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The Information Content of Implied Volatility Skew: Evidence on Taiwan Stock Index Options

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Abstract. *Inspired by the intraday calibration result of Shifted Speculation Model on the implied volatility skew of Taiwan stock index option, eg. volatility asymmetry in option quote and hint on market prediction. Our findings suggest that major traders of Taiwan stock index options, at least a part of them, are rational speculators and individual traders should utilize the intraday change of the implied volatility skew for their trading decisions.*

Keywords: Volatility skew; speculation; volatility asymmetr; market prediction.

1. **Introduction.** Information embodied in the stock options, if it exists, will be very useful to market prediction, a practical issue in the research on investment, and to controversy on the Efficient Market Hypothesis (EMH), an academic issue concerning the possibility of "beat the market." The related research can be divided into two branches: one branch is "information share approach," proposed in [12] and applied on the price discovery of the individual stock option in [6]. They used three variables, i.e. leverage, trading volume and bid-ask spread, to search the information about stocks and got a good result, but fail on the information about the whole stock market; The other branch is the "stealth trading hypothesis", proposed in [3], followed by Chakravarty [5], and [1], which investigates the price discovery process of the option through the large traders' trade size choice. However, both branches have supported the price discovery of individual stock option, but not of the stock index option.

Information also embodies in the options across their strike prices, results in so-called "volatility smile" in stock options or so-called "volatility skew" in stock index options. The related research can be divided into three areas. First, the negative skew/smile, suggested by [13] after observing the 1987 Crash, implies higher implied volatility for out-of-the money puts, the deeper the higher. This crashaphobia pushes the price of puts higher compared to that of calls. Supportive evidences are provided by [4] and [10]. Second, some studies, e.g. [1], [9], and [7], suggest that there are additional risk premiums of jump and stochastic volatility inside the options. Finally, [7] provides a quote method useful for option traders who consider the price and the volatility at the same time. Their pricing formulae of option are derived from the flexible hedging approach, not the well-known dynamic hedging one in Black-Scholes model, to fit the volatility skew as good as the SABR model of [9]. The flexible hedging approach implies that the options are not used for hedging all the time, never mention for managing risks, and then its application will be limited to trades in practical. However, [7] just verify the feasibility of their models and the related empirical work is lack.

Since their model are designed for rational speculators to quote option premium with their anticipated future price and volatility, if their model can be fitted to the implied volatility skew well, we can investigate the information embodying in the option market. Then we make sure of the use of options for speculation, not limited for hedge, and this rejects the consensus on the role of the option in financial market.

The rest of this paper is arranged as follows. First, we introduce the methodoloy of this study in the Section 2. Then we describe our empirical results in the Section 3. Finally we have the conclusion in Section 4.

2. **Methodology.** we use the implied volatility curve of stock index options to be calibrated with the option pricing formula in Shift Speculation Model in Chen, Tsai and Chiu [7], which is able to including the trader's perceived future price and future volatility, to see whether the calibrated result could lead the price change of the stock index futures. For introducing the implementation, we rewrite their pricing formula of calls and puts as follows:

$$C(\bar{F}_0, \sigma, \lambda | F_t, K, T, r_f) = \frac{B_0^T}{\lambda}[F^* N(d_1) - K^* N(d_2)], \tag{1}$$

$$P(\bar{F}_0, \sigma, \lambda | F_t, K, T, r_f) = \frac{B_0^T}{\lambda}[F^* N(-d_2) - K^* N(-d_1)], \tag{2}$$

where

$$F^* = \lambda F_t + (1-\lambda)\bar{F}_0; K^* = \lambda K + (1-\lambda)\bar{F}_0, \tag{3}$$

$$d_1 = \frac{ln(\frac{F^*}{K^*}) + \frac{1}{2}(\lambda\sigma)^2 T}{\lambda\sigma\sqrt{T}}, \tag{4}$$

$$d_2 = \frac{ln(\frac{F^*}{K^*}) - \frac{1}{2}(\lambda\sigma)^2 T}{\lambda\sigma\sqrt{T}}. \tag{5}$$

