividend payment or early exercise case in our further research.

Clearly, the larger implied volatilities are the higher the call or put option prices claim. Following Amin, Coval, and Seyhun (2004), we refer to the difference between call and put implied volatilities as the call-put implied volatility spread(CPIV). It is suggested that a positive(negative) CPIV could be viewed as a bullish(bearish) signal regarding the underlying stock.

The aggregate Intraday CPIV are construced as following steps:

1. We first divided a single day into 14 of 5-minutes interval. Each interval contains the tick data from 2.5 minutes ahead and behind. For example, the 9 a.m. invertal, we collect valid data from 08:47:30 to 09:32:30 to represent this interval. As for open(close) interval, we choose to accumulate the full 5 minutes data behind(ahead)[1]

2. Similar to Xing, Zhang, and Zhao (2010), in each interval, we eliminate an option from the sample if its time to expiration is less than 10 days or more than a year, if its open interest is negative, if its moneyness[2] is smaller than 0.9 or more than 1.1. Furthermore, the option quotes must not violate basic no-arbitrage relations.

3. Then, in each time interval, there must be several valid option pairs with

[1] We collect the whole transaction data in 5 minutes for trade data. However, the size of quote data is extremely unbalanced in different intervals, we restricted 1000 to 2000 quotes as maximum for call and put in collecting quote data.

[2] Moneyness is defined as the ratio of the strike price to the stock price.

identical maturity(T) and exercise price(K). For each option pair we choose only one pair to be the representitive. For quote data, we choose the mean of best bid(β^*) best offer(α^*) as the chosen call and put price. For trade data, we capture the transaction that is closet to the centering time.

4. After collecting several time interval valid option pairs. we calculated the CPIV by applying,

$$CPIV_t = IV_t^{call} - IV_t^{put} = \sum_{j=1}^{N_t} \theta_{j,t}(IV_{j,t}^{call} - IV_{j,t}^{put}) \tag{5}$$

$CPIV_t$ denotes the implied volatility spread on interval t; $IV_{j,t}$ describe the B-S implied volatility, where the j refers to valid pairs of put and call options; $\theta_{j,t}$ are weights, there are N_t valid pairs of option on interval t.

Follow by Holowczak, Hu, and Wu (2013), the aggregation of option information could be adjusted by the level of moneyness and maturity.

$$CPIV_t = IV_t^{call} - IV_t^{put} = \sum_{j=1}^{N_t} w_{j,t}(IV_{j,t}^{call} - IV_{j,t}^{put}) \tag{6}$$

The equation is identical except for the weight expression. $w_{j,t}$ is actually $exp(-(m_j^2)/2-(M_j-1)^2)*\theta_j$ where m_j^2 measures the moneyness of the option contract. $m_j = (\frac{K_i}{S_i} - 1)$ and K_i represents exercise prices and S_i represents underlying prices; the M_j evaluates the maturity of option contract. $M_j = max(1, T_i * 12)$ and T_i represents the maturity in month unit.

3.2 Data

In our analysis, the primary quote and trade intraday data for SPX option originates from CBOE MDR. The sample period studied is from January 2007 to December 2017. The option data includes trade date, trade time, expiration date, put-call code, exercise price, maturities, bid price, ask price, underlying price. The daily price of S& P 500 index is obtained from Bloomberg. The zero-coupon bond (ZCB) rate represent risk-free rate in B-S formula are collected from WRDS with different duration. The size of the sample data is about 1-TB around and the amount is about 1 billion. After we exclude the tick data fall outside the 5-minutes intervals, it remains about 40 million. Furthermore, we follow the approach from Ofek, Richardson, and Whitelaw (2004) to exclude the invalid option pairs. Finally, we have 1,692,542 valid volatility spreads for SPX option from January 2007 to December 2017.

Following the prior studiesBollerslev, Tauchen, and Zhou (2009), several macroeconomic variable are suggested to be crucial and informative with regard to future returns. Specifically, we collect data of the default spread(between Moody's BAA and AAA corporate bond spreads), the term spread(between the 10-year T-Bond and 3-month T-bill yields) [3] as control variables in our regression analysis. The set of macro-economics controls used in regressions changes as the measurement window of the expected market returns changes.

