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The Performance of Trading Strategies Based on Deviations from Put-Call Parity of Stock Options

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Abstract

According to Cremers and Weinbaum [6], we compute the implied volatility spread by option put-call parity theory. Then, we build strategy based on implied volatility spread and compares it with OS, 52-week high, and contrarian investment strategies to explore whether the investment performance of the implied-volatility-spread based strategy is better than other strategies. Moreover, we combine the implied-volatility-spread based strategy with other strategies to form the two-dimensional investment strategy to explore whether the performance of two-dimensional implied-volatility-spread strategy is better than one-dimensional implied-volatility-spread strategy. The empirical results show that it needs more than one year of investment horizon to get positive abnormal return by implied-volatility-spread based strategy. Otherwise, it will only receive negative abnormal return when the investment horizon is less than one year. In addition, two-dimensional strategy improves bad performance of one-dimensional strategy. After combining the contrarian 52-week high and contrarian investment strategy with implied-volatility-spread strategy, we find that there is the best strategic effect when the holding period is 12 months. Nevertheless, the abnormal returns decrease after the holding period is 24 months.

JEL classification numbers: G11, G12.
Keywords: Implied-volatility-spread, OS strategy, 52-week highs strategy, Trading volume strategy, Price momentum strategy, Option volume.

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1. Introduction

Jegadeesh and Titman [11] used the momentum strategy to divide the stocks listed in the New York Stock Exchange (NYSE) and the American Stock Exchange (AMEX) into winners and losers based on past performance. Buying the winners' stocks and selling the losers' stocks is used to test whether the USA stock market has momentum strategy effects and whether it can get excess returns with the momentum strategy. Empirical results show that there is a positive return by short-term investment and a negative return by long-term investment. The momentum strategy is the operation of buying high and selling low, suitable for traders with information for short-term investments. De Bondt and Thaler [8] used the stocks in USA stock market with contrarian investment strategy of buying lower and selling higher stocks. They found that the prices of stocks whose prices are overvalued will be revised downwards over time because the market overreacted to the information. Moreover, the prices of stocks whose prices are undervalued will be revised upwards overtime to maintain balance. The contrary investment strategy is suitable for long-term investments.

The historical high and low stock prices will affect investment willingness. Chan and Wu [5] found that there is an anchoring bias in Taiwan stock market. Investors are used to find a certain point stock prices as an investment benchmark. The 52-week high strategy is to buy when the stock price breakthrough or approach the 52-week high since the stock is under-reaction. Li and Yu [14] examined the Dow Jones Industrial Average (DJIA) by 52-week highs and historical highs. The 52-week high stock prices stand for short-term information and the historical high stock prices stand for long-term information. Because of the lack of response to short-term information and overreaction to long-term information for retail investors, the nearness to the 52-week high is associated with positive future stock returns, and the nearness to the historical high is associated with negative future stock returns.

In the past, there have been many literatures discussing whether there is a correlation between the option volumes and stock prices. Black [4] showed that the high leverage characteristic of option let investors with private information trade option in the options market. Anthony [1] found that the option trading volume can effectively predict the future stock price and the effect is better than the stock trading volume. Roll, Schwartz and Subrahmanyam [15] first proposed the ratio of options trading volume to stock trading volume (OS) can effectively predict the future stock price. Moreover, OS ratio before earnings announcement increases significantly, and OS ratio before the earnings announcement can predict the stock return after the earnings announcement. Huang and Wu [10], based on the OS concept proposed by Johnson and So [12] and found that the better performance of OS strategy is associated with the longer holding period, indicating that the OS strategy is more suitable for medium and long-term investment.

The implied volatility of the option market can show the strength of purchase and sale in the stock market. For example, the increasing implied volatility of the option indicates that the buyer's strength is greater than the seller's strength. In the past,

many literatures pointed out that the implied volatility of options has significant predictive power for future fluctuations of the stock price. Lamoureux and Lastrapes [13] found that implied volatility significantly reflect market information. Cremers and Weinbaum [6] studied the US stock option data and used the implied volatility spread (VS) variable to classify individual stocks into various investment portfolios. They found that the deviations from the Put-Call Parity could predict the abnormal stocks returns. The stronger information asymmetry is accompanied with higher predictability for stock returns. Following Cremers and Weinbaum [6], Chen [7] used the Taiwan call and put options on individual stocks with the same maturities, the same strike prices, and the same underlying stocks to calculate the implied volatility spreads, which are used as the surrogates of the deviations from put-call parities for the Taiwan stock options. They found that there are no significant abnormal returns on portfolios that are constructed based on the implied volatility spreads.

