Observations on Market Expectations Behaviour in Taiwan Stock Markets

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Abstract

This study adopts derivative pricing as an indicator of market expectations, with those results suggesting that general investors can use market expectations to predict the final settlement value of underlying assets. Most investment textbooks note that one of the major functions of futures is price discovery. Similarly, the implied volatility associated with option prices can be used to discover the volatility of the underlying asset. This study combines futures price and implied volatility to establish a probability space of market expectations regarding the final settlement value of the underlying asset, and verifies this probability space using empirical data from the Taiwan stock market. The verification results suggest that market expectations closely reflect the actual behavior of the final settlement value of the underlying asset, and thus provide a practical perspective on future price behavior. According to this study, investors can easily estimate underlying asset behavior based on the behavior of the related futures and options and without incurring significant measurement error, which can be helpful in risk management and planning investment strategies.

Keywords: forecasting, market expectation, implied volatility, futures, probability space.

1. Introduction

Most financial texts confer that the futures markets aggregate diverse information and expectations regarding the future prices of underlying assets, and thus provide a common reference price which is known as the price discovery function of futures.

Similar to futures markets, options markets may also provide a common reference of subsequent real volatility (RV) by calculating the implied volatilities (IV). For example, Lantane and Rendleman (1976) found that actual option valuations were better explained by actual volatility over the life of the contract than by historical volatility. However, some studies have found that IV is a poor method of forecasting subsequent RV, while other studies have found that IV is a good method of forecasting RV. For example, Canina and Figlewski (1993) found virtually no relation between the IV and subsequent RV throughout the remaining life of S&P 100 index options before maturity date. On the contrary, Fleming (1998) examined the performance of the implied volatility of the S&P 100 for forecasting future stock market volatility, and found that although IV has an upward bias but it contains relevant information regarding future volatility.

Although the volatility discovery function of options yields mixed results, the mutual influences between options and futures cannot be ignored where futures and options contracts exist for the same underlying asset. Put-call parity is a strong arbitrage relation, first identified by Stoll (1969), that exists between the prices of European put and call options that share same underlying asset with the same strike and expiry, and the combination of options can create positions that are equivalent to holding the underlying itself. However, in real world scenarios it is difficult to duplicate a stock index with limited stock positions but such an index can be easily duplicated using the related futures. Thus, this study examines futures and options prices of the Taiwan Stock Exchange Capitalization Weighted Stock Index and finds that the market expectations can display the real final settlement value via a nearly normal distribution in which the mean equals the futures price and the standard deviation equals the implied volatility.

2. Empirical Test of Market Expectations

This section outlines the verification procedure and results of testing the accuracy of market expectations formed by FP and IV. The notations used in this study are as follows:

Table 1: Notations List

C = Call Price
P = Put Price
σ = Volatility
r = Interest Rate
S = Spot Price
K = Exercise Price
T = Time to Maturity in years
t = Time to Maturity in days
$N()$ = Cumulative Standard Normal Distribution Function
$Nd(\mu,\sigma)$ = Normal Distribution Function with mean of μ and standard deviation of σ
IV = Implied Volatility, annual
V_t = Implied Volatility over t days.

FP = Futures Price *SP* = Final Settlement value

The first step in generating a market expectation probability space is calculating the implied volatilities. Most studies on the observed market prices of various options based on a single underlying asset estimated the volatility using at-the-money or near-the-money options since these instruments are more sensitive to volatility changes and least susceptible to the influence of the bid-ask spread (Whaley,1982). Notably, Beckers (1981), Wiggins (1987) and Canina and Figlewski (1993) indicated that near-the-money options are better predictors of future real volatility than IVs of deep in or out of the money options. Thus, this study uses only the daily close price of near-the-money nearby options contracts with the same underlying asset of the same strike and expiry for verification.

According to the Black-Scholes model, the call price C and put price P of a European option can be calculated as follows:

$$C = SN(d_1) - Ke^{-rT}N(d_2) \tag{3.1}$$

$$P = Ke^{-rT}N(-d_2) - SN(-d_1) \tag{3.2}$$

$$d_1 = \frac{\ln(\frac{S}{K}) + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \tag{3.3}$$

$$d_2 = \frac{\ln(\frac{S}{K}) + (r - \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \tag{3.4}$$

This study modified the method used to calculate implied volatility to yield an unbiased probability space. Traditionally, calculating an implied volatility (IV) requires solving (3.1) or (3.2) repeatedly using different trial values for the volatility input. However, the derived IV of a call option (3.1) rarely equals the value obtained from a put option (3.2) with the same exercise price, and thus most IV related studies only consider call or put options. However, with the relationship indicated by put-call parity, the FP, C and P of the same underlying with the same strike and expiry are tightly coupled, and a slight change in the price of one will immediately affect the price of the other two. Thus, to verify the possibility space created by FP and IV, this study combined put and call IVs to yield a single value IV, i.e., the union IV (IV_u). Combining (3.1) and (3.2) can solve IV_u using the following formula:

$$C + P = SN(d_1) - Ke^{-rT}N(d_2) + Ke^{-rT}N(-d_2) - SN(-d_1) \tag{3.5}$$

Let $O_c = \{C_1, C_2, ..., C_n\}$ denote the historical near-the-money call option prices in time interval I, while $O_p = \{P_1, P_2, ..., P_n\}$ represents the historical near-the-money put options prices in I and $F = \{FP_1, FP_2, ..., FP_n\}$ is the futures prices in I. For the i^{th} historical data in I, (C_i, P_i, FP_i) is used to generate the i^{th} sampling distribution space and the actual final settlement value of (C_i, P_i) is SP_i.