In our study, the amount of intraday CPIV should be 38,668 (14 Intervals * 2,762 Days). However, most of option quote data are short date contract(less than 10 days) in the middle of month so that we have mutiple missing values by this

[3]The daily data are collected from the public website of the Federal Reserve Bank of St. Louis.

approach. Meanwhile, our research also winsorized the outliers of intraday CPIV on 1% at the front and end. The final valid interval CPIV of trade data is 36,959, as for quote data is 27,554.

Table 1 1 presents the descriptive statistics of intraday CPIV.

3.3 Figure

1stock trading volume, and stock returns data are taken from CRSP for the construction of control measures.

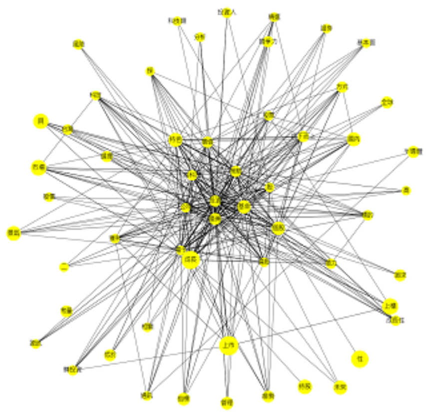

Figure 1: Network ot words

3.4 Variable Definitions

All measures using implied volatility are calculated using all options with 90 or fewer days to expiration. Following Cremers and Weinbaum (2010), CPIV is the open interest-weighted call implied volatility less open interest weighted put implied volatility. CPIV STD is the standard deviation of CPIV over the past 20 days. IV is the open interest-weighted implied volatility. ME is stock price multiplied by the number of shares outstanding at the end of the measurement period and is reported in billions. Return is the daily, weekly, or monthly return on the day, week, or month, respectively, following CPIV measurement. Reversal is return in the calendar month prior to CPIV measurement. Momentum is the cumulative return in calendar months in brackets relative to the date of CPIV measurement. Turnover is monthly volume divided by the number of shares outstanding over calendar months prior to CPIV measurement with months designated in brackets. Illiquidity is the illiquidity measure of Amihud (2002), the absolute value of the return divided by the dollar trading volume averaged over calendar days prior to CPIV measurement, with days designated in brackets.

3.5 Descriptive Statistics

This table presents descriptive statistics for xxxx.

References

Amin, Kaushik, Joshua D Coval, and H Nejat Seyhun (2004). "Index option prices and stock market momentum". In: *The Journal of Business* 77.4, pp. 835–874.

Anthony, Joseph H (1988). "The interrelation of stock and options market trading-volume data". In: *The Journal of Finance* 43.4, pp. 949–964.

Bergsma, Kelley et al. (2018). "Intraday option to stock volume ratios and stock return predictability". In: *Social Science Electronic Publishing. Available online: https://papers. ssrn. com/sol3/papers. cfm*.

Black, Fischer and Myron Scholes (1973). "The pricing of options and corporate liabilities". In: *Journal of political economy* 81.3, pp. 637–654.

Bollerslev, Tim, George Tauchen, and Hao Zhou (2009). "Expected stock returns and variance risk premia". In: *The Review of Financial Studies* 22.11, pp. 4463–4492.

Chakravarty, Sugato, Huseyin Gulen, and Stewart Mayhew (2004). "Informed trading in stock and option markets". In: *The Journal of Finance* 59.3, pp. 1235–1257.

Chan, Kalok, Y Peter Chung, and Herb Johnson (1993). "Why option prices lag stock prices: A trading-based explanation". In: *The Journal of Finance* 48.5, pp. 1957–1967.

Cremers, Martijn and David Weinbaum (2010). "Deviations from put-call parity and stock return predictability". In: *Journal of Financial and Quantitative Analysis* 45.2, pp. 335–367.

Easley, David, Maureen O'hara, and Pulle Subrahmanya Srinivas (1998). "Option volume and stock prices: Evidence on where informed traders trade". In: *The Journal of Finance* 53.2, pp. 431–465.

Fleming, Jeff, Barbara Ostdiek, and Robert E Whaley (1996). "Trading costs and the relative rates of price discovery in stock, futures, and option markets". In: *Journal of Futures Markets: Futures, Options, and Other Derivative Products* 16.4, pp. 353–387.