This study focuses on the implied volatility spread strategy, and compares it with OS, 52-week high, and contrary investment strategies to explore whether the investment performance of the implied volatility spread strategy is better than other strategies. In addition, we will observe the changes in short-term investment and long-term investment, and understand whether various strategies have significant profit-making effects.

The paper is organized as follows. Section 1 introduces the background and purpose of this paper. Section 2 reviews the literature. In Section 3, we show data and methodology. Section 4 presents the empirical results. In Section 5, we present the conclusions.

2. Hypothesis

Based on Amin, Coval and Seyhun [2], Cremers and Weinbaum [6], we use the deviation of implied volatility from the put-call parity model to establish an implied volatility spread (VS) strategy. Then, we compare the performance of one-dimensional and two-dimensional implied volatility spread strategies with OS, 52-week high, and contrarian investment strategies. Thus, we postulate the following hypotheses.

Hypothesis 1:

a) The performance of VS portfolio strategy is better than that of OS strategy.
b) The performance of VS portfolio strategy is better than that of 52-week high strategy.
c) The performance of VS portfolio strategy is better than that of contrarian strategy.

Hypothesis 2:

a) The performance of VS & OS two-dimensional strategy is better than that of VS one-dimensional strategy.
b) The performance of VS & contrary 52-week high two-dimensional strategy is better than that of VS one-dimensional strategy.
c) The performance of VS & contrary two-dimensional strategy is better than that of VS one-dimensional strategy.

3. Data and Methodology

3.1 Data

We select the composite stocks of the S&P 100 index as the sample. The S&P100 index is a composite of the 100 strongest stocks of Standard & Poor's in the S&P500. Many of the companies in the S&P100 are global industry leaders with huge production scale, market trading volume, and profitability. According to the 2014 Global Best Brands Report, 52 companies are accounted for in the S&P500 Index among the top 100 global brands. S&P100's comprehensive stocks involve all walks of life, and the stock market is highly representative, enough to represent the rise and fall of the US economy. We use the OptionMetrics database to find data such as the implied volatility of the options of the S&P100 constituent stocks, and the CRSP database to find the relevant information of the S&P100 stocks in the New York Stock Exchange (NYSE) and Nasdaq (NASDAQ).

According to Cremers and Weinbaum [6], we calculate the volatility difference VS with the implied volatility IV of the daily and the same performance price. Based on Johnson and So [12], we require all data to meet the following screening conditions: First, the stock price is higher than $1. Second, weekly call and put trading volume must be higher than 50. Third, if there is incomplete information during the sample period, the stock would not be included in the sample. After screening, there are a total of 81 stocks as our samples.

3.2 Forming and Holding Period

According to Jegadeesh and Titman [11], we format the forming period in 1, 3, and 6 months (J=1, 3, 6), and the holding period in 1, 3, 6, 12, and 24 months (K=1, 3, 6, 12, 24) to construct a portfolio. Each strategy is formed in the form of cross-matching. Each strategy has a total of 15 groups of 3*5. We use the cumulative return to evaluate the performance of each strategy:

We use the following variables (VS, OS, 52-week high, and price momentum), to format the forming period (J months), and then divide the sample into three groups. That is, there are three groups in our portfolio and we focus on the top 33% and the last 33%. The holding period is calculated by the method of buying and holding, and the product of the t-th period is calculated by the product method after being bought and held for K months:

$$AR_{i,t} = R_{i,t} - R_{m,t} \quad (1)$$

$$KCAR_{i,t}^{J,K} = \prod_{j=t+1}^{t+K} (1 + AR_{i,j}) - 1 \cdot K = 1 \cdot 3 \cdot 6 \cdot 12 \cdot 24 \quad (2)$$

Where: $R_{i,t}$ is return of portfolio i at time t and $R_{m,t}$ is S&P 100 market return at time t. $AR_{i,t}$ represents the abnormal return of stock i in period t. K is the number of months held, $KCAR_{i,t}^{J,K}$ is the cumulative abnormal return of the stock i in the holding period of K month and the forming period of J month (J, K) in the period t.

In order to minimize the sample bias and enhance the power of interpretation, we use the overlapping period way to construct the portfolio, which only move one month and holding period. Figure 1 shows that the forming period and holding period are both 6 months, and the first group portfolio trading period is from January 2010 to January 2011. The second group of portfolio trading period is from February 2011 to February 2012, and so on:

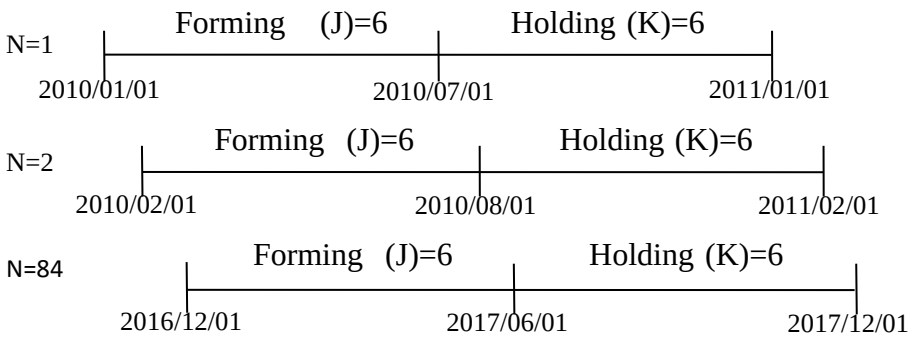

Figure 1: Architecture diagram of the overlap period

4. Empirical results

4.1 VS strategy

According to Cremers and Weinbaum [6], we explore the relationship between the deviated from put-call parity theory and the return of the underlying stock of option, Following Amin, Coval and Seyhun [2], we calculate the implied volatility spread by subtracting the implied volatility of call and put options.

$$C - P = S - K(1 + R)^{-T} \quad (3)$$

Where: C is call price, P is put price, S is underlying stock price, K is strike price, and T is time from expiry date.

Since the European option pricing model of Black and Scholes [3] (thereafter BS model) assumes stock price corresponds with Geometric Brownian Motion, we can get the following formula:

$$C^{BS}(\sigma) + PV(K) = P^{BS}(\sigma) + S, \forall \sigma > 0 \tag{4}$$

Where: C^{BS} is call price in B-S model, P^{BS} is put price in B-S model and σ is volatility parameter.

If we use eq. (3) to subtract eq. (4), we can get eq. (5)

$$C^{BS}(\sigma) - C = P^{BS}(\sigma) - P, \forall \sigma > 0 \tag{5}$$

We can obtain the implied volatility IV^{CALL} to hold eq. (6) and (7):

$$C^{BS}(IV^{CALL}) = C \tag{6}$$

$$P^{BS}(IV^{CALL}) = P \tag{7}$$

Thus, we can get eq. (8)

$$IV^{CALL} = IV^{PUT} \tag{8}$$

Under the European option B-S model with expiration restrictions, the implied volatility of the paired call and put must be equal. In this study, we use the implied volatility in eq. (8) of call option to subtract the implied volatility of put option to get the volatility spread ($VS_{i,t}$) in eq. (9).

$$VS_{i,t} = IV_{i,t}^{calls} - IV_{i,t}^{puts} = \sum_{j=1}^{N_{i,t}} w_{j,t}^{i} \left(IV_{j,t}^{i,calls} - IV_{j,t}^{i,puts} \right) \tag{9}$$

Where: $w_{j,t}^{i}$ is the weight of the j th pair of call and put volatility spread, $N_{i,t}$ is pairs of the options of the i th stock under the t th day, and $IV_{j,t}^{i}$ is implied volatility of the Black-Scholes [3] formula.

Table 1 shows that most of the implied volatility spread in each year and quantile are positive, which means that the option parity theory is apt to deviation when the call option is more expensive than the put option. This result is inconsistent with Cremers and Weinbaum [6], which presents that the deviation occurs more often when the put option is more expensive than the call option.

According to the implied volatility spread, we divide the stocks into three parts: the top 33% high VS_h portfolio, the bottom 33% low (VS_L) portfolio and the middle portfolio. We buy the stocks in the lowest 33% (VS_L) portfolio and sell the stocks in the highest 33% (VS_H) portfolio for K months to explore the profitability of the VS strategy.

Table 1: VS Basic statistics analysis

VS statistics (year)				
Year	**mean**	**Q1**	**Q2**	**Q3**
2010	-0.0040	-0.0081	-0.0026	0.0018
2011	0.0028	-0.0035	0.0027	0.0089
2012	0.0079	-0.0012	0.0069	0.0156
2013	0.0104	0.0071	0.0112	0.0153
2014	0.0127	0.0067	0.0125	0.0185
2015	0.0098	0.0065	0.0097	0.0151
2016	0.0032	0.0009	0.0045	0.0081
2017	0.0108	0.0046	0.0115	0.0175
average	0.0067	0.0016	0.0071	0.0126

If H_0 is rejected, there is an implied volatility spread strategy effect.

$$\begin{cases} H_0: VS_L - VS_H \leq 0 \\ H_1: VS_L - VS_H > 0 \end{cases} \tag{10}$$

Table 2 presents that the effect of the implied volatility spread strategy is not significant. Only 2 of the 15 investment portfolios have statistically significant values. This result is similar with Chen [7], which used the implied volatility spread to predict Taiwan stock return. The return of VS portfolio strategy have a tendency to gradually increase with the longer holding period (K). In the case of short-term holding period less than one year, the return is usually negative. The return on investment for holding period more than one year is positive. For example, in the forming period (J = 6), the strategy return varies from -0.33% to 1.25% in the holding period from K = 6 to K = 12. Therefore, the hidden volatility difference strategy is suitable for long-term investments over one year.