As the notation used in textbooks, K, T, r_f represent the strike price, date of maturity and the risk-free rate. B_0^T is the discount factor derived from the risk-free rate and F_t is the stock index futures price at date t. The premiums of calls and puts, notated as $C(.)$ and $P(.)$, are gotten from the real-time data and used to calibrated out the $\bar{F}_0$, σ and λ with the optimization procedure of GRG nonlinear solver on a series of out-of-the money options, including four puts and three calls, with different Ks. the calibrated $\bar{F}_0$ and σ every 5 minute represent the option trader's perceived future price and volatility respectively. λ represents the trade-off among these traders with different strike prices. In other words, λ is influenced by the whole market participants' interaction.

At normal time, the series of out-of-the money options at the same near month contracts, composing the implied volatility curve, have the well-known pattern, i.e. so-called volatility skew, describing the negative relation of calibrated σs with Black-Scholes model and the corresponding s. If we could fit this curve well with the above model, then we can pricing exotic options by the similar approach of extending the Black-Scholes model. However, this is not the focus of this study. The goal of this study is to investigate the information content of skewed implied volatility curve. After each calibration, if the correlation between $\bar{F_0}$ and σ is negative, then we can say that the option traders quote after considering the styled fact: volatility asymmetry. And we also hope to find whether the $\bar{F_0}s$ can lead to the F_ts.

We use DDE to receive the real-time data of TX and TXOs for calibrating SSM, but unfortunately we can't have enough data to run any statistical test. The computing loading of calibrating every one minute is to hard to bear, not to mention the coming of fast market. The frequency of 5 minute will result in only 60 samples each day because that the trading hours of Taiwan option market are only 5. However, ignoring the issue of sample size and focusing on the financial intuition, no rational speculator will manipulate the price of TX for her/his profit of TXO position all the time. Hence we implement explanatory data analysis in the following section.

3. **Empirical Analysis.** The price and volumn of TX in the representative day is presented in Figure 1. We can easily see that the direction of TX is downward before 10:00 am and then goes up until the end of trading hours. The corresponding calibration of SSM with TXO data, applying equation 1, is presented in Table 1. Our findings have two folds. One is about the volatility aymmetry. The correlation between the future price $\bar{F_0}$ and the future volatility σ is -0.89923. This coincides with the styled fact of stock market: when the market goes up, its volatility decreases; when the market goes down, its volatility increases. This implies that the option traders may quote premium with considering the feature of volatility. The other is to display the predictability of SSM. We denote the direction indicated by SSM as "neutral" when deviation between the future price $\bar{F_0}$ and the futures price F_t (the close price of TX) is less than 10 points. If $\bar{F_0}$ is higher than the level of F_t plus 10, the direction is denoted as "Up"; when it is lower than the level of F_t minus 10, the direction is denoted as "Down". The result of calibration suggests that the direction of F_t should be downward until 9:50, but we can make sure of it after 9:55. Then it displays the transition until 10:25. Finally, it suggests the direction should be upward until the close of market. In general, the implication provided by the calibration, though in the form of explanatory data analysis, has a good practical contribution to day traders. Meanwhile, it provides an evidence that volatility skew may have some kind of information about market direction.

4. **Conclusion.** If options are used by major traders for speculation, not the well-known hedge, then their position of options will have some useful information for individual traders. In this study we verify that intraday option traders are rational because that they quote with considering the similar phenomenon in the underlying asset: volatility asymmetry. Then, the calibration result of Shifted Speculation Model could suggest market direction, implying that the changing of volatility skew should have some information about these rational speculators. In sum, the function of the option should not be limited in hedge, as proposed in Nobel Laurel Black-Scholes Model; speculation with options should not be underestimated.