Considering the i^{th} historical data in I, substituting C_i and P_i into (3.5), the annual IV_u of the i^{th} day in I can be solved. Let $V = \{V_1, V_2, ..., V_n\}$ denote the IV_u in I. Furthermore, transfer the annual IV_u into the same scale as days to mature, and let v_t denote the union implied volatility of t days to mature:

$$v_t = \sqrt{\frac{t \times V_i^2}{365}} \tag{3.6}$$

Assume that SP_i and FP_i are the relative final settlement value and future price of the i^{th} historical data in I, then the actual SP is located at d_i standard deviations of an $Nd(\mu,\sigma) = N(FP_i, v_t)$ distribution space:

$$d_i = \frac{\ln(\frac{SP_i}{FP_i})}{v_t} \tag{3.7}$$

Thus, for each historical record in I a d_i can be calculated, and collectively these d_i form a sampling space of standard deviations $D = \{d_1, d_2, ..., d_n\}$. If the final settlement value follows the distribution of $N_d(\mu,\sigma) = N_d(FP_i, v_t)$ as expected by the market, the distribution of D will be a standard normal distribution, $N_d(\mu,\sigma) = N_d(0, 1)$.

2.1. Observations on Low Frequency Samples

To confirm the accuracy of the market expectations of (FP, IV), this study uses the option and futures prices of the Taiwan Stock Exchange Capitalization Weighted Stock Index (TX) from 24/12/2001 to 30/12/2005 to test the results, I=[24/12/2001,30/12/2005]. The index values of TX in I are demonstrated as Figure2.

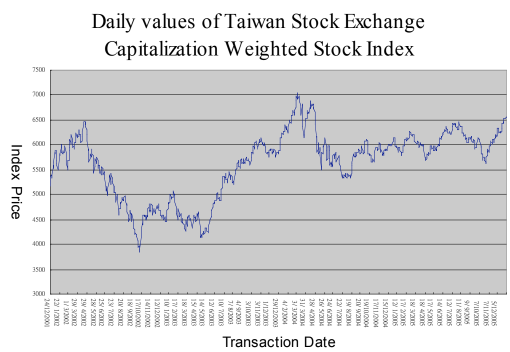

Fig. 1 Stock index values in I.

The risk-less interest rate r applied in this study is the monthly fixed deposit interest rate adopted by the Central Bank of Taiwan. The calculation results of D are collected in Figure 2.for comparison with the normal distribution $N_d(0, 1)$, and the mean, standard deviation, skewness and kurtosis of D are 0.0163, 1.1109, -0.2920 and 3.4500, respectively.

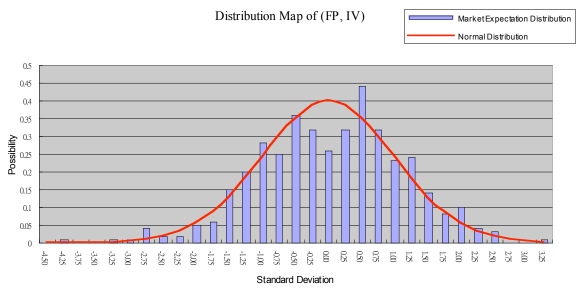

Fig. 2 Market expectation distribution map of (FP, IV) compared to the normal distribution, $D(\mu,\sigma,skewness,kurtosis) = D(0.0163, 1.1109, -0.2920, 3.4500)$.

Figure 3 exhibits that the distribution of D approximates that of $N_d(0,1)$, and is skewed left and peaked compared to $N_d(0.0163,1.1109)$ but slightly flatter and skewed right compared to $N_d(0,1)$ also has thicker tails. That is, the actual final settlement values for Taiwan Stock Index futures and options roughly follow the market expectation formed by FP and IV, but have slightly larger volatilities. Another interesting observation is that two possibility peaks located at exactly +0.5 and -0.5 standard deviations.

Using the closing price of the stock index rather than the FP in (3.7), another possibility space formed by IV only can be generated. Letting D' = $\{d'_1, d'_2, \ldots, d'_n\}$, (3.7) becomes:

$$d'_i = \frac{\ln(\frac{SP_i}{S_i})}{v_t} \qquad (3.8)$$

The computed results of D' in I are summarized in Figure 4. Compared to the normal distribution $N_d(0, 1)$, the mean, standard deviation, skewness and kurtosis of D' are 0.0050, 1.0609, -0.3102 and 3.4146, respectively.