Table 2: Average monthly return of VS portfolio strategy

	K=1	**K=3**	**K=6**	**K=12**	**K=24**
J=1	-0.0012 (0.3844)	0.0023 (0.3710)	-0.0026 (0.3696)	-0.0033 (0.3800)	0.0083 (0.2907)
J=3	-0.0011 (0.3939)	0.0010 (0.4323)	-0.0016 (0.4105)	0.0105 (0.1281)	0.0129 (0.1916)

J=6	-0.0031 (0.2421)	-0.0026 (0.3418)	-0.0033 (0.3131)	0.0125* (0.0948)	0.0231* (0.0697)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

4.2 OS strategy

Following Johnson and So [12], we calculate the ratio of the options trading volume to the stock trading volume $(OS_{i,t})$ of individual stock i in month t as follows:

$$OS_{i,t} = \frac{OPVOL_{i,t}}{STVOL_{i,t}} \tag{11}$$

We use the OS ratio in formation period to divide the stocks into high (OS_H), low (OS_L) and middle portfolios. Because low (OS_L) company stocks perform better than high (OS_H) company stocks (Johnson and So, [12]), we establish the lowest 33%(OS_L) portfolio in long position, and the highest 33% (OS_H) portfolio in short position for K months to explore the profit of OS strategy. If H_0 is rejected, there is an O/S effect.

$$\begin{cases} H_0: OS_L - OS_H \leq 0 \\ H_1: OS_L - OS_H > 0 \end{cases}, \tag{12}$$

First, calculate the ratio of stock trading volume to option trading volume of a sample during the study period to obtain the OS value, and use the obtained OS value as the indicator basis for establishing the investment portfolio. The operating strategy is to buy the lowest OS value and sell the highest OS value. If it is positive return on investment and significant, it means that the OS strategy has a profitable effect.

According to Table 3, the OS strategy has a significant positive return in the holding period from K=3 to K=24, indicating that the OS strategy is more suitable for long-term investment in more than three months. That is, the longer the formation and holding period are associated with higher returns of OS strategies. Specifically, the highest return of 11.13% is happened in the formation (J=6) and holding (K=24) period. The results of the OS strategy in this study are similar to those of Johnson and So [12]. Option trading volume can predict future stock prices, and the effect is better than stock trading volume. The reason may be highly leveraged option profits to attract investors prefer trading in the options market.

Table 3: Average monthly return of OS portfolio strategy

	K=1	**K=3**	**K=6**	**K=12**	**K=24**
J=1	0.0034 (0.1987)	0.0143*** (0.0054)	0.0222*** (0.0001)	0.0490*** (0.0000)	0.0829*** (0.0000)
J=3	0.0049 (0.1109)	0.0183*** (0.0031)	0.0341*** (0.0000)	0.0613*** (0.0000)	0.1099*** (0.0000)
J=6	0.0061* (0.0670)	0.0185*** (0.0042)	0.0354*** (0.0000)	0.0634*** (0.0000)	0.1113*** (0.0000)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

4.3 52 week high strategy

According to George and Hwang [9], we use the closing price of each stock at time t divided by the highest closing price of the stock in the past 52 weeks as an investment anchor. The ratio $(H_{i,t})$ of the 52-week high is constructed as follow:

$$H_{i,t}\text{ratio} = \frac{P_{i,t}}{\text{high}_{i,t}} \tag{13}$$

Where: $P_{i,t}$ is the closing price of the i th stock in period t, and $\text{high}_{i,t}$ is the highest closing price of the i th stock in 52 weeks in period t.

Based on the closeness to the 52-week high, we divide the stocks into three parts. Then we long the portfolio in 33% of the stocks (H_H) close to the 52-week high, and short the portfolio in 33% of the stocks (H_L) far away from the 52-week high for K months to explore the profitability of 52-week high strategy. If H_0 is rejected, there is a 52-week high strategy effect.

$$\begin{cases} H_0: H_H - H_L \leq 0 \\ H_1: H_H - H_L > 0 \end{cases} \tag{14}$$

Table 4 presents that in the forming period (J=1, 3, 6), there is no significant positive return. The longer holding period is associated with the lower return. In the holding period from K=1 to 24, the profit of 52-week high strategy is getting lower and lower. For example, in the forming period (J=1) group, with the increasing holding period, the average return is from the highest -0.49% all the way to the lowest -5.2%. Thus, the 52-week high of the momentum strategy cannot be used to profit in the S&P100 market. On the contrary, we can use the opposite 52-week high strategy, which is to buy the portfolio far away from the 52-week high and sell the portfolio close to the 52-week high to obtain a positive return.