REFERENCES

[1] A. Anand and S. Chakravarty, "Stealth trading in options markets," *Journal of Financial and Quantitative Analysis*, vol. 42(1), pp. 167–187, 2007.

[2] G. Bakshi, C. Cao, and Z. Chen, "Empirical performance of alternative option pricing models," *The Journal of Finance*, vol. 52(5), pp. 2003–2049, 1997.

[3] M. Barclay and J. B. Warner, "Stealth trading and volatility: which trades move prices," *Journal of Financial Economics*, vol. 34(3), pp. 281–305, 1993.

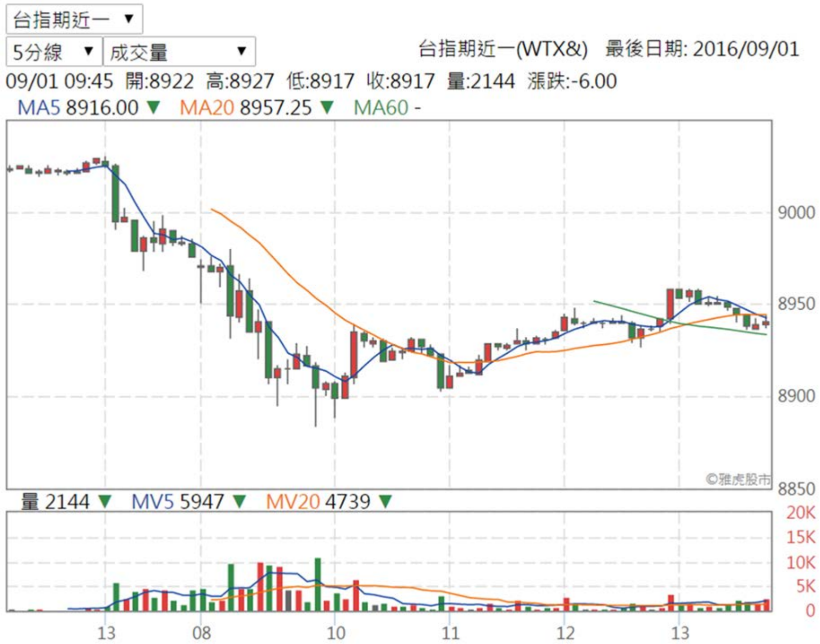

Figure 1. The 5-minute price and volumn of TX is displayed in two separated panels. The meaning of red and green sticks in Taiwan is contrasted to that of the international convention. Source: https://tw.futures.finance.yahoo.com.

[4] N. P. Bollen and R. E. Whaley, "Does net buying pressure affect the shape of implied volatility functions?," *The Journal of Finance*, vol. 59(2), pp 711–753, 2004.

[5] S. Chakravarty, "Stealth-trading: Which traders' trades move stock prices?," *Journal of Financial Economics*, vol. 61(2), pp. 289–307, 2001.

[6] S. Chakravarty, H. Gulen, and S. Mayhew, "Informed trading in stock and option markets," *The Journal of Finance*, vol. 59(3), pp. 1235–1257, 2004.

[7] S. N. Chen, H. H. Tsai, and C. C. Chiu, "Explaining the implied volatility skew from the rational speculation perspective: Calibration on the Taiwan stock index option market," *Journal of Futures and Options*, vol. 3(2), pp. 1–33, 2010.

[8] J. Conrad, R. F. Dittmar, and E. Ghysels, "Ex ante skewness and expected stock returns," *The Journal of Finance*, vol. 68(1), pp. 85–124, 2013.

[9] J. S. Doran, D. R. Peterson, and B. C. Tarrant, "Is there information in the volatility skew?," *Journal of Futures Markets*, vol. 27(10), pp. 921–959, 2007.

[10] N. Garleanu, L. H. Pedersen, and A. M. Poteshman, "Demand-based option pricing," *Review of Financial Studies*, vol. 22(10), pp. 4259–4299, 2009.