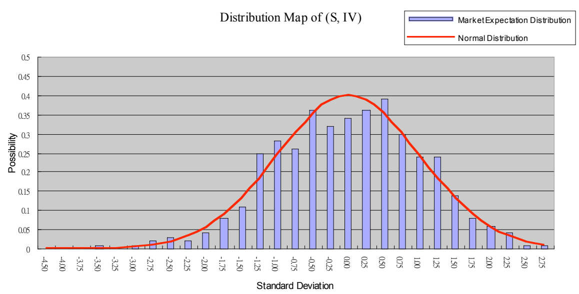

Fig. 3 The market expectation distribution map of (S, IV) compared to the normal distribution, $D'(\mu,\sigma,skewness,kurtosis) = D'(0.0050, 1.0609, -0.3102, 3.4146)$.

Figure 4 displays that the distribution of D' resembles $N_d(0,1)$ more closely than does that of D and is skewed left and peaked compared to $N_d(0.0050,1.0609)$, but slightly flatter and skewed right compared to $N_d(0,1)$ and also has thicker tails. Comparing D and D', the actual final settlement values of Taiwan Stock Index futures and options roughly follow the market expectations formed by FP and IV but more closely follow the expectations of S and IV.

The cumulative possibility distributions from intervals $\pm\sigma$ to $\pm 3\sigma$ of the normal distribution, D and D', are listed below:

Table 2: Cumulative possibility distributions

		±σ	±2σ	±3σ
Normal Distribution	Value	0.6827	0.9545	0.9973
Market Expectation Distribution of D(FP, IV)	Value	0.632	0.932	0.989
	Delta (%)	-7.4264	-2.3573	-0.8322
Market Expectation Distribution of D'(S, IV)	Value	0.657	0.941	0.994
	Delta (%)	-3.7645	-1.4144	-0.3309

By using three years tick transactions I = [2/1/2003,30/12/2005] into consideration, the cumulative possibility distributions from intervals $\pm\sigma$ to $\pm 3\sigma$ compared to the normal distribution are listed below:

Table 3: Cumulative possibility distributions of High Frequency Market Expectations

		±σ	±2σ	±3σ
Normal Distribution	Value	0.6827	0.9545	0.9973
Market Expectation Distribution of D(FP, IV) High Frequency	Value	0.5956	0.9254	0.9910
	Delta (%)	-12.7526	-3.0486	-0.6284
Market Expectation Distribution of D'(S, IV) High Frequency	Value	0.657	0.941	0.994
	Delta (%)	-10.7544	-2.8157	-0.7880
Market Expectation Distribution of D(FP, IV) Low Frequency	Value	0.5979	0.9236	0.9893
	Delta (%)	-12.4279	-3.2381	-0.8046
Market Expectation Distribution of D'(S, IV) Low Frequency	Value	0.6247	0.9303	0.9920
	Delta (%)	-8.5008	-2.5359	-0.5357

Table 2 reveals that the cumulative possibility of D is smaller than the normal distribution, being approximately 7.43% in the plus minus one standard deviation, and 0.83% smaller in $\pm 3\sigma$. D' is even closer to the normal distribution in the testing example presented here, but both D and D' clearly demonstrate that the option price is slightly under estimated. Observing Figure 3, Figure 4 and Table 2 reveals that the final settlement value of the stock index roughly meets market expectations as indicated by both the futures and options. This conclusion also indicates that investors can expect the final settlement value of a stock index to equal the futures price, with a standard deviation equalling the implied volatility derived from option price. Based on this conclusion, investors can expect the performance of their stock positions to roughly follow that of holding both futures and options combinations, but most likely with an expectation bias of ±0.5 implied volatilities. Another observation of this study also suggests that (S, IV) combinations more closely reflect stock index price behaviour than (FP, IV) combinations; that is, applying options only may achieve better risk management performance than using combinations of both options and futures.

3. Conclusions

This study used derivatives prices to indicate market expectations and found that the final settlement value of the stock index moves roughly in accordance with market expectations. Although market expectations cannot precisely forecast the final settlement value of the underlying assets, general investors can easily adopt the futures price as the expected final settlement value, with standard deviation equaling the near-the-money implied volatility derived from option prices.

Another interesting finding was that market participants tend to slightly under estimate actual volatility in the Taiwanese stock market. Two possible explanations for this finding exist. The first explanation may be the pricing error of the naïve Black-Scholes model, which constantly underestimates the near-the-money option price. However, this study finds that option market makers suffer only a 2% loss during the four sample years, indicating that the Black-Scholes model only insignificantly underestimates the near-the-money option price. The second explanation is that general market participants tend to be conservative in anticipating stock index volatility and may slightly under-estimate option prices.

The final and most interesting finding of this study was that overall market expectations exhibit two peaks, located at the +0.5 and -0.5 standard deviations. This phenomenon is particularly clear for the market expectations regarding FP and IV, and thus further research is required to explore this market behavior and its influence on general investors.

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