Table 4: Average monthly return of 52-week high portfolio strategy

	K=1	K=3	K=6	K=12	K=24
J=1	-0.0049 (0.1707)	-0.0099 (0.1004)	-0.0155* (0.0690)	-0.0391*** (0.0046)	-0.0520*** (0.0014)
J=3	-0.0047 (0.1848)	-0.0071 (0.1893)	-0.0130 (0.1221)	-0.0432*** (0.0028)	-0.0440*** (0.0079)
J=6	-0.0035 (0.2014)	-0.0101 (0.0762)	-0.0225 (0.0182)	0.0529* (0.0001)	0.0487* (0.0033)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

4.4 Contrarian investment strategy

According to the De Bondt and Thaler [8], we use the stock return in the forming period (J) to divide the stocks into a winner portfolio (R_w), which stock return is highest 33% and a loser portfolio (R_L), which stock return is lowest 33%. Then we buy the stocks in loser portfolio and sell the stocks in winner portfolio as a trading strategy for K months to explore the profit of contrarian investment strategy. If H_0 is rejected, there is a contrarian investment strategy effect.

$$\begin{cases} H_0: R_L - R_W \leq 0 \\ H_1: R_L - R_W > 0 \end{cases} \tag{15}$$

The contrary strategy uses the monthly return rate of individual stocks as the main target. The top 33% of the stocks with the best return rate are set as the winner portfolio, and the bad performing 33% is set as the loser portfolio.Beside, an investment strategy is established through the operation of buying losers and selling winners. If the positive returns are significant, it means that the reverse strategy has a profitable effect.

According to the Table 5, the average return of contrary portfolio strategy in the forming period J=3 and J=6 are all positive. The longer holding period and forming period are associated with the higher return. Specifically, the highest return (3.96%) is happened in the period (J=6, K=24).

The result is consistent with De Bondt and Thaler [8]**.**The reason may be that the stocks in the winner portfolio are overvalued and the stocks in the loser portfolio are undervalued. Thus, buying those undervalued stocks in the loser portfolio and selling those overvalued stocks in the winner portfolio can make profit. We infer that there is no momentum effect in the S&P100 market.

Table 5: Average monthly return of contrary portfolio strategy

	K=1	K=3	K=6	K=12	K=24
J=1	0.0003 (0.4677)	0.0020 (0.3842)	-0.0002 (0.4915)	0.0091 (0.2490)	-0.0012 (0.4724)
J=3	0.0018 (0.3576)	0.0089 (0.1199)	0.0119 (0.1154)	0.0183 (0.1020)	0.0259* (0.0834)
J=6	0.0027 (0.2572)	0.0085* (0.0562)	0.0138** (0.0490)	0.0307** (0.0144)	0.0396*** (0.0086)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

4.5 Two-dimensional VS & OS strategy

If H_0 is rejected, it means that the implied volatility spread with OS two-dimensional strategy can be profitable.

$$\begin{cases} H_0: VS_L OS_L - VS_H OS_H \leq 0 \\ H_1: VS_L OS_L - VS_H OS_H > 0 \end{cases} \tag{16}$$

According to Table 6, the combination of implied volatility spread & OS strategy improves the poor profitability in the short holding period and retains the one-dimensional strategy characteristics of implied volatility spread strategy. That is, there are significant positive returns in holding period of more than one year. In the formation period (J=3), the strategy effect is the best. For example, in the holding period (K=24) and the forming period (J=3), the average return (11.53%) is higher than that in the forming period (J=1, or 6). In sum, the overall significant value and profitability in two-dimensional VS & OS strategy are better than those in one-dimensional implied volatility spread strategy.

4.6 Two-dimensional VS & 52-Week high strategy

If H_0 is rejected, it means that the implied volatility spread with 52-week high two-dimensional strategy can be profitable.

$$\begin{cases} H_0: VS_L H_L - VS_H H_H \leq 0 \\ H_1: VS_L H_L - VS_H H_H > 0 \end{cases} \tag{17}$$

Table 6: Average monthly return of VS & OS two-dimensional portfolio strategy

	K=1	K=3	K=6	K=12	K=24
J=1	0.0026 (0.2054)	0.0206** (0.0289)	0.0258*** (0.0096)	0.0642*** (0.0001)	0.1078*** (0.0000)
J=3	0.0066* (0.0529)	0.0139** (0.0492)	0.0202** (0.0409)	0.0703*** (0.0001)	0.1153*** (0.0000)
J=6	0.0038 (0.1989)	0.0083 (0.1609)	0.0101 (0.1646)	0.0502*** (0.0031)	0.1045*** (0.0000)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