Holowczak, Richard, Jianfeng Hu, and Liuren Wu (2013). "Aggregating information in option transactions". In: *Journal of Derivatives* 21.3, p. 9.

Manaster, Steven and Richard J Rendleman Jr (1982). "Option prices as predictors of equilibrium stock prices". In: *The Journal of Finance* 37.4, pp. 1043–1057.

Mayhew, Stewart, Atulya Sarin, and Kuldeep Shastri (1995). "The allocation of informed trading across related markets: An analysis of the impact of changes in equity-option margin requirements". In: *The Journal of Finance* 50.5, pp. 1635–1653.

Ofek, Eli, Matthew Richardson, and Robert F Whitelaw (2004). "Limited arbitrage and short sales restrictions: Evidence from the options markets". In: *Journal of Financial Economics* 74.2, pp. 305–342.

Pan, Jun and Allen M Poteshman (2006). "The information in option volume for future stock prices". In: *The Review of Financial Studies* 19.3, pp. 871–908.

Stephan, Jens A and Robert E Whaley (1990). "Intraday price change and trading volume relations in the stock and stock option markets". In: *The Journal of Finance* 45.1, pp. 191–220.

Stoll, Hans R (1969). "The relationship between put and call option prices". In: *The Journal of Finance* 24.5, pp. 801–824.

Xing, Yuhang, Xiaoyan Zhang, and Rui Zhao (2010). "What does the individual option volatility smirk tell us about future equity returns?" In: *Journal of Financial and Quantitative Analysis* 45.3, pp. 641–662.

List of Tables

Table 1: Descriptive Statistics of Intraday CPIV

This table shows descriptive statistics for CPIV of each interval. Panel A presents the summary statsitics for CPIV. Panel B presents the correlation matrix between the CPIV of each interval. In panel A, the columns

	08:30	09:00	09:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00
Mean(%)	-2.45	-3.73	-3.65	-3.59	-3.57	-3.57	-3.62	-3.61	-3.60	-3.62	-3.62	-3.58	-3.51	-3.41
Std(%)	1.11	0.71	0.77	0.80	0.79	0.76	0.78	0.82	0.82	0.78	0.77	0.77	0.71	0.80
Min(%)	-51.17	-14.81	-11.38	-14.24	-10.65	-10.65	-11.86	-11.64	-13.95	-11.60	-10.09	-14.39	-11.22	-15.84
Max(%)	43.20	11.69	20.39	3.49	8.91	7.09	6.52	4.38	5.21	4.92	3.51	4.22	5.62	4.67
Median(%)	-3.36	-3.72	-3.59	-3.55	-3.47	-3.49	-3.50	-3.47	-3.46	-3.51	-3.43	-3.41	-3.33	-3.20
# Pos. CPIV	647	47	24	25	19	22	18	20	19	22	14	19	19	32
# Neg. CPIV	1916	2366	2183	2099	2048	1982	1943	1901	1847	1802	1758	1710	1649	1399
Nan Value Rate(%)	3.8	9.1	16.8	19.9	22.1	24.5	26.1	27.6	29.7	31.2	33.2	34.8	37.1	46.0

Table 2: Multivariate Regressions of SPX Return on IVS and Controls -2

	12:00	12:30	13:00	13:30	14:00	14:30	15:00
Intercept	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-0.19	(-0.33)	-0.84	-0.50	-0.16	-0.35	-0.09
IVS	-0.03	-0.05	0.03	0.01	-0.01	0.00	-0.04
	(-1.08)	(-1.97)***	-0.87	-0.19	(-0.32)	(-0.02)	(-0.81)
DDEF	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-0.82)	(-0.97)	(-0.55)	(-0.86)	(-0.68)	(-0.74)	(-1.01)
DTERM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-0.54	-0.96	-0.99	-1.21	-1.02	-1.10	-1.14
lag_return	-0.10	-0.10	-0.10	-0.10	-0.10	-0.11	-0.10
	(-3.13)***	(-3.04)***	(-3.07)***	(-3.01)***	(-2.89)***	(-3.26)***	(-3.23)***
Adj Rsquare(%)	1.24	1.99	1.25	1.14	1.02	1.27	1.36