[11] P. S. Hagan, D. Kumar, A. S. Lesniewski, and D. E. Woodward, "Managing smile risk," *Wilmott*, vol. 1, pp. 84–108, 2002.

[12] J. Hasbrouck, "One security, many markets: Determining the contributions to price discovery," *The journal of Finance*, vol. 50(4), pp. 1175–1199, 1995.

[13] M. Rubinstein, "Implied binomial trees," *The Journal of Finance*, vol. 49(3), pp. 771–818, 1994.

TABLE 1. The calibration results of $\bar{F}_0$ and σ in SSM on the volatility skew of TXO and the close price of TX, represented by C_TX are displayed every 5 minutes. The column of Direction is the forecast on TX with the data derived from $\bar{F}_0$. When $\bar{F}_0$ is higher than the level of TX plus 10, the direction is denoted as "Up"; when it is lower than the level of TX minus 10, the direction is denoted as "Down". The rest is denoted as "Neutral".

Time	**C_TX**	F_0	σ	**Direction**	**Time**	**C_TX**	F_0	σ	**Direction**
8:55	8968	8894.28	12.99	Down	11:20	8928	8984.31	12.81	Up
9:00	8971	8897.15	12.96	Down	11:25	8926	8973.69	12.78	Up
9:04	8947	8860.88	13.24	Down	11:29	8928	8991.39	12.81	Up
9:10	8956	8901.93	13.08	Down	11:35	8932	9007.03	12.68	Up
9:14	8941	8897.55	13.08	Down	11:40	8929	9007.10	12.67	Up
9:20	8945	8853.24	13.09	Down	11:44	8931	9014.13	12.70	Up
9:24	8913	8857.93	13.19	Down	11:49	8929	9006.74	12.73	Up
9:30	8915	8876.17	13.02	Down	11:55	8936	9010.80	12.72	Up
9:35	8917	8861.22	13.11	Down	11:59	8941	9027.10	12.72	Up
9:40	8922	8903.85	12.89	Down	12:05	8940	9036.59	12.68	Up
9:45	8919	8881.88	12.92	Down	12:09	8939	9037.43	12.67	Up
9:49	**8907**	**8851.85**	**13.18**	**Down**	12:15	8940	9043.41	12.68	Up
9:55	8906	8896.59	12.87	Neutral	12:20	8940	9046.60	12.70	Up
10:00	8904	8888.31	13.06	Down	12:25	8940	9051.24	12.71	Up
10:05	8910	8908.88	13.00	Neutral	12:29	8942	9056.47	12.70	Up
10:08	8922	8912.61	12.88	Neutral	12:34	8933	9053.13	12.79	Up
10:15	8928	8904.95	12.83	Down	12:39	8936	9042.32	12.83	Up
10:19	8929	8936.67	12.79	Neutral	12:45	8936	9059.22	12.76	Up
10:24	**8920**	**8947.28**	**12.83**	**Up**	12:50	8941	9060.58	12.69	Up
10:30	8925	8947.50	12.82	Up	12:54	8956	9079.09	12.68	Up
10:34	8926	8925.49	12.90	Neutral	13:00	8953	9086.40	12.60	Up
10:40	8930	8947.11	12.93	Up	13:05	8957	9085.83	12.56	Up
10:44	8926	8952.13	12.99	Up	13:10	8951	9085.48	12.59	Up
10:50	8922	8955.47	12.91	Up	13:15	8951	9095.82	12.56	Up
10:55	8906	8942.92	12.93	Up	13:19	8951	9093.29	12.65	Up
10:59	8910	8951.50	12.95	Up	13:24	8947	9102.01	12.63	Up
11:04	8913	8957.59	13.01	Up	13:30	8946	9098.74	12.63	Up
11:10	8912	8974.22	12.95	Up	13:35	8937	9091.16	12.69	Up
11:14	8920	8965.68	12.88	Up	13:40	8939	9103.18	12.64	Up
					13:44	8943	9109.09	12.71	Up

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