Because the above result shows that there does not exist 52-week momentum effect, we use the 52-week high and contrarian investment strategy. Table 7 presents that the combination of the implied volatility spread and the contrarian 52-week high contrarian strategy can improve the poor performance in the early holding period and retain the characteristics of the implied volatility spread strategy. When the holding period is more than one year (K=12, or 24), there is a significant positive return, and the return is higher than the one-dimensional implied volatility spread strategy. In addition, the highest return (6.08%) is happened in the period (J=6, K=24).

Table 7: Average monthly return of VS & contrary 52-week high two-dimensional portfolio strategy

	K=1	K=3	K=6	K=12	K=24
J=1	0.0067 (0.1104)	0.0136 (0.1327)	0.0212* (0.0536)	0.0364** (0.0258)	0.0321* (0.0969)
J=3	0.0008 (0.4466)	0.0085 (0.1960)	0.0209* (0.0586)	0.0598*** (0.0050)	0.0552** (0.0285)
J=6	0.0025 (0.3379)	0.0103 (0.1194)	0.0137 (0.1693)	0.0549*** (0.0048)	0.0608** (0.0279)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

4.7 Two-dimensional VS & Contrary investment strategy

If H_0 is rejected, it means that the implied volatility spread with contrary investment two-dimensional strategy can be profitable.

$$H_0: VS_L R_L - VS_H R_W \leq 0$$
$$H_1: VS_L R_L - VS_H R_W > 0 \quad (18)$$

According to Table 8, the performance of implied volatility spread combined with the contrarian strategy is the better when the longer forming period and holding period. One-year holding period (K=12) is the best time for this strategy. In the forming period (J=6) and the holding period (K=12), the average return (3.62%) is the best. The overall profit is better than the one-dimensional strategy of implied volatility spread. However, the significant values are very poor, and higher in a longer period of time.

Table 8: Average monthly return of VS & contrary two-dimensional portfolio strategy

	K=1	**K=3**	**K=6**	**K=12**	**K=24**
J=1	0.0040 (0.2136)	0.0134 (0.1355)	0.0107 (0.2097)	0.0118 (0.2421)	0.0087 (0.3488)
J=3	-0.0010 (0.4279)	0.0071 (0.2313)	0.0132 (0.1816)	0.0222 (0.1074)	0.0164 (0.2743)
J=6	0.0019 (0.3791)	0.0099 (0.1460)	0.0223** (0.0398)	0.0362** (0.0172)	0.0355* (0.0784)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

4.8 Comparison of one-dimensional investment strategies

We focus on the implied volatility spread strategy and compare with OS, 52-week high, and contrarian strategies. If the average return of the implied volatility spread strategy minus the average return of other one-dimensional strategies is positive with significant value, it means that the effect of the implicit volatility spread strategy has more advantages than other strategy.

If H_0 is rejected, the performance of implied volatility spread strategy is higher than OS strategy.

$$\begin{cases} H_0: (VS_L - VS_H) - (OS_L - OS_H) \leq 0 \\ H_1: (VS_L - VS_H) - (OS_L - OS_H) > 0 \end{cases} \quad (19)$$

If H_0 is rejected, the performance of implied volatility spread strategy is higher than 52-week high strategy.

$$\begin{cases} H_0: (VS_L - VS_H) - (H_H - H_L) \leq 0 \\ H_1: (VS_L - VS_H) - (H_H - H_L) > 0 \end{cases} \quad (20)$$

If H_0 is rejected, the performance of implied volatility spread strategy is higher than contrarian strategy.

$$\begin{cases} H_0: (RVS_L - RVS_H) - (R_L - R_W) \leq 0 \\ H_1: (RVS_L - RVS_H) - (R_L - R_W) > 0 \end{cases} \quad (21)$$

Table 9 presents the comparison of performance between one-dimensional investment strategies. Panel A shows the comparison of the investment effects of the implied volatility spread strategy to the OS Strategy. Among the 15 situations, 12 groups are significantly negative. Thus, we can reject hypothesis 1(a), indicating that the performance of implied volatility spread strategy is lower than the OS strategy. Basically, the longer the holding period, the larger the return on investment difference, especially in the holding periods of more than one year. In the forming period (J=3) and the holding period (K=24), there exists a maximum average return difference of -9.7%.

Panel B shows the comparison of investment performance between the implied volatility spread strategy and the 52-week high strategy. In the holding period more than one year (K=12 or 24), the difference of return is significantly positive, indicating that hypothesis 1(b) is supported. That is, after one year of holding period, the performance of implied volatility spread strategy is higher than the 52-week high strategy. In addition, the average return increases with the longer holding period. The maximum average return difference (7.18%) is happened in the formation period (J=6) and the holding period (K=24).

Panel C shows the comparison of investment effects between implied volatility spread strategies and contrarian strategies. In the formation period (J=6) and the holding period (K=3 or 6), the difference is significantly negative, indicating that hypotheses 1(c) are rejected. In other situations, the differences are insignificantly negative. Thus, the effect of the implied volatility spread strategy is inferior to the contrarian strategy.

Therefore, the performance of implied volatility spread investment strategy is not as good as expected. The implied volatility spread strategy is inferior to other strategies except for the 52-week high momentum strategy. The effect of one-dimensional strategy from good to bad is OS, contrarian, implied volatility spread, and 52-week high strategy.

Table 9: Comparison of one-dimensional investment strategies

Panel A: VS and OS strategy comparison

	K=1	K=3	K=6	K=12	K=24
J=1	-0.0046 (0.2661)	-0.0121* (0.0857)	-0.0248*** (0.0039)	-0.0523*** (0.0001)	-0.0746*** (0.0001)
J=3	-0.0060 (0.2063)	-0.0174** (0.0443)	-0.0357*** (0.0011)	-0.0509*** (0.0000)	0.0129 (0.0000)
J=6	-0.0092 (0.1179)	-0.0210** (0.0216)	-0.0387*** (0.0002)	-0.0509*** (0.0000)	-0.0882*** (0.0000)

Panel B: VS and 52-week high strategy comparison

	K=1	K=3	K=6	K=12	K=24
J=1	0.0037 (0.2788)	0.0122 (0.1070)	0.0129 (0.1723)	0.0358** (0.0335)	0.0603*** (0.0099)
J=3	0.0036 (0.2869)	0.0081 (0.2274)	0.0113 (0.2311)	0.0537*** (0.0043)	0.0569** (0.0235)
J=6	0.0004 (0.4781)	0.0076 (0.2517)	0.0192 (0.1019)	0.0653*** (0.0003)	0.0718*** (0.0080)

Panel C: VS and contrary strategy comparison

	K=1	K=3	K=6	K=12	K=24
J=1	-0.0015 (0.3638)	0.0003 (0.4871)	-0.0024 (0.4145)	-0.0124 (0.2500)	-0.0095 (0.3429)
J=3	-0.0030 (0.3436)	-0.0080 (0.2085)	-0.0136 (0.1241)	-0.0078 (0.3324)	-0.0130 (0.2777)
J=6	-0.0058 (0.1464)	-0.0111* (0.0606)	-0.0171** (0.0333)	-0.0183 (0.1491)	-0.0165 (0.1983)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

4.9 Comparison of two-dimensional investment strategies

In this section, we combine implied volatility spread with OS, contrarian 52-week high, and contrarian investment one-dimensional strategies into two-dimensional strategies respectively. We use the average return of the two-dimensional strategy with implied volatility spread to minus the average return of the one-dimensional strategy with implied volatility spread to examine whether the performance of two-dimensional implied volatility spread strategy is higher than the one-dimensional strategy.

If H_0 is rejected, the performance of implied volatility spread strategy with OS is higher than VS strategy.

$$\begin{cases} H_0: (VS_L OS_L - VS_H OS_H) - (VS_L - VS_H) \leq 0 \\ H_1: (VS_L OS_L - VS_H OS_H) - (VS_L - VS_H) > 0 \end{cases} \quad (22)$$

If H_0 is rejected, the performance of implied volatility spread strategy with 52-week high is higher than VS strategy.

$$\begin{cases} H_0: (VS_L H_L - VS_H H_H) - (VS_L - VS_H) \leq 0 \\ H_1: (VS_L H_L - VS_H H_H) - (VS_L - VS_H) > 0 \end{cases} \quad (23)$$

If H_0 is rejected, the performance of implied volatility spread strategy with contrarian is higher than VS strategy.

$$\begin{cases} H_0: (VS_L R_L - VS_H R_W) - (VS_L - VS_H) \leq 0 \\ H_1: (VS_L R_L - VS_H R_W) - (VS_L - VS_H) > 0 \end{cases} \quad (24)$$

Table 10 presents the comparison of performance between two-dimensional and one-dimensional investment strategies. According to Panel A, the difference of return is almost significantly positive, indicating that hypothesis 2(a) is accepted. Implied volatility spread & OS two-dimensional strategy is better than implied volatility spread one-dimensional strategy. The difference of average return increases with the longer the holding period. In the forming period (J=3) and the holding period (K=24), there exists a maximum average return difference of 10.24%. Panel B shows that the difference of return are all positive (10 of 15 situations significantly). Thus, we can accept hypothesis 2(b), indicating that the implied volatility spread & contrarian 52-week high two-dimensional strategy is better than implied volatility spread one-dimensional strategy. It is worth noting that the performance of implied volatility & contrarian 52-week high two-dimensional strategy is the best in the holding period (K=12). In the forming period (J=3) and the holding period (K=12), there exists a maximum average return difference of 4.39%.

According to Panel C, among the 15 situations, the differences of return are significantly positive only in 4 situations. Thus, we can accept hypothesis 2(c) mainly in forming period (J=6). We have a maximum average return difference of 2.56% in the forming period (J=6) and the holding period (K=6).

Thus, the performance of three two-dimensional implied volatility spread strategies are better than one-dimensional implied volatility spread strategies in all situations. The empirical results are in line with the hypotheses that the implied volatility spread combined with other strategies to form a two-dimensional strategy is better than the original one-dimensional implied volatility spread strategy.

Table 10: Comparison of two-dimensional investment strategies

Panel A: VS&OS two-dimensional and VS strategy comparison

	K=1	K=3	K=6	K=12	K=24
J=1	0.0038 (0.2006)	0.0183** (0.0335)	0.0283*** (0.0040)	0.0675*** (0.0000)	0.0995*** (0.0000)
J=3	0.0078** (0.0428)	0.0129** (0.0274)	0.0219*** (0.0049)	0.0625*** (0.0000)	0.1024*** (0.0000)
J=6	0.0069* (0.0658)	0.0108** (0.0495)	0.0135** (0.0344)	0.0377*** (0.0029)	0.0814*** (0.0000)

Panel B:VS&contrary 52-week high two-dimensional and VS strategy comparison

	K=1	K=3	K=6	K=12	K=24
J=1	0.0079* (0.0630)	0.0114 (0.1454)	0.0238** (0.0263)	0.0397** (0.0154)	0.0238 (0.1411)
J=3	0.0020 (0.3549)	0.0075 (0.1596)	0.0225** (0.0163)	0.0439*** (0.0041)	0.0423** (0.0185)
J=6	0.0057 (0.1409)	0.0156** (0.0289)	0.0171* (0.0591)	0.0425*** (0.0061)	0.0377** (0.0364)

Panel C: VS & contrary two-dimensional and VS strategy comparison

	K=1	K=3	K=6	K=12	K=24
J=1	0.0052 (0.1233)	0.0111 (0.1269)	0.0132 (0.1122)	0.0151 (0.1454)	0.0004 (0.4930)
J=3	0.0001 (0.4896)	0.0062 (0.2166)	0.0149* (0.0833)	0.0117 (0.2374)	0.0034 (0.4393)
J=6	0.0050 (0.1872)	0.0124** (0.0411)	0.0256*** (0.0044)	0.0238* (0.0757)	0.0123 (0.2629)

Note: The number in parentheses is p-value. ***, **, * denote significant at 1%, 5%, 10% level.

5. Conclusion

This paper mainly uses the implied volatility spread VS of options mentioned in Cremers and Weinbaum [6] to discuss whether the implied volatility spread of options can be used to establish investment strategies. We compare the performance of implied volatility spread strategy with other traditional strategies to explore which strategy is better. The S&P100 constituent stocks are our sample, and the difference between the implied volatility of call option and the implicit volatility of put option are used to construct the implied volatility spread strategy.

We find that under the VS strategy in the S&P100 market, we have to hold more than one year to get a positive return. Otherwise, the performance of VS strategy less than one year is negative. The profit of OS strategy is better in the longer forming period and the longer holding period, especially for holding more than one year. Comparing the 52-week high momentum to the contrarian investment strategy effect, we find that there is no momentum effect in the S&P100 market. Therefore, we use the contrarian strategy, which is to buy those undervalued stocks and sell those overvalued stocks. Two-dimensional strategy, which is composed of VS strategy combined the other strategies, can improve the poor short-term return effect in the original VS one-dimensional strategy. In addition, the performance of VS strategy combined with the contrarian 52-week high and contrarian investment strategy is the best in the holding period (K=12). Nonetheless, after the holding period increases (K=24), the return has a decreasing trend.

The performance of the VS strategy is not good because the return is negative in short holding periods. Although it turns positive as the holding period increases, return is still smaller than other strategies. The performance of VS strategy is only better than the momentum 52-week high strategy. The performances of three two-dimensional VS strategies are better than the original one-dimensional VS strategies. Therefore, the implied volatility spread combined with other strategies to form a two-dimensional strategy is better than the original one-dimensional implied volatility spread strategy